Consumers' choice of chicken meat

The case of local dual-purpose breeds and local protein feedstuff

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Summary

As poultry production and consumption have increased over the last decade, current production methods have been under scrutiny by several stakeholders, including consumers. Practices such as culling day-old male chicks from layer breeds due to their "non-profitability" have gathered attention and have raised ethical concerns regarding the current production practices and the impacts they have on animal welfare. As these concerns continue to grow, consumers have started looking for alternative products such as the use of dual-purpose breeds, i.e., breeds that can be used for both laying eggs (female) and producing meat (male). Although this concept is not familiar to many consumers, once explained it is seen as a positive alternative that is more animal-friendly than current practices. Additional to the ethical issues, the poultry industry requires a high amount of protein-rich feedstuff. Soybeans are widely used as a protein source in the poultry industry; however, the European Union's yield cannot cover its demand and are therefore forced to import from overseas. The price volatility of this crop and concerns regarding sustainability issues related to the production (i.e., genetically modified organisms and deforestation) have led to the search for alternative locally produced protein-rich and affordable feedstuff. Faba bean (*Vicia faba* L.) is one of the oldest and most widely cultivated legumes in Europe. Due to their high protein content and rich amino acid composition, they can substitute soybeans as a protein source in poultry diet.

Against this backdrop, this dissertation contributes to a deeper understanding of consumers' acceptance of specific local and dual-purpose breeds, as well as their expectations from chicken farming. Moreover, this work contributes to the increasing literature regarding alternative protein sources for poultry feedstuff. Hence, this dissertation presents five research papers, from which three focus on the different attributes that lead to product acceptance, while the other two focus on different meat quality parameters of specific dual-purpose breeds and faba bean-based diets.

In the first section (studies 1, 2, and 3) quantitative and qualitative methods were used to gather data to explore and understand whether chicken meat from local dual-purpose breeds and local protein feedstuff would be an accepted alternative to commercial chicken meat. The use of different methods, including eye-tracking, online questionnaires, and focus groups allowed to obtain data to help identify which extrinsic and intrinsic product attributes are preferred by consumers and whether these include our research subject. Results show that the use of chicken pictures as a communication outlet to identify breeds is only suitable for niche markets as most

consumers do not want to see such pictures on their products. Additionally, price and product origin are the attributes consumers consider more relevant when purchasing chicken meat, followed by freshness, labels, and appearance. Although consumers are interested in dual-purpose breeds, this attribute by itself is not enough to motivate purchase, and therefore other important characteristics (e.g., animal welfare, product origin) have to be promoted as well. A lack of information on husbandry systems and animal welfare was considered, by consumers, to be a barrier in buying specific products.

The second section (studies 4 and 5) of the dissertation focuses on product quality testing, i.e., physicochemical parameters, nucleotide content, proximal composition and sensory attributes. The data obtained from the different parameters allowed to examine whether the use of a high or low vicin/convincine content in a faba bean-based diet differed from a soybean-based diet, and whether this change was accepted by consumers. The results show that while there are slight differences in some physicochemical and sensory characteristics, the use of local faba beans does not compromise the quality of the chicken meat (breast fillets) of dual-purpose breeds Bresse Gauloise, Vorwerkhuhn, White Rock and the crossbreeds thereof. Similarly, a faba bean-based diet does not compromise hedonic consumer preference of chicken breast from the crossbreeds.

As consumers are, in general, not well informed about poultry production systems it is difficult to highlight the positive aspects of using dual-purpose breeds and local protein feedstuff. And although consumers have in mind an ideal chicken farm that is far from the reality of current practices, they only take into account a few product attributes when purchasing chicken meat. Therefore, to successfully market dual-purpose breeds and local protein feedstuff, it is necessary to understand which attributes consumers value the most. While consumers are mostly in favor of dual-purpose breeds, this product attribute does not drive the purchase of the product. However, the promotion of regional feedstuff and regional production as well as highlighting the ethical issues tackled with dual-purpose breeds could incentive consumers to purchase such products, particularly if promoting local breeds. This information needs to be easily recognizable and understood so the advantages of these products are effectively communicated. Additional to these extrinsic properties, meat quality is also of relevance to consumers when purchasing chicken meat. Although there are many factors that can influence the meat quality of chicken, this research shows that faba beans can be used as an alternative to soybeans as protein feedstuff without compromising the physicochemical and organoleptic quality of the meat.

Zusammenfassung

In den letzten zehn Jahren hat Geflügelproduktion und -konsum zugenommen, daher wurden die derzeitigen Produktionsmethoden von verschiedenen Interessengruppen, einschließlich der Verbraucher, kritisch hinterfragt. Die Tötung von männlicher Eintagsküken aufgrund ihrer "Unrentabilität" hat Aufmerksamkeit geweckt und ethische Bedenken hinsichtlich der derzeitigen Produktionsmethoden und ihrer Auswirkungen auf den Tierschutz aufkommen lassen. Diese Sorgen nehmen weiter zu, deshalb suchen die Verbraucher nach alternativen Produkten, wie z. B. Zweinutzungsrassen, d. h. Rassen, die sowohl zum Eierlegen (weiblich) als auch zur Fleischproduktion (männlich) verwendet werden können. Dieses Konzept ist vielen Verbrauchern nicht bekannt, aber sobald es erklärt ist, wird es als positive Alternative angesehen. Des Weiteren ist zu berücksichtigen, dass die Geflügelindustrie eine große Menge an proteinreichen Futtermitteln benötigt. Sojabohnen werden in der Geflügelindustrie in großem Umfang als Eiweißquelle verwendet. Die Europäischen Union kann jedoch ihren Bedarf nicht decken und ist daher gezwungen Sojabohnen aus Übersee zu importieren. Die Preisvolatilität dieser Pflanze und die Sorge um die Nachhaltigkeit der Produktion (d. h. GMO und Entwaldung) haben zur Suche nach alternativen, lokalen, proteinreichen und kostengünstigen Futtermitteln geführt. Die Ackerbohne (*Vicia faba* L.) ist eine der ältesten und am meisten angebauten Hülsenfrüchte in Europa. Aufgrund ihres hohen Proteingehalts und ihrer reichhaltigen Aminosäuren Zusammensetzung können sie Sojabohnen als Proteinquelle in der Geflügelernährung ersetzen.

Vor diesem Hintergrund trägt diese Dissertation zu einem tieferen Verständnis der Verbraucherakzeptanz bestimmter lokaler und Zweinutzungsrassen sowie ihrer Erwartungen an die Hühnerzucht bei. Darüber hinaus trägt diese Arbeit zur zunehmenden Literatur über alternative Proteinquellen für Geflügelfutter bei. In dieser Dissertation werden daher fünf Studien vorgestellt. Drei beschäftigen sich mit den verschiedenen Attributen, die zur Produktakzeptanz führen, und zwei mit verschiedenen Fleischqualitätsparametern von spezifischen Zweinutzungsrassen und Futtermitteln auf Ackerbohnenbasis konzentrieren.

Im ersten Abschnitt (Studien 1, 2 und 3) wurden mit Hilfe quantitativer und qualitativer Methoden Daten erhoben, um zu erforschen und zu verstehen, ob Hühnerfleisch von lokalen Zweinutzungsrassen und lokalen Proteinfuttermitteln eine akzeptierte Alternative zu kommerziellem Hühnerfleisch darstellt. Durch den Einsatz verschiedener Methoden, darunter Eye-Tracking, Online Umfragen und Fokusgruppen, konnten Daten gesammelt werden, die

dabei helfen, herauszufinden, welche extrinsischen und intrinsischen Produktmerkmale von den Verbrauchern bevorzugt werden. Die Ergebnisse zeigen, dass die Verwendung von Hühnerbildern als Kommunikationskanal zur Identifizierung von Rassen nur für Nischenmärkte geeignet ist, da die meisten Verbraucher solche Bilder auf ihren Produkten nicht sehen wollen. Darüber hinaus sind der Preis und die Herkunft des Produkts die Attribute, die die Verbraucher beim Kauf von Hühnerfleisch für am wichtigsten halten, gefolgt von Frische, Etikett und Aussehen. Obwohl die Verbraucher an Zweinutzungsrassen interessiert sind, reicht dieses Attribut allein nicht aus, um sie zum Kauf zu motivieren, so dass auch andere wichtige Merkmale (z. B. Tierschutz, Herkunft des Produkts) beworben werden müssen. Ein Mangel an Informationen über Haltungssysteme und Tierschutz wurde von den Verbrauchern als Hindernis für den Kauf bestimmter Produkte angesehen.

Der zweite Abschnitt (Studien 4 und 5) der Dissertation konzentriert sich auf die Analyse der Produktqualität, d. h. physikalisch-chemische Parameter, Nukleotid-Gehalts, der Nährstoffzusammensetzung und sensorische Eigenschaften. Mit Hilfe der gewonnenen Daten konnte untersucht werden, ob sich die Verwendung eines hohen oder niedrigen Vicin/Convincin-Gehalts in einer Ernährung auf Ackerbohnenbasis von einer Ernährung auf Sojabasis unterscheidet und ob diese Änderung von den Verbrauchern akzeptiert wird. Die Ergebnisse zeigen, dass trotz leichter Unterschiede bei einigen physikalisch-chemischen und sensorischen Merkmalen die Verwendung lokaler Ackerbohnen die Qualität des Hühnerfleisches (Brustfilets) der Zweinutzungsrassen Bresse Gauloise, Vorwerkhuhn, White Rock und deren Kreuzungen nicht gefährdet. Ebenso beeinflusst eine Ernährung auf Ackerbohnenbasis nicht die hedonische Präferenz der Verbraucher für Hühnerbrust der Kreuzungsrassen.

Da die Verbraucher im Allgemeinen nicht gut über Geflügelproduktionssysteme informiert sind, ist es schwierig, die positiven Aspekte der Verwendung von Zweinutzungsrassen und lokalen Eiweißfuttermitteln hervorzuheben. Obwohl die Verbraucher eine ideale Hühnerfarm vor Augen haben, die weit von der Realität der derzeitigen Praktiken entfernt ist, berücksichtigen sie beim Kauf von Hühnerfleisch nur wenige Produktmerkmale. Um Zweinutzungsrassen und einheimische Eiweißfuttermittel erfolgreich zu vermarkten, muss man daher wissen, welche Eigenschaften die Verbraucher am meisten schätzen. Auch wenn die Verbraucher Zweinutzungsrassen überwiegend befürworten, ist dieses Produktmerkmal nicht entscheidend für den Kauf des Produkts. Die Förderung regionaler Futtermittel und regionaler Produktion sowie die Hervorhebung der ethischen Probleme, die mit Zweinutzungsrassen

verbunden sind, könnten jedoch einen Anreiz für die Verbraucher darstellen, solche Produkte zu kaufen, insbesondere wenn lokale Rassen gefördert werden. Diese Informationen müssen leicht erkennbar und verständlich sein, damit die Vorteile dieser Produkte wirksam kommuniziert werden können. Neben diesen extrinsischen Eigenschaften ist auch die Fleischqualität für die Verbraucher beim Kauf von Hühnerfleisch von Bedeutung. Obwohl es viele Faktoren gibt, die die Fleischqualität von Hühnerfleisch beeinflussen können, zeigt diese Untersuchung, dass Ackerbohnen als Alternative zu Sojabohnen als Eiweiβfuttermittel verwendet werden können, ohne die physikochemische und organoleptische Qualität des Fleisches zu beeinträchtigen.

Introduction

Meat and its derived products are an important part of the daily diet in many western societies. However, this has not always been the case and the meat industry has significantly changed as there was a shift from extensive to intensive farming (Hoffmann and Scherf, 2006). After World War II, animal housing changed to specialized indoor environments, some manual labor was replaced by machinery, production concentrated on fewer farms and producers started selecting specific breeds with the purpose of increasing production in a shorter period of time (Fraser, 2008). These changes led to a large increase in meat and poultry production and consumption. However, in the last decades, worldwide meat consumption has declined; this decline in consumption has also been observed in Germany. In the past decade (2010 to 2020) pork production and consumption have slowly declined by 7% and 15.5%, respectively (BMELa, 2022), while poultry meat production and consumption have increased by 16.6% and 20.9% (BMELa, 2022). Moreover, in the next decade, it is expected that poultry production in the European Union (EU) will increase 0.4% annually while poultry consumption will increase 0.5% annually (EC, 2021). The preference for poultry meat over other types of meat is associated to several factors such as the healthier image it has when compared to red meat (EC, 2021), its versatility and practicality to cook (Damico et al., 2020; Kennedy et al. 2004), a cheaper price when compared to other meats (Aral et al., 2013; Damico et al., 2020), and a lower environmental impact than beef and pork (de Vries and de Boer, 2010; Macleod et al., 2019).

In order to manage the increasing demand for poultry meat, this industry has specialized chicken husbandry in two production systems: fattening (meat production) and laying (egg production) lines. The goal of these separate lines is to rear specific chicken breeds in order to achieve a high growing performance or a high laying performance (Arthur and Albers, 2003). This increase in production demand has contributed to the growth of large-scale farms, which hold more than 50,000 animals (BLE, 2020). The growth of these large-scale farms has added to the poultry industry being under scrutiny due to the conditions the animals live in, for instance, high stocking densities in barns (Bessei, 2006; Halle and Sandilands, 2006), a lack of outdoor access (Busch and Spiller, 2018), increased animal stress (Clark et al., 2019), increased incidence of animal illness and/or diseases (Bessei, 2006; Clark et al., 2019), and lack of cleanliness (Bessei, 2006; Busch et al., 2015; Clark et al., 2019). Additionally, the culling of day-old male chicks from laying breeds also raises ethical concerns (Bruijnis et al., 2015; de Hass et al., 2021).

This practice (killing of day-old male chicks) is due to the division of fattening and laying lines, as the fattening line consists of male and female broilers that achieve a high growth rate and the laying line consists of only female birds. Since the male chicks of the laying line cannot lay eggs and cannot grow to produce enough meat (when compared to broilers) they are considered uneconomical and are killed in their first day of life, despite of the production method practiced (i.e., conventional, free-range, organic) (BMELb, 2022). Around 45 million day-old male chicks were annually culled in Germany (BMELb, 2022), while 330 million in the EU (EC, 2008). However, starting January 2022, the killing of hatched day-old chicks has been prohibited, making Germany the first country in the world to ban this practice (BMELb, 2022). As this practice is prohibited, it is important to find alternatives to it or solutions to the "non-profitability" of layer-type male chicks. The main alternatives to the killing of day-old chicks include: 1) *in-ovo* gender determination, 2) fattening of the laying brothers, and 3) the use of dual-purpose breeds (DPBs). The first alternative, *in-ovo* gender determination, refers to identifying the sex of the embryo in order to determine whether it will continue to grow (female) or will be eliminated (male) (BLE, 2022). The second alternative, fattening of the laying brothers, means that rather than culling male chicks after hatching they are reared and fattened as broilers would, however they grow slower and produce less meat and therefore the extra production costs are usually assigned to the eggs (BLE, 2022). Finally, the term "dual-purpose breeds" refers to chicken breeds that can be used for both, meat (male) and egg (female) production, and are not specialized for one type of production (BLE, 2022).

In order for the specialized and intensive farming to happen, an increase in animal feed production was necessary. However, with this increase in feed production, concerns related to environmental issues began to arise since most greenhouse gas (GHG) emissions produced in poultry farming are associated to the production and transfer of feedstuff (Benavides et al., 2020; Boggia et al., 2010; Leinonen and Kyriazakis, 2016). The poultry industry requires a high amount of protein feedstuff which is usually imported from overseas in form of soybean meal (Ahrens, 2021). However, in order to keep up with the rising demand for poultry meat, these imports are unlikely to stop as protein-rich feedstuff remains necessary for poultry farming (Röös et al., 2017). An alternative to protein-rich feedstuff imports is the production of such feedstuff locally.

This dissertation deals with two research topics (dual-purpose breeds and local faba beans as protein feedstuff); hence, these will be introduced separately in the next pages. An introduction

to consumers' choices of quality attributes will follow, ending with an overview of the research results contributing to this dissertation.

Dual-purpose chicken breeds

Although DPBs are a viable solution to the culling of male chicks, there are downsides to them too. The main disadvantage of DPBs is their low profitability associated to the low laying and fattening performance when compared to specialized lines. While a broiler is usually fattened for 34 days to reach a slaughter weight of 2.1 kg (DLG, 2021), a DPB requires twice the amount of time (if not longer, depending on the particular breed) to reach a similar weight (Nolte et al., 2020b; Tiemann et al., 2020). Similarly, conventional laying hens lay around 310-330 eggs annually (DLG et al., 2020), while the laying performance of DPBs is 20-40% lower (Baldinger and Bussemas, 2021; Nolte et al., 2020a; Schultz, 2012). Although the production performance of DPBs is lower than that of conventional lines, their performance is usually better than native breeds or laying brothers (Lambertz et al., 2018; Mueller et al., 2018). However, there are native breeds that are also used as dual-purpose, therefore providing not only an acceptable fattening and laying performance but also genetic resources that might be slowly disappearing.

The selection of specific breeds, for meat and egg production, has contributed to the loss of genetic variability (Gandini and Villa, 2003; Hodges, 1990; Spalona et al., 2007). It is, however, important to conserve animal genetic resources through native breeds, as these are not only part of a culture's heritage, but they could also contribute to solving future problems through valuable traits, for instance disease resistance (Hoffmann and Scherf, 2006). In Germany, the Animal Welfare Law defines a native breed as that which originated or has been reared in German territory at least since 1949 (BLE, 2019). That is the case for the German breed Vorwerkhuhn (VH), originally from Hamburg, which has been reared for more than 100 years by hobby breeders in Germany (Titze, n.d.). After World War II this breed was at risk of extinction and continued to be for years (Titze, n.d.); today, with the help of the conservation breeding ring (Initiative zur Erhaltung alter Geflügelrassen e.V.), VH is not considered at risk anymore and is only classified as "under observation" by the Central Documentation on Animal Genetic Resources in Germany (GEH, 2022; Weigend et al., 2009). Vorwerkhuhn is both, a native breed and a DPB, however since its laying and fattening performances are well below those of a commercial line (laying: 170 vs. 310 eggs annually, fattening: 2.2 kg in 16 weeks vs. 2.1 kg in 34 days) it is difficult to market (DLG, 2021; DLG et al., 2020; Nolte et al., 2020b; Titze, n.d.; Weigend et al., 2009). Similar to VH, Bresse chickens are also a native breed and a DPB originally from the Bresse region in France. This breed is also reared in Germany and it

is referred to as “Bresse Gauloise” (BG) since outside the Bresse region, the breed has to be called that way. The uniqueness of the breed, along with the region of origin and specific production methods and conditions have awarded this breed a protected designation of origin (PDO) (La Volaille de Bresse, 2015). Additionally, the laying and fattening performance of BG is better than that of VH (laying: 240 vs. 170 eggs annually, fattening: 2.2 kg vs. 2.5 kg in 16 weeks) (Schultz, 2012). Moreover, the meat from BG is considered a delicacy (La Volaille de Bresse, 2015) and it is therefore easier to market at a higher price. Since native breeds have a low fattening and laying performance, they are usually kept by hobby breeders or small-scale farmers as a source of income or high-quality protein (Padhi, 2016). An advantage of local breeds is their better adaptation to extensive husbandry and local housing conditions (Tixier-Boichard et al., 2009), since they are good foragers and can tolerate hard environmental conditions (Padhi, 2016). In order to enhance the laying and fattening performance of native breeds, improvement in husbandry practices or crossbreeding with commercial lines can be implemented. For instance, Kollbecksmoor (KM) is a crossbreed between VH cocks and White Rock (WR) hens, a commercial laying line from Lohmann Tierzucht GmbH (Cuxhaven, Germany) (Schultz, 2012; Weigend et al., 2009). This crossbreed has a similar fattening performance and a better laying performance (250 eggs annually) than VH (Nolte et al., 2020b; Weigend et al., 2009), although its performance is still below commercial lines (Schultz, 2012).

The low laying and fattening performance of DPBs make it necessary for animals to be reared for longer periods of time when compared to broilers. The costs of keeping these breeds (e.g., housing and feeding) for less product (i.e., eggs and meat) make it necessary to increase prices to compensate for the higher production costs (Damme et al., 2015; Diekmann et al., 2017; Gangnat et al., 2018). Research has shown that although many consumers are not familiar with the concept of DPBs, once it is explained, they have a positive attitude towards this concept (Brümmer et al., 2017; Gangnat et al., 2018; Leenstra et al., 2011). While an increase in the egg price could help mitigate the additional costs of rearing these breeds (Diekmann et al., 2017), it is unclear how much more consumers would be willing to pay for DPB eggs or meat. Although some consumers would not be willing to pay more for DPB products (Brümmer et al., 2017), others would pay a varying surcharge from 13% to 50% (Brümmer et al., 2017; Gangnat et al., 2018; de Haas et al., 2021; Leenstra et al., 2011).

Local faba beans as protein source

In poultry diets, wheat or corn usually comprises the largest part of the diet, however protein-rich crops are also an important part of these diets. Soybeans, particularly soybean meal, have a high content of crude protein (about 40%) and are therefore the most commonly used protein source for poultry feedstuff; additionally, their favorable amino acid composition complements maize meals (DBV, 2021; Miller, 2003; Leinonen and Kyriazakis, 2016). The world's largest producers of soybeans are Brazil, United States of America (USA), and Argentina (DBV, 2021), while in Europe, soybean production is more limited since this crop requires warm conditions to grow; hence, it can only grow in southern parts of Europe, mainly in Italy (DBV, 2021, Sobko et al., 2020). Since production in Europe is not enough to cover its own demand, soybeans have to be imported from USA and Brazil (Ahrens, 2021). In the period 2020/21 the EU imported 16.8 million tons of soybean meal while Germany imported 2.2 million tons (DBV, 2021). The use of soybeans in poultry diets has been criticized as most soybean produced in USA is genetically modified (GM) and European consumers, particularly in Germany, disapprove the use of GM crops (Lucht, 2015). Additionally, soybean production is associated to land use changes, mainly deforestation, which contribute to climate change (Leinonen and and Kyriazakis, 2016). Deforestation driven by soybean production in South America has occurred mainly in Brazil where the soybean area increased from 0.4 Mha to 4.6 Mha in almost two decades (2000-2019) (Song et al., 2021). Moreover, the high demand of soybean imports affects the European poultry industry as the price volatility of soybeans on the global market influences farmers' production systems in a way they cannot control (de Visser et al., 2014).

In order to reduce the (soybean meal) protein imports and reduce the environmental impact associated with poultry feedstuff production and transportation, while stabilizing feedstuff prices, an alternative protein source is needed. One alternative is the use of synthetic and crystalline amino acids as this is an effective way to improve animal nutrition; however, this practice is prohibited in organic farming (Regulation 2018/848) and it produces more GHG emissions than soybean meal (Benavides et al., 2020). Another alternative is the use of insects as protein source as many insects have a good nutritional profile (protein rich with balanced amino acid content) when compared to soy (Sánchez-Muros et al., 2014). Since research regarding this topic is relatively new and still on-going, there is only small-scale production of insects intended for using as feedstuff which increases the price per kg (Gasco et al., 2020). A third alternative is selecting crops that grow locally and have a balanced nutrient content, such as grain legumes. These crops also have the ability to fix nitrogen in soil with the help of

Rhizobium bacteria; legumes are therefore valuable for agricultural practices as well as reforestation and soil stabilization (Plá and Cobos-Porras, 2015). The cultivated area of legumes in the EU increased 3% from 2020 to 2021 (DBV, 2021), while in Germany the cultivation of legumes expanded by almost 11% in the same year (BMEL, 2022c). The most cultivated legumes in Germany are peas, field beans, soybeans, and sweet lupins (Destatis, 2020). This thesis focuses on the second crop: field beans.

Faba beans (*Vicia faba* L., FB), also known as field beans, have been widely cultivated since Neolithic times due to their ability to grow in different climatic conditions (Duc, 1997). Depending on the genotype, FB contain between 27-30% protein, which is complemented by rich lysine content (Crépon et al., 2010; Duc, 1997). Nonetheless, FB seeds are considered to have anti-nutritional effects in poultry diet as they contain tannins and vicin and convicine (VC) that can affect the apparent metabolizable energy (AMEn) (Crépon, 2006; Crépon et al., 2010; Rubio et al., 1990). Tannins decrease protein and energy digestibility, but they can be easily removed by dehulling the seeds of FB; on the other hand, VC affects the metabolism of the animals and are difficult to remove since they are heat-stable (Crépon, 2006; Crépon et al., 2010; Duc, 1997). However, the content of tannins and VC varies depending on the cultivar.

While the inclusion of FB in poultry diet has been widely discussed, no conclusive result has been drawn. The inclusion of VC in the diet of laying hens has shown contradictory results, as some found a decrease in egg weight due to the inclusion of VC (Koivunen et al., 2014), others found that the inclusion of VC had no negative effect on laying performance or egg quality (Dänner, 2003; Laudadio and Tufarelli, 2010), and others found that a VC-rich diet decreases the egg weight and a VC-poor diet decreases laying performance, however only in specific breeds (Nolte et al., 2020a). Literature regarding broiler performance when fed with FB is limited; a recent study shows that a FB-based diet does not affect growth performance of cockerels (Nolte et al., 2020b). Moreover, research shows that a FB-based diet does not affect meat quality parameters or sensory properties (Escobedo del Bosque et al., 2020; Hejdysz et al., 2019). It is difficult to compare results of previous research as the conditions in each vary greatly; however, it appears that animal performance (laying or fattening) depends on many factors, including the variety of FB, the given treatment to the seeds (e.g., dehulling, pelleting), the content of antinutritional factors in the FB, and specific characteristics of each animal breed.

Although the use of dual-purpose breeds and faba beans as feedstuff have positive aspects, it is still consumers' decision whether the advantages these products offer are enough to purchase the products or not.

Food choices: quality attributes

The choice to purchase a product is a complex process of decisions that are heavily influenced by different factors such as education, income, attitudes, beliefs, health, and cultural identity (Cantarero et al., 2012; Contento, 2016; Leng et al., 2017; Monterrosa et al., 2020). Additionally, a product's price and quality are the most important factors that consumers consider when determining whether to purchase a product or not (EC, n.d.; Steenhius et al., 2011). However, the term quality is subjective as it may allude to different aspects; for instance, quality may refer to a product's compliance of regulations created by a specific government, or it may refer to consumers' organoleptic and nutritional expectations or it may refer to preferred characteristics such as production method (e.g., organic or conventional) or place of origin (FAO, 2004). Therefore, one can say that food quality is a multi-dimensional concept, as it involves several aspects or dimensions such as freshness, origin, nutritional value, organoleptic, convenience, etc. In order for consumers to evaluate the quality of any product, information on the different product characteristics is needed to make a decision with respect to their expectations and demands (Brečić et al., 2017; Grunert, 2002).

This information, called qualitative cues, can be divided into two categories: measurable quality (intrinsic attributes) and consumer perceived quality (extrinsic attributes) (Becker, 1999; EC, n.d.; Espejel et al., 2007; Grunert, 2002). Intrinsic attributes are those that are part of the physical product and cannot be altered without changing the physical product itself (Olson and Jacoby, 1972). A product's color, fat content, sweetness, tenderness, and juiciness are examples of intrinsic product attributes. On the other hand, extrinsic attributes are related to the product but they are not evident in the product itself and are therefore invisible to the consumer before and after consuming the product (Espejel et al., 2007; Grunert, 2002; Olson and Jacoby, 1972). A product's brand, quality labels, place of origin, production method, and sustainability are examples of extrinsic attributes. These quality cues (extrinsic and intrinsic) are available in a product and then used by consumers to deduce those quality attributes that cannot be tested prior to consumption (Steenkamp, 1990). For instance, a consumer can use the product's color, brand, price, and production method (intrinsic and extrinsic quality cues) to infer the taste (quality attribute) of the product. Quality attributes are classified as search quality attributes (those that are available when purchasing, e.g., price), experience quality attributes (those that are discovered when consuming the product, e.g., taste), and credence quality attributes (those that cannot be verified before, during or after normal use, but instead require additional

resources and knowledge to validate these attributes, e.g., fair trade) (Bernués et al., 2003; Darby and Karni, 1973; Fernqvist and Ekelund, 2014).

Since extrinsic and intrinsic attributes help consumers determine product quality, it is expected that producers communicate (e.g., via labels) as many attributes as possible to best describe their product. Food choices are also heavily influenced by how products are marketed and labelled (Leng et al. 2017); however, too much available information is confusing to consumers as it is usually delivered in different ways (e.g., via pictures, text) and for different topics, mostly regarding to environmental and ethical criteria (Fernqvist and Ekelund, 2014; Grunert et al., 2014). Also, consumers are faced with other factors (e.g., personal, social, environmental) that further influence their decision at the place of purchase. In order to ease the decision-making process at the time of purchase, it is crucial to avoid information overload by focusing on communicating only relevant information, specifically that of extrinsic attributes thar inform about food quality, via simple front labels (Enriquez and Archila-Godinez, 2021). Additionally, different consumer groups prioritize different aspects of quality when purchasing food (Henchion et al., 2014). This, along with consumers ever-changing expectations and demands for food quality, particularly for animal products (Bernués et al., 2003; Fernqvist and Ekelund, 2014), challenge producers as it creates the question of which quality attributes need to be communicated and how to raise awareness of their value (Henchion et al., 2014).

In the case of chicken meat, intrinsic attributes that are preferred by consumers include meat color and form, good taste, tenderness and juiciness, fat content, and nutritional quality (Bett et al., 2013; Kennedy et al., 2004; Mir et al., 2017). On the other hand, some of the preferred extrinsic attributes include price, place of origin, animal welfare, accreditation, and free-range (Erian and Phillips, 2017; Vukasovič, 2014). These extrinsic attributes are communicated as credence attributes which are becoming more important to consumers and are based on trust (e.g., towards the seller or certifying association) (Darby and Karni, 1973; Fernqvist and Ekelund, 2014). As consumers have an important part in setting market trends of food consumption (Enriquez and Archila-Godinez, 2021), it is important to investigate what their expectations are from chicken meat from a dual-purpose breed fed with local faba beans. Moreover, it is important to determine whether these expectations are practical and attainable, as it has been shown that when regarding poultry farming, consumers lack knowledge of production methods (Erian and Phillips, 2017), which can lead to expectations of unrealistic or too costly practices.

Objectives and content of this dissertation

Against this background, the main objective of this thesis was to determine whether chicken meat from local dual-purpose breeds and local faba beans as protein feedstuff is accepted by consumers. This contributes to an assessment of consumers' potential preference for chicken meat from this production method (dual-purpose breed and local feedstuff) over traditional methods (i.e., conventional or organic broiler fed with imported feed). The first objective was to explore consumers' interest in local dual-purpose breeds, local feedstuff and their interest in purchasing meat from this production method. The second objective was to evaluate different meat quality parameters (including physicochemical and sensory) of male chickens of specific breeds fed with two faba bean-based diets versus a soybean meal-based diet. The first part of this dissertation focuses on the extrinsic attributes that influence consumer choices, therefore addressing the first objective. Through the use of qualitative and quantitative methods such as eye-tracking technology, think-aloud method, online surveys and focus groups the use of pictures or extrinsic cues (e.g., animal origin, breed, feed origin) on packaging, as well as consumers' expectations of chicken farming were tested. By analyzing consumers' preferences and perceptions, conclusions can be drawn on which extrinsic attributes are preferred by consumers in the case of chicken meat and whether dual-purpose breeds fed with local feedstuff are part of these attributes. The second part of this dissertation focuses on the second objective of the thesis, which is to evaluate intrinsic attributes related to the meat quality of the specific breeds and feedstuff. By analyzing physicochemical properties, nucleotide content, proximate composition and sensory characteristics of particular local dual-purpose breeds fed with conventional feed (soybean as a protein source) and two variants with a local protein source it was possible to evaluate the effect of feedstuff and breed in the different parameters that influence meat quality. Furthermore, consumer evaluation took place in order to determine preference for a specific breed and feedstuff. An overview of the structure of the dissertation as well as the scientific articles contained herein is given in Table 1.

Table 1. Structure of the dissertation

Introduction	
Section I Extrinsic attributes	I.1 My meat does not have feathers: Consumers' associations with pictures of different chicken breeds
	I.2 Who wants chicken? Uncovering consumer preferences for produce of alternative chicken product methods
	I.3 Consumers' opinions and expectations of an 'ideal chicken farm' and their willingness to purchase a whole chicken from this farm
Section II Intrinsic attributes	II.1 Meat quality parameters and sensory properties of one high-performing and two local chicken breeds fed with Vicia faba
	II.2 Meat quality parameters, sensory properties and consumer acceptance of chicken meat from dual-purpose crossbreeds fed with regional faba beans
Discussion and Conclusions	

Section I – Extrinsic attributes

Consumers have very little knowledge about the different breeds used in chicken farming; thus, complicating the communication of the advantages of dual-purpose or traditional breeds. At the moment of research, it was unknown how people view images of different chicken breeds and what they think of these upon seeing them. The first article (I.1) addresses this gap in literature as it examines how people view and evaluate images of four different chicken breeds (Bresse Gauloise, Vorwerkhuhn, White Rock, and Kollbecksmoor), which serve as the object of investigation in this article. The first part of the study uses the method of eye-tracking when the participants look at the pictures; this method allows to follow participants' eye movements in order to evaluate attraction of specific areas in specific stimuli and record this information to later process (Duchowski, 2002). In this case, it was examined which image areas were looked at, for how long, and if this differed between breeds. Along with eye-tracking, the think-aloud method, a method in which participants vocalize their thoughts while performing a specific task (van Someren et al., 1994), was used to gather participants' initial thoughts and associations of each breed when observing an image of each. Through an online survey, the second part of the study evaluates and quantifies participants' associations with the presented breeds and consumers' interest in meat with the breed picture on the packaging. The results of this article provide guidance for the use of images of chickens for communicating the different breeds on the packaging of meat products.

The second article (I.2) deals with consumers' choices when presented different information in labels regarding breeding form, breed, price, product origin, and feed origin. Literature has

shown that consumers' willingness to pay for animal products from local origin (Printezis et al., 2019; Wägeli et al., 2015) and produced with local feed (Profeta and Hamm, 2018; Wägeli et al., 2015) is higher; however, at the moment of research, it was still unknown whether consumers would prefer chicken meat from a dual-purpose breed (DPB) over laying brother, organic, or conventional, or if they would prefer meat from a specific breed (or specific looking breed). This study addresses this research gap by using a discrete choice experiment, which is a technique that creates a hypothetical shopping situation, where consumers are presented with different options of a product or product category and consumers choose one or none (Lancsar and Louviere, 2005). Additionally, the theory of planned behavior (TPB), which states that consumers' intention to behave a certain way is determined by their attitudes, social norms, and perceived behavioral control (Azjen, 1991), was complemented by moral elements of the value belief norm (VBN) theory, which predicts pro-environmental behavior by linking different factors (Stern et al., 1999), to evaluate different aspects that help understand consumers' purchase intention of DPBs or specific chicken breeds. Participants were then segmented into different groups based on their responses in the choice experiment; each group was then further described using the results of TPB and VBN along with purchase frequencies of other products. The results of this article provide insight into the attributes that are most valued by consumers when purchasing chicken meat. Moreover, the target consumer for DPB and local faba beans as feedstuff was found – an origin-oriented consumer interested in the idea of dual-purpose breeds. The findings of this article support the use of DPB and local faba bean feedstuff as an alternative to the *status quo* (i.e., broilers fed with soy imports).

The last article (I.3) of the first section explores consumers' expectations of an "ideal" chicken farm. As learned from the second article, consumer preference for place of origin has an important weight in consumers' choices. Additionally, animal welfare has also been shown to be an important attribute considered when purchasing animal products (Tonsor et al., 2009; Vanhonacker and Verbeke, 2014). Nonetheless, at the time of research, it was still unclear which other attributes were considered when purchasing chicken meat; moreover, it was unknown what consumers expected from a chicken farm – an ideal chicken farm. Therefore, this study addresses this gap in literature through the use of focus groups, a method in which information on a specific topic is collected by group discussions in a natural setting, almost like a conversation among participants with similar and different opinions (Lamnek, 2005; Morgan, 1996). Based on the results of article I.2, participants with the same characteristics of the consumer group interested in DPB were recruited to take part in these discussions. From the

previous research it was learned that although participants are interested in DPB this attribute alone was not enough to persuade consumers to purchase a product; therefore, in this article the characteristics of the "ideal" chicken farm, from a consumers' point of view, were explored in order to understand which other attributes are important enough to persuade consumers to purchase DPB chicken meat. As the market for whole animals is a small one, the idea of purchasing a whole chicken from this "ideal" farm rather than cuts was also explored. The results of this study highlight the different aspects that consumers consider part of an "ideal" chicken farm. These findings contribute to a better understanding of consumers' expectations and give guidance to a better labeling of DPB meat which highlights relevant attributes.

Section II – Intrinsic attributes

Although extrinsic attributes have an important part in consumers' choice of food products, intrinsic attributes, especially organoleptic and nutritional properties are just as important. Therefore, the first article (II.1) evaluates through instrumental and sensory methods, the quality of chicken breast meat in terms of physicochemical properties (pH, color, water holding capacity, and instrumental tenderness), nucleotide content (inosine 5′-monophosphate, adenosine 5′-monophosphate, and inosine), and sensory properties (odor, appearance, taste, and texture). Sensory evaluation is a discipline that evokes, measures, analyzes and interprets people's reactions to specific products characteristics as perceived by all five senses (IFT, 1981). The particular method used in this study was a descriptive analysis, which allows to quantify the perceived intensities of different sensory attributes (e.g., saltiness) of products (Lawless and Heymann, 2010a). In the case of meat, sensory attributes are important for consumer acceptability; however, sensory properties are linked to physicochemical parameters (e.g., a lower pH is related to a pale color and decreased water holding capacity and therefore loss of juiciness and tenderness (Bowker, 2017)) and nucleotide content (e.g., a high IMP content is linked to a higher flavor intensity, particularly umami (Kawai et al., 2002)). It was therefore important that these properties were assessed to determine whether faba beans could replace soybeans in poultry diet in three breeds (Bresse Gauloise, Vorwerkhuhn, and White Rock). The results of this study provide guidance to those breeders interested in using local crops (i.e., faba beans) as protein sources in the diets of chickens, particularly the abovementioned breeds. This study supports the use of local faba beans as an acceptable dietary protein source for dual-purpose breeds.

Similar to the first article in this section (II.1), the second article (II.2) also evaluates with instrumental and sensory methods, the quality of chicken breast meat. However, this article focuses on the crossbreeds of Bresse Gauloise, Vorwerkhuhn and White Rock as these have a higher laying performance than the parent breeds (Nolte et al., 2020b). Similar methodologies as those in article II.1 were implemented to measure physicochemical characteristics, nucleotide content, and sensory properties. Additionally, part of the nutritional value (macronutrient content) of samples was analyzed (proximate composition, specifically water, protein, and intramuscular fat content) to identify any differences between crossbreeds or feedstuff. Moreover, consumer acceptance of the chicken meat was also tested with a hedonic test, which is a type of sensory testing where the degree of liking or disliking of a product is quantified by a large number of consumers (Lawless and Haymann, 2010b). The results of this study provide a clearer result of consumers' organoleptic preferences regarding the use of DPBs and faba beans. The use of faba beans, particularly with a VC content of 0.136%, is an acceptable protein source for local dual-purpose breeds.

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Section I – Extrinsic characteristics

I.1 My meat does not have feathers: Consumers' associations with pictures of different chicken breeds

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Abstract

The use of traditional chicken breeds with a dual purpose (egg and meat production) has become a relevant topic in Germany mainly due to animal welfare concerns and the importance of conserving genetic variability in poultry farming. However, consumers have little knowledge about the different chicken breeds used in the industry; making it challenging to communicate traditional breeds and their advantages to consumers. Hence, this study takes the approach to look at consumers' perceptions of different breeds. We analyze consumers' evaluations of pictures showing four dual-purpose chicken breeds. First, an eye-tracking study (n = 24) and think-aloud protocols (n = 28) were used to obtain open associations consumers make with each breed. Based on the results, an online survey was conducted (n = 933) to quantify consumers associations with different breeds and consumers' interest in meat products with animal pictures on the packaging. Results show that consumers' attention to pictures of chickens is mostly focused on their body and head, particularly with the Vorwerkhuhn. Consumers associate white breeds to white egg and meat production, while brown breeds are associated to brown egg production. Only a smaller segment of consumers (32%; n = 292), who are more engaged to animal welfare, accept pictures of animals on meat packages. We conclude that the marketing of meat products of traditional chicken breeds by using pictures is not a useful approach for the mass market. However, within smaller market concepts, such pictures can be used to communicate an alternative chicken meat production system that may lead to purchases of traditional dual-purpose breeds.

Keywords

picture evaluation; image association; traditional chicken breed; meat-paradox

1. Introduction

Intensive animal production methods that include specialized environments have gained popularity since the late 1940's (Fraser 2008). Producers have selected specialized chicken breeds to achieve a higher performance at comparably low cost. Although these specialized breeds provide economic benefits, such as fast growth rates, high laying or fattening performances, and good feed use efficiencies, they give concern to animal health and welfare as well as to ethical questions (Leenstra et al. 2011). Among these ethical concerns is the killing of day-old male chicks of the laying breeds, which is commonly practiced in the commercial production of eggs in organic and conventional farming, since fattening males of laying breeds is not profitable (Leenstra et al. 2011). In Germany alone, nearly 45 million male chicks are annually killed due to non-profitability (BMEL 2019).

The culling of male chicks raises ethical concerns among consumers (Aerts et al. 2009). The mass killing of "baby" animals that are considered a "by-product" of an intensive production method is a common reason for the dislike of this practice, since people perceive that the animals are seen as "instruments" or "objects" rather than subjects by the industry (Bruijnis et al. 2015). Increasing interest in this topic has led to the development of various alternatives. Among these alternatives is the use of dual-purpose breeds (DPBs) that can be used for egg production (female animals) and broiler production (male animals) (Damme 2015; Krautwald-Junghanns et al. 2018). However, the concept of DPBs is not familiar to most consumers (Gangnat et al. 2018; Brümmer et al. 2017; Busse et al. 2019). Nonetheless, when introduced to this alternative, consumers see it as a positive practice that is more animal-friendly and ethically justifiable (Gangnat et al. 2018; Brümmer et al. 2017; Leenstra et al. 2011; Busse et al. 2019). Nowadays, there are commercial DPBs available such as Lohmann Dual (Lohmann Tierzucht GmbH, Cuxhaven, Germany), and traditional DPBs that have a lower fattening/laying performance (Mueller et al. 2018), for example Vorwerkhuhn, which are used rarely on farms.

The dominance of few breeds in commercial poultry production has resulted in a low genetic variability in the market. Conservation of traditional breeds has the potential to increase genetic variability (Spalona et al. 2007; Weigend et al. 2009; Padhi 2016). Projects aimed to establish and maintain a flock of chickens of the Vorwerkhuhn breed have helped remove this breed from risk of extinction (BLE 2019). Additionally, traditional breeds are also crucial for the economy of small-scale (or household) farming (Padhi 2016), due to the breeds' robustness and their "forage-hunter" behavior (Padhi 2016; BLE 2019). This forage-hunter behavior allows breeders

to feed the animals with “kitchen waste”, wheat, grass, insects, etc. (Padhi 2016) and avoid depending solely on commercial feedstuff which contains soy beans. Traditional breeds could offer small-scale farmers an opportunity to target niche markets which have aroused from a demand of more specialized food and more ethical production methods.

However, the marketing of traditional animal breeds is difficult because consumers generally seem to have little knowledge about animal breeds. It is difficult to explain the benefits of animal breeds in view of the alienation of many consumers from agriculture due to a growing urbanization (Albersmeier and Spiller 2008, Böhm et al. 2009). Many consumers have no idea that animals are specifically bred for meat or egg production (Gangnat et al. 2018).

An innovative way of introducing traditional DPBs to consumers could be through the use of pictures in marketing, since they might have the potential to attract attention, convey an emotional message and to indicate differences in the breed and therefore in the product for interested consumers. In fact, some traditional breeds look very specific or conspicuous. However, pictures of living animals on meat products are rarely used for marketing purposes. This might be attributed to the so-called “meat-paradox”. This paradox refers to many people liking to eat meat but disliking killing animals or causing them pain (Loughnan et al. 2010).

The state of discomfort described in the meat-paradox (resulting from the liking of meat but the disliking of being aware about the participated responsibility for animal well-being) was first referred to as cognitive dissonance (Festinger 1957). Usually, people try to avoid such mental states of dissonance. One approach to avoid these states of dissonance is by changing behavior or attitudes (Harmon-Jones and Harmon-Jones 2007; Piazza et al. 2015). Meat changing behavior might lead to some consumers following their attitudes and eating less meat or preferring to eat ‘better’ meat; others might reduce or suppress their moral concerns for animals while keeping animal products’ consumption stable (Kunst and Hohle 2016; Piazza et al. 2015).

There is little empirical research testing the meat-paradox specifically with chicken meat (e.g. Kunst and Hohle 2016) and to the best of our knowledge, there is no empiric research testing the meat-paradox that might result when people see pictures of chickens on animal products. This is of particular interest since the results might vary from studies with mammals because studies have shown that people feel more empathy towards mammals (e.g. pigs) and less empathy towards birds (Kubberød et al. 2002; Westbury and Neumann 2008).

Research related to the marketing of animal products based on animal breeds is limited. In these cases, the marketing of a specific breed mostly focuses on the animals’ origin (Verrier et al.

2005; Belk et al. 2014), genetic conservation of the species (Frison and Coolsaet 2018; BESH 2019), or a specific attribute of the product (Wahl et al. 1995). Perhaps the most popular example of breed marketing in poultry is the case of France's Bresse chicken which is marketed mainly based on its origin (Bresse region, France) and traditional breeding (Verrier et al. 2005; La Volaille de Bresse 2015).

While these studies show that animal origin and traditional breeding are of importance for the marketing of animal products of specific breeds, to the best of our knowledge, there is no empirical research on how consumers perceive pictures of chicken breeds, what they associate with the breeds, and if such pictures could be used to help market meat from traditional breeds. This topic is especially important for countries like Germany, where there is no well-known traditional chicken breed, as opposed to France where the strong desire for traditional agricultural products led to the development of "AOC" (controlled designation origin) for the Bresse chicken (visually well-known for its blue legs, white plumage and red crest) to protect its traditional production method and the breed itself (Fermet-Quinet and Bussière 2010).

Today's poultry production is characterized by breeds for egg production and breeds for meat production. The market is dominated by the large breeding companies, leading to very limited breed diversity in poultry production. The use of traditional breeds could help preserve genetic biodiversity in poultry production and could offer opportunities for small-scale farmers to gain a competitive advantage. Further, such traditional breeds can often be used for dual purposes and by doing so, preventing the killing of day-old-chicks which is a contentiously discussed practice.

From a marketing perspective, the main challenge is the lack of consumers' awareness of different breeds which generates problems to communicate such breeds and their advantages to consumers. As consumers today are very distanced from agriculture, textual information could be very difficult to transmit. They would require a high level of consumer involvement, which is typically rare. Information about traditional breeds could be increased through pictures of the animals. The danger is that this might cause cognitive dissonance (meat-paradox) and, in the worst case, has the opposite effects, namely an orientation of consumers towards other meat products without pictures such as conventional ones.

Therefore, the aim of this study is to gain a better understanding of consumers' evaluation and acceptance of pictures showing chicken breeds in the context of marketing. The following research questions (RQ) were investigated:

- What raises consumers' awareness when looking at pictures of different chicken breeds? (RQ1)
- Which associations do consumers have with different breeds? (RQ2)
- Do consumers like to see a picture of the animal when purchasing chicken meat? (RQ3)

We hypothesize that diverse chicken breeds are perceived differently among consumers due to their variance in phenotype. Additionally, we hypothesize that chicken meat, although usually perceived differently (i.e., healthier, classified as white meat, less empathy with birds) compared to red meat (Kubberød et al. 2002), also suffers from the "meat-paradox"-effect since animals also have to be killed for consumption. Nonetheless, we expect a small group of animal welfare concerned consumers, our niche market, to accept and moreover, to be interested in seeing such pictures even on products.

2. Methods

The present study combines two methodological approaches. First, an exploratory test consisting of an eye-tracking study and a think-aloud method was carried out. Then, results obtained were used to develop a standardized online questionnaire to test consumers' associations with chicken pictures in a bigger population.

We chose five chicken breeds for the study to be presented to consumers:

1. Bresse Gauloise (BG): a French DPB known for its sensory qualities; also commonly bred in Germany due to its good laying/fattening performance.
2. Vorwerkhuhn (VH): a German DPB which has been bred to prevent the extinction of the species.
3. White Rock (WR): a commercial line used for egg production, occasionally used as DPB.
4. Kollbecksmoor (KM): a dual-purpose crossbreed of Vorwerkhuhn and White Rock; used due to its good laying/fattening performance.
5. Lohmann Brown (LB): a commercial line used for meat production from one of the leading international breeding companies.

These particular breeds were chosen to test any difference between two commercial lines (WR for eggs, LB for meat) and three locally bred DPBs (BG, VH, KM). Within the poultry industry there are different animal lines, breeds and crossbreeds. However, to ease lecture, from this point on we refer to all of these as "breeds".

In both studies, all participants gave written informed consent to take part in the study before the experiment started. Both studies were conducted in accordance with the Declaration of Helsinki, and both protocols were approved by the Ethics Committee of the University of Goettingen.

2.1 Exploratory study: eye-tracking and think aloud method

Eye-tracking (ET) is a method used to investigate eye movements in order to understand human information reception, i.e. attraction and awareness of particular areas in specific stimuli (Duchowski 2002). Eye movements are categorized in 1) saccades, or rapid eye movements, and 2) fixations, which are moments when the eye is still and focused (Wedel and Pieters 2006; Balcombe et al. 2015). With eye-tracking, the unconscious movements of the pupil can be recorded and give hints on what attracts peoples' attentions.

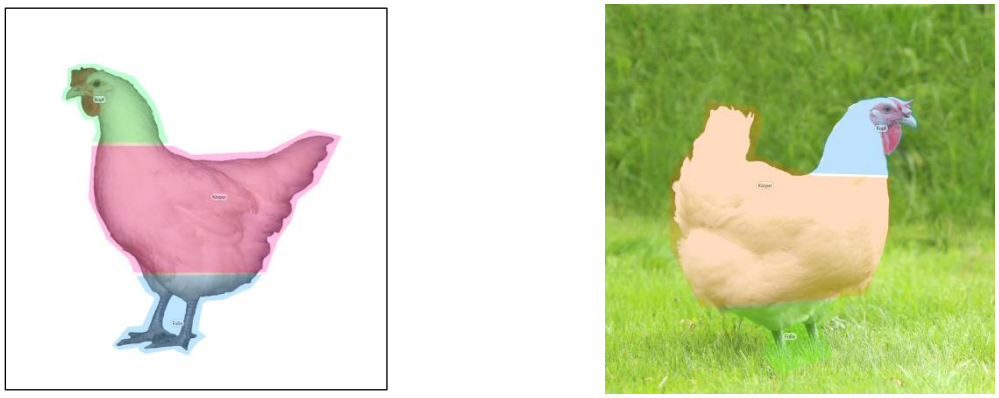
All eye movements were recorded by the Tobii Pro Glasses 2 (Version 1.67.7669, Tobii AB, Stockholm). This head unit consists of four eye cameras, one high definition scene camera in the front, two sensors, and one microphone (Tobiipro 2016). The glasses register and measure each participant's pupil movement through the presented images and their areas of interest (AOI). These AOIs are delimited regions of the picture that are defined by the researcher because they are of interest for answering the research question.

Think-aloud (TA) is a method in which participants perform a specific task and are asked to simultaneously vocalize what they are thinking or doing. These results, called protocols, are then used for analysis to better understand problem-solving processes (van Someren et al. 1994). However, in this study, this method was used to analyze the perception of images through participants' vocalization of their thoughts when looking at a picture.

2.1.1 Study design

A sample of twenty-eight adults (aged 20-61 years) was recruited at the University of Goettingen in Germany during October and November 2017. All participants consumed chicken meat and eggs at least once a month. Participants were equipped with a Tobii Pro Glasses 2 Eye-Tracker (Version 1.67.7669, Tobii AB, Stockholm). The eye-tracker was individually calibrated by measuring participants' specific eye movement characteristics. All pictures used in the study were presented on a 23.8-inch flat screen with a 1920x1080 resolution (DELL, Hamburg), placed about 70 to 80cm from the head of the participants (Tobiipro 2016) for fifteen seconds with a three second pause after each picture.

The stimuli used for the experiment were a total of ten pictures showing five different chicken breeds: Bresse Gauloise (BG), Vorwerkhuhn (VH), White Rock (WR), Lohmann Brown (LB), and Kollbecksmoor (KM). We selected three major AOIs for each animal: 1) head, 2) body, and 3) feet. Each AOI was manually delimited in each picture by the researcher. To test whether participants' attention to the AOIs changes with different backgrounds, we tested a white and natural (grass) background for each breed. All in all, each picture showed an individual animal at the same age. Figure 1 shows the different AOIs of two BG chickens in a white and grass background, as an example. Pictures of BG, VH, WR and KM were taken by a professional animal photographer at a farm in Bad Laer (Lower Saxony, Germany) with consent from the breeder and farm owner. Pictures of LB were purchased from Fotolia (Adobe, New York) and modified by the photographer in order to have a similar grass background to the rest. Similarly, pictures of BG, VH, WR and KM were modified by the photographer to obtain a white background.



(a) White background **(b)** Grass background

Figure 1. Areas of interest for Bresse Gauloise with (a) white and (b) grass backgrounds.

The study consisted of three different parts: first participants were asked to observe five pictures of different chicken breeds: BG, VH, WR, LB, and KM with a white background. Second, participants were given the following instructions *"Please say out loud what you think of the chickens in the following pictures"* and then pictures of the same chickens with the natural background were shown and participants' thoughts were recorded. All pictures were randomized to avoid order effects. Third, participants were asked how many chicken breeds they had seen, if they were familiar with any chicken breeds and if they recognized one or more breeds.

2.1.2 Data analysis

Two participants had a gaze sample percentage of 52% and 44%, while the average of the remaining twenty-six participants was 93%; this indicated that for these two participants one eye or both eyes were found only for about half of the recording. This low gaze sample percentage can be a reflection of configuration errors, difficulty to track a participant, light interferences, etc. (Tobiipro 2018). Holmqvist et al. (2012) present different methods and examples of how to deal with data quality of eye tracking measurements. In order to keep a gaze sample percentage of approximately 90% (5-10% data loss is caused by blinking) these two participants were excluded, resulting in 26 participants that remained for the ET analysis. However, in order to gather as many observations as possible, all 28 participants were considered for the TA.

All ET data were saved and processed on the Tobii Pro Lab Software (Version 1.67.7669, x64, Tobii AB, Stockholm). Fixations data for each AOI was collected, processed and filtered (by a Velocity-Threshold Filter) from raw data by the software and later obtained as an Excel file with results for each participant. Results were saved in the following metrics: 1) fixation duration – the duration of each individual fixation within one AOI, 2) fixation count – number of fixations the participant gives to a specific AOI, 3) visit duration – duration of each individual visit to a specific AOI, and 4) visit count – the number of visits on an active AOI (Tobiipro 2016).

The software also provides the researcher with heat maps by using the average amount of fixations in the stimuli. These heat maps are graphical representations of how fixations are distributed over the stimulus (Raschke et al. 2014). These maps use different colors to show the amount of fixations in a particular area: the red color indicates areas with the most fixations, red then turns into orange/yellow to show fewer amount of fixations, while the green color indicates areas with the least amount of fixations (Tobiipro 2016). It should be noted that the heat maps do not refer to the AOIs but to single data points in the pictures. All other statistical analysis, i.e. means (μ), standard deviations (σ), analysis of variance (ANOVA) and post-hoc tests were calculated using SPSS (Version 26, IBM, New York).

All TA protocols were recorded with a voice recorder (LS-14, Olympus). First, protocols were transcribed and segmented following van Someren et al. (1994). Next, a coding scheme was

constructed, following van Someren et al. (1994), based on the categories presented in Table 1. Finally, words mentioned in the categories of "subjective description: animals" and "others: consumption association" were used for the online survey.

Table 1. Categories used for think aloud protocol measurements.

Category	Subcategories (assigned code)	Examples
Objective description	Animal (OA)	White, yellow feet
	Background (OB)	Green, grass
Subjective description	Animal (SA)	Happy, aggressive
	Background (SB)	Free-range
	Consumption association (OCA)	Meat, eggs
Others	Breed related (OBR)	Same breed, "X" breed
	Others (OO)	

Since this study was used as a basis for the online survey, only results of BG, VH, WR and KM will be presented. The breed Lohmann Brown was not included in the survey since it is not a traditional breed. Aditionally, participants showed the same fixation pattern in pictures with both backgrounds, therefore only results of pictures with a grass background, which were then used for the online survey, will be presented in the results section.

2.2 Online Survey

2.2.1 Study Design

A sample of 1,100 participants was recruited by a professional online provider (Respondi AG) during July and August 2018 in Germany. The sample was selected by a quota sampling procedure with gender, age, education, and income, to achieve representativeness of the German population with regard to these categories.

Participants were screened according to their consumption behavior: only participants who consume chicken meat at least once a month were selected. Additional questions regarding participants' consuming and buying patterns were asked: chicken meat and egg consumption and buying frequency, as well as buying frequency of regional, organic, and animal products with animal welfare labels. Afterwards respondents' attitudes to the meat-paradox were measured with a total of sixteen statements presented in Table 2. These statements were quantified using a 7-point Likert scale ranging from 1) I totally agree to 7) I totally disagree, with "neither nor" as a mid-point on the scale. All items were randomized to prevent systematic order effects.

Table 2. Statements related to the meat-paradox used in the survey.

	Wording
1	I would like to see what the animal looked like before it was slaughtered.
2	I would like to buy meat with pictures of the animals on the package.
3	When I see chicken meat, I try not to associate it with an animal.[1]
4	I do not like to think about where the chicken meat I eat comes from. [1]
5	I am aware that I eat living beings. [1]
6	The thought that chickens as living animals are later consumed for human nutrition is unpleasant to me. [3]
7	If I knew how chickens are slaughtered and cut, I would no longer eat their meat. [3]
8	I like the sight of raw meat. [3]
9	I am aware of the slaughtering process when eating meat. [3]
10	I feel with animals.[2]
11	It is necessary that animals are kept for our nutrition. [2]
12	Animals are doing well in today's animal husbandry. [2]
13	I cannot do anything about the system of animal husbandry today. [2]
14	I think that politics should do something about the system of animal husbandry. [2]
15	When I buy meat, I try to ensure that animals are kept in good conditions. [2]
16	I will try to ensure that there are better conditions for keeping animals. [2]

Source: authors' own elaboration and Rothgerber (2013)[1], Bastian and Loughnan, (2016)[2], and Ermann (2018)[3]

The following part of the survey showed participants all four pictures (same pictures as in the exploratory study described in section 2.1) in a randomized order. Figure 2 shows the pictures that participants evaluated in the survey.

(a) Bresse Gauloise

(b) Vorwerkhuhn

(c) White Rock

(d) Kollbecksmoor

Figure 2. Pictures used for participants' evaluation of each breed: (a) Bresse Gauloise, (b) Vorwerkhuhn, (c) White Rock, (d) Kollbecksmoor

Each picture was presented along with eighteen pairs of words on a 7-point semantic differential scale. For each of the pairs, participants could indicate their answer between two opposite words (e.g. "pretty" and "ugly"), marked from 1 (positive adjective) to 7 (negative adjective) for analysis. Table 3 presents the eighteen pairs of opposite words which participants rated.

Table 3. List of words used for semantic differential.

Pair	Positive	Negative
1	Typical chicken[1]	Exotic chicken[1]
2	Nice color[1]	Ugly color[1]
3	Happy[1]	Sad
4	Healthy[1]	Unhealthy
5	Fat / Inflated[1]	Thin[1]
6	Big[1]	Small[1]
7	Natural[1]	Overbred[1]
8	Well-shaped	Shapeless
9	Robust	Fragile
10	Strong[1]	Weak
11	Old[1]	Young
12	Calm[1]	Aggressive[1]
13	Pet	Wild animal[1]
14	Agile[1]	Sluggish
15	Well-fed[1]	Rickety
16	Tasty	Disgusting
17	Appetizing[1]	Unappetizing
18	Proud[1]	Crouched

[1]Taken directly from TA results

Then, the same picture appeared and participants' association of this picture to meat or egg production / consumption was measured with the following statements: *1) This chicken is suitable for meat production, 2) This chicken is suitable for egg production, 3) This chicken will certainly lay many eggs, 4) It looks as if it lays brown eggs, 5) It looks as if it lays white eggs,* and *6) This chicken is well suited for the grill.* These were evaluated using a 7-point Likert scale from 1) I totally agree to 7) I totally disagree, with "neither nor" as a mid-point in the scale. All pictures and statements were randomized to avoid order effects.

Finally, consumers' direct association of pictures with products they had consumed was measured with the following questions: *"Please remember the last time you consumed chicken meat. Which picture comes to your mind?"* and *"Please remember the last time you consumed eggs. Which picture comes to your mind?*" Participants had to choose between the pictures of BG, VH, WR, KM or "I do not know".

2.2.2 Data analysis

A total of 977 participants completed the survey. After data cleaning (participants who needed less than half of the average response time or more than twice the average response time), the total sample was reduced to 933 participants. All statistical analyses were carried out using SPSS (Version 26, IBM, New York).

Initially, descriptive statistics were calculated. Next, to analyze the differences between breeds on the semantic differential scale, an ANOVA with post-hoc tests Tukey for variance homogeneity and Games-Howell for variance heterogeneity was calculated. Finally, all meat-

paradox items were analyzed and participants that indicated to be interested in seeing pictures of animals and seeing what the animals looked like before slaughter were grouped based on their responses: participants that answered from "I totally agree" to "neither nor" in both statements were grouped. Their responses on the meat-paradox items were compared to the rest of participants with an ANOVA.

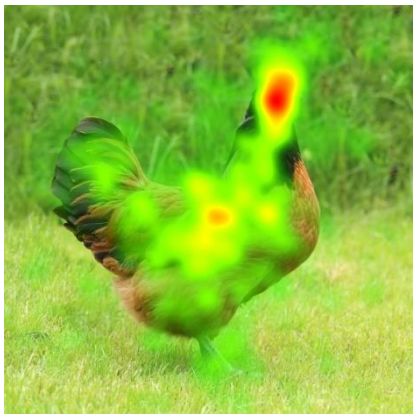
3. Results

3.1 Consumers' observations when presented with pictures of different chicken breeds (RQ1).

In the ET study (n=26), participants were mostly men (54%), between the ages of 20 and 30 (58%) and had a university degree (70%). Most participants consumed chicken meat and eggs at least once a week (64% and 81%, respecively). The majority of participants (89%) was not familiar with chicken breeds and 96% could not identify any breed in this study. The only breed that was identified by one person was VH.

Figure 3 shows each breed's individual heat map based on the amount of fixations. These maps show that the main focus on all pictures is the head/face of the animal, followed by the body. Additionally, participants also focused more on the bodies of VH and KM.

(a) Heat map of Bresse Gauloise



(b) Heat map of Vorwerkhuhn

(c) Heat map of White Rock

(d) Heat map of Kollbecksmoor

Figure 3. Heat maps based on amount of fixations for the four breeds: (a) Bresse Gauloise, (b) Vorwerkhuhn, (c) White Rock, and (d) Kollbecksmoor (n=26).
Note: red color indicates areas with the most fixations; orange/yellow colors show fewer amount of fixations, green color indicates areas with the least amount of fixations

Table 4 shows the means and standard deviations of fixation counts and fixation duration for each area of interest for each breed. There was no difference in fixating the heads of the animals between breeds. On the other hand, the AOIs body and feet showed differences ($p \leq 0.05$) between breeds. The AOI body had higher fixation counts and duration in VH compared to BG ($p \leq 0.05$). Similarly, the AOI feet was looked at differently between breeds: WR had a higher amount of fixations and the longest fixation duration ($p \leq 0.05$) than the rest of the breeds.

Table 4. Means and standard deviations of fixation counts and total fixation duration in seconds per AOI for each breed (n=26).

	BG (a)	VH (b)	WR (c)	KM (d)	F value
HEAD_Fixation counts	163.50 (114.03)	158.34 (96.86)	147.92 (107.12)	152.69 (102.07)	0.108^{NS}
HEAD_Total fixation duration (s)	3.26 (2.28)	3.16 (1.93)	2.95 (2.14)	3.05 (2.04)	0.108^{NS}
BODY_Fixation counts	224.23^{b} (115.12)	310.80^{a} (116.94)	230.69 (103.71)	266.53 (113.54)	3.254*
BODY_Total fixation duration (s)	4.48^{b} (2.30)	6.21^{a} (2.34)	4.61 (2.07)	5.33 (2.27)	3.255*
FEET_Fixation counts	44.57^{c} (35.91)	27.46^{cd} (23.00)	106.23^{abd} (78.42)	51.88^{bc} (36.30)	12.973***
FEET_Total fixation duration (s)	0.89^{c} (0.71)	0.54^{cd} (0.46)	2.12^{abd} (1.56)	1.03^{bc} (0.72)	12.969***

$^{a, b, c, d}$ indicate sig. difference ($p \leq 0.05$) to the corresponding column according to post-hoc tests, Tukey for homogeneous variance, Games-Howell for heterogeneous variance

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$ indicate significant or ^{NS}: not significant differences according to ANOVA

3.2 Consumers' associations with different breeds (RQ2)

Results of the TA method show that participants mostly subjectively described each animal (e.g. pretty, healthy) rather than associate it with its use (e.g. meat or egg production). Since the aim of this study was to gain knowledge on what participants associate with different chicken breeds, we decided to only use the results of the categories "subjective descriptions" and "others: consumption association" for the quantitative (online) survey. Table 5 shows a summary of the most frequently mentioned words for each category.

Table 5. Results of the categories "subjective description" and "others" for all breeds.

Category	Subcategories	Mentions (n=223)	Most mentioned words
Objective description	Animal	37	White, black, brown, small beak
	Background	22	Grass, green, field, outdoors
Subjective description	Animal	119	Slender, fat, pretty, healthy
	Background	16	Free-range husbandry
Others	Consumption association	5	Meat, eat, eggs

Table 3 (Section 2.2.1) shows the final list of words used to quantitatively assess differences between the breeds in the online survey.

The socio-demographic characteristics of the sample are described in Table 6. Gender, age and income show a fair represenation of the German population (Destatis 2017). Education levels, although close to the population values, are in some categories over- or underrepresented.

Table 6. Socio-demographic characteristics of the sample (n=933) and the German population.

	Sample (%)	Population (%)
Gender		
Female	50.8	50.7
Male	49.2	49.3
Age		
18 – 24 years old	8.8	9.1
25 – 39 years old	20.7	22.6
40 – 64 years old	43.5	43.1
65 or more years old	27.0	25.2
Education		
No education	0.5	4.0
Lower secondary education	34.2	31.4
High school diploma	30.9	29.4
Technical college	15.3	13.7
University degree	19.1	17.1
Income (net/month)		
Less than 1,300€	25.1	26.3
1,300€ - 2,599€	39.2	39.6
2,600€ - 4,999€	28.1	27.1
5,000€ or more	7.6	6.5

Source: authors' own data for sample, German population (Destatis 2017)

Most participants consume (55.9%) and buy (49.9%) chicken meat at least once a week, mostly in supermarkets (46.4%), discounters (36.7%) or directly from the butcher (5.9%). 84% of participants consume eggs more than once a week, and buy them at least once a week (60.9%), mostly in discounters (36.2%), supermarkets (35.5%) or directly from farmers (14%).

Table 7 presents mean values of evaluation of the different breeds. All word pairs show differences ($p \leq 0.01$) between groups. From all 18 pairs of words, only healthiness and age (pair 5 and 11) were rather evaluated as "neither nor". The other 16 pairs were rated as positive, meaning to the word presented on the left side of the scale. As suggested by these results, VH is considered the nicest, happiest, healthiest, most robust, and proudest of all breeds. WR is considered more typical and well-fed. On both pictures showing white breeds (BG and WR) the animals were considered fatter. VH and WR are considered more appetizing and tastier than BG and KM.

Table 7. Mean comparison of evaluation of four pictures of different chicken breeds. Means, standard deviations and F-values are shown (n=933).

Pair No.	Wording	BG (a)	VH (b)	WR (c)	KM (d)	F value
1	Typical – Exotic	2.17^{bc} (1.27)	3.01^{acd} (1.92)	1.96^{abd} (1.09)	2.25^{bc} (1.34)	94.95***
2	Nice – Ugly	2.27^{bd} (1.29)	1.74^{acd} (1.08)	2.17^{b} (1.24)	2.11^{ab} (1.19)	33.28***
3	Happy – Sad	2.84^{bcd} (1.54)	2.14^{acd} (1.15)	2.44^{ab} (1.26)	2.51^{ab} (1.27)	45.06***
4	Healthy – Unhealthy	2.42^{bcd} (1.37)	1.82^{acd} (0.94)	2.05^{ab} (1.09)	2.14^{ab} (1.12)	43.62***
5	Fat – Thin	3.01^{bd} (1.26)	3.36^{acd} (1.24)	2.98^{bd} (1.26)	3.92^{abc} (1.29)	111.12***
6	Big – Small	2.51^{bd} (1.23)	2.35^{ad} (1.16)	2.47^{d} (1.27)	3.02^{abc} (1.36)	51.73***
7	Natural – Overbred	2.51^{bcd} (1.48)	2.11^{a} (1.17)	2.24^{a} (1.33)	2.25^{a} (1.22)	15.11***
8	Well-shaped – Shapeless	2.42^{bc} (1.41)	2.04^{ad} (1.07)	2.14^{ad} (1.18)	2.40^{bc} (1.24)	22.12***
9	Robust – Fragile	2.53^{bc} (1.35)	2.13^{acd} (1.12)	2.29^{abd} (1.19)	2.58^{bc} (1.27)	26.65***
10	Strong – Weak	2.30^{bcd} (1.23)	2.08^{ad} (1.04)	2.11^{ad} (1.08)	2.70^{abc} (1.35)	54.96***
11	Old – Young	4.03^{bcd} (1.27)	4.25^{a} (1.14)	4.22^{ad} (1.17)	4.36^{ac} (1.19)	12.20***
12	Calm – Aggressive	2.46^{b} (1.21)	2.72^{acd} (1.32)	2.41^{b} (1.18)	2.50^{b} (1.23)	11.16***
13	Pet – Wild animal	2.49 (1.43)	2.62^{c} (1.50)	2.41^{b} (1.40)	2.57 (1.44)	3.84**
14	Agile – Sluggish	2.97^{bcd} (1.52)	2.52^{a} (1.21)	2.62^{a} (1.38)	2.56^{a} (1.24)	21.95***
15	Well-fed – Rickety	2.11^{cd} (1.10)	2.20^{cd} (1.07)	1.97^{abd} (1.01)	2.61^{abc} (1.28)	56.03***
16	Tasty – Disgusting	2.89^{c} (1.31)	2.76^{d} (1.30)	2.72^{ad} (1.30)	2.93^{bc} (1.30)	5.66**
17	Appetizing – Unappetizing	2.94^{bc} (1.40)	2.75^{ad} (1.32)	2.76^{ad} (1.38)	2.95^{bc} (1.35)	5.8***
18	Proud – Crouched	2.89^{bcd} (1.54)	2.06^{acd} (1.12)	2.34^{ab} (1.24)	2.42^{ab} (1.23)	66.75***

Scale: 1 positive (left side) adjective, 4 neither nor, 7 negative (right side) adjective

$^{a, b, c, d}$ indicate sig. difference ($p \leq 0.05$) to the corresponding column according to post-hoc tests, Tukey for homogeneous variance, Games-Howell for heterogeneous variance

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$indicate significance or ^{NS}: not significant differences according to ANOVA

BG: Bresse Gauloise, VH: Vorwerkhuhn, WR: White Rock, KM: Kollbecksmoor

Participants' associations of the breeds with egg or meat production show significant differences between breeds. BG and WR are evaluated as more suitable for meat and egg production when compared to VH and KM ($p \leq 0.05$). Similarly, BG and WR are evaluated as more likely to lay many eggs and eggs with white color than VH and KM. On the other hand, VH and KM are significantly more associated to laying brown eggs than BG and WR. However, all breeds are evaluated neutral when considering them for a barbecue; although WR is considered more suitable for a barbecue than KM. Table 8 presents the results for each breed in more detail.

When consumers were exposed to the same four pictures and asked *"Please remember the last time you consumed chicken meat. Which picture comes to your mind? Why?",* 44% answered "I do not know", 24% WR, 14% BG, 9% KM and 9% VH. Only 13% (n=125) of participants which answered "I do not know" explained their choice. From these participants, 30 (3% from

total participants) explained their answer with statements like: *"I am absolutely not familiar with chicken breeds", "in the end product/package it is not written which type/breed of animal it is", "when I eat meat I do not associate it with any breed; I do not know anything about chicken breeds".* Interestingly, statements related to the dissociation of animals to meat, such as *"I only ate the meat and not the chicken", "When I eat chicken meat I do not think about how the living animal looked like", "My meat does not have feathers", "I do not think about that"* were also made by 3% of participants.

Table 8. Mean comparison of evaluation of four pictures of different chicken breeds associated to consumption. Means, standard deviations and F-values are shown (n=933).

Wording	BG (a)	VH (b)	WR (c)	KM (d)	F value
This chicken is suitable for meat production.	2.76^{bd} (1.47)	3.05^{acd} (1.59)	2.71^{bd} (1.47)	3.25^{abc} (1.56)	25.1***
This chicken is suitable for egg production.	2.41^{bd} (1.33)	3.08^{acd} (1.76)	2.35^{bd} (1.33)	2.62^{abc} (1.35)	48.68***
This chicken will certainly lay many eggs.	2.74^{bd} (1.34)	3.36^{acd} (1.65)	2.66^{bd} (1.30)	3.03^{abc} (1.33)	46.26***
It looks as if it lays brown eggs.	4.73^{bd} (1.50)	3.53^{ac} (1.79)	4.71^{bd} (1.50)	3.38^{ac} (1.52)	198.37***
It looks as if it lays white eggs.	3.00^{bd} (1.57)	4.72^{acd} (1.56)	3.06^{bd} (1.59)	4.42^{abc} (1.46)	309.24***
This chicken is well suited for a barbecue.	3.49 (1.61)	3.55 (1.63)	3.40^{d} (1.60)	3.62^{c} (1.54)	3.11*

Scale: 1 totally agree, 4 neither nor, 7 totally disagree

$^{a, b, c, d}$ indicate sig. difference ($p \leq 0.05$) to the corresponding column according to post-hoc tests, Tukey for homogeneous variance, Games-Howell for heterogeneous variance

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$indicate significant differences according to ANOVA between breeds

BG: Bresse Gauloise, VH: Vorwerkhuhn, WR: White Rock, KM: Kollbecksmoor

The 38% of participants which associated the pictures of either WR or BG, both white breeds, to the meat they ate lately explained their choices with statements like *"it looks like a typical chicken as you know it", "typical chicken for slaughter", "because it is a typical chicken and it is used for meat production", "looks like a conventional German chicken".* Lastly, the 18% of participants that chose brown breeds (KM and VH) explained their answers with statements like *"used to know only this variety", "we had chickens like this at home", "I know that from my childhood", "reminds me of the typical chickens we used to have ourselves"*.

Similarly, when asked *"Please remember the last time you consumed eggs. Which picture comes to your mind? Why?",* the most selected option (42%) was a white breed with 28% for WR and 14% for BG, while 30% answered "I do not know", followed by KM (17%) and VH (11%).

3.3 Consumers' Acceptance of animal pictures when buying meat (RQ3)

Participants were presented with 16 statements related to the meat-paradox, where two statements directly measured participants' willingness to see animal pictures when buying meat. Most participants (54.7%) disagreed with the statement "I would like to buy meat with pictures of the animals on the package" (μ=5.12, σ=1.65) while 27.2% were neutral and 18.1% agreed with it. Similarly, 52.8% of participants disagreed with the statement "I would like to see what the animal looked like before it was slaughtered" (μ=5.03, σ=1.89), 36.8% were neutral and 10.4% agreed.

Participants who agreed or were neutral to seeing what the animal looked like before slaughter and to seeing pictures of animals on the packages (31.3%, n=292) were grouped ("accepting consumers") and compared to the rest of participants ("non-accepting participants"). Results (Table 9) show that accepting consumers eat less meat, buy more organic and are significantly more aware of the slaughter process when eating meat than the rest of participants. Although both groups rather think that animals are not doing very well in husbandry systems, accepting consumers feel more empathy with animals and, when buying meat, they try to ensure that animals were kept in good conditions. Non-accepting participants in contrast try to not associate chicken meat with an animal and do not like to think about the origin of the chicken meat more than accepting consumers. The non-accepting participants also agree more strongly that it is necessary that animals are kept for human nutrition and that they cannot do anything about the current animal husbandry systems. Table 9 shows these results in more detail.

Table 9. Means, standard deviations and F-values for consumption/purchasing behavior and meat-paradox items between accepting consumers (n=292) and non-accepting participants (n=641).

	Wording	Accepting consumers (n=292)	Non-accepting participants (n=641)	F-value between groups
Consumption/purchasing behavior				
	Consumption frequency of chicken meat[1]	3.73 (1.31)	3.45 (1.23)	9.943**
	Purchase frequency of organic products[2]	2.90 (1.04)	3.24 (1.08)	21.070***
	Purchase frequency of products with animal welfare label[2]	2.70 (0.95)	2.94 (0.95)	12.711***
Meat-paradox[3]				
1	I would like to see what the animal looked like before it was slaughtered.	3.12 (1.41)	5.90 (1.47)	815.65***
2	I would like to buy meat with pictures of the animals on the package.	3.55 (0.89)	5.83 (1.40)	649.24***
3	When I see chicken meat, I try not to associate it with an animal.	4.26 (1.70)	3.77 (1.98)	13.02***
4	I do not like to think about where the chicken meat I eat comes from.	4.29 (1.82)	3.66 (1.93)	21.95***
5	I am aware that I eat living beings.	1.73 (1.23)	1.62 (1.09)	1.69 n.s.
6	The thought that chickens as living animals are later consumed for human nutrition is unpleasant to me.	4.61 (1.80)	4.68 (1.90)	0.24 n.s.
7	If I knew how chickens are slaughtered and cut up, I would no longer eat their meat.	4.53 (1.82)	4.54 (1.92)	0.003 n.s.
8	I like the sight of raw meat.	4.13 (1.67)	4.49 (1.60)	10.11**
9	I am aware of the slaughtering process when eating meat.	2.52 (1.36)	2.85 (1.65)	8.88**
10	I feel with animals.	2.99 (1.38)	3.24 (1.70)	4.70*
11	It is necessary that animals are kept for our nutrition.	2.60 (1.54)	2.32 (1.47)	6.99**
12	Animals are doing well in today's animal husbandry.	4.85 (1.52)	4.76 (1.52)	0.67 n.s.
13	I cannot do anything about the system of animal husbandry today.	4.44 (1.71)	3.94 (1.78)	16.08***
14	I think that politics should do something about the system of animal husbandry.	2.21 (1.44)	2.32 (1.46)	1.08 n.s.
15	When I buy meat, I try to ensure that animals are kept in good conditions.	2.52 (1.45)	2.81 (1.51)	7.20**
16	I will try to ensure that there are better conditions for keeping animals.	2.95 (1.37)	3.40 (1.62)	16.99***

[1]Scale: 1 daily, 2 more than once a week, 3 once a week, 4 every 2 weeks, 5 once a month

[2]Scale: 1 very often, 2 often, 3 sometimes, 4 seldom, 5 never

[3]Scale: 1 I totally agree, 4 neither nor, 7 I totally disagree

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$indicate significance or n.s.: not significant differences according to ANOVA

When evaluating whether the two groups (accepting consumers and non-accepting participants) associated the use of the breeds for egg or meat production differently, differences were found regarding the associations with meat: less of the "accepting consumers" answered with "I do not know".

4. Discussion

4.1 Consumers' observations when presented with pictures of different chicken breeds (RQ1).

We find that participants' eye movements, in general, are similar for all four breeds. Regardless of the breed, participants look at the body and face for the longest time. These results support previous findings where participants also looked mostly at the body and face of farm animals (pigs) when presented in pictures (Busch et al. 2017) and where both humans and animals (chimpanzees) looked mostly at the face of other animals or humans when different pictures were shown (Kano and Tomonaga 2009). The fixation on the face area could be attributed to the presence of the eyes. Birmingham et al. (2007) suggest that people look at the eyes because these are informative regions, e.g. they can convey emotion.

Looking at fixation counts and durations it must be noted that the AOI body of the animal is fixated more often and longer comapred to the head, although the head is predominant in the heat maps. This difference is attributed to the fact that heat maps are calculated on single data points whereas the counts and durations of the AOIs are accumulated values for the whole AOI of the pictures.

Regarding fixation durations of the chickens, clear differences can be seen for the body and feet of the animals. The longer fixation time on VH's body can be attributed to the unfamiliarity with this chicken breed and in particular with the general perception that VH is the most unknown of the four breeds. Wang and Green (1994) explain how familiarity with objects make visual search faster compared to objects that are unfamiliar to viewers.

Based on these results, we suggest that when looking at the head of the chickens, consumers make no difference between breeds or feather color. However, when participants look at the body and feet, they evaluate breeds of the same color very similar and different from breeds of other color. The change in visual attention suggests that the different color of the plumage of brown breeds might stimulate to watch the entire animal instead of focusing on some parts. Results indicate a color based evaluation of chickens, rather than a breed based evaluation, which is expected since most participants are not familiar with chicken breeds.

Based on the lack of knowledge that most consumers have about chicken breeds, color attribution might be an interesting feature to target since consumers seem to pay more attention to this attribute.

Therefore, the color of a breed can be used as a bridge to expand consumer knowledge on specific traditional breeds. A German breeding company from the organic market named

"Ökologische Tierzucht Gemeinnützige GmbH" has used this approach and uses colors of animals as commercial names for specific breeds, such as "coffee" and "cream" for a white-brown-black breed and a white breed, respectively (ÖTZ, 2016).

4.2 Consumers' associations with different breeds (RQ2)

From the TA protocols we can see that participants mostly use subjective adjectives (e.g. pretty, healthy) to describe the animals in the different pictures. Only five participants (17%) make a direct association to consumption (e.g. eggs, meat, eat), thus showing that spontaneously, most participants do not associate animals to meat.

Results from the semantic differential scale indicate that BG is considered as a typical, calm, pet and well-fed animal. VH and WR are considered nice, happy, and healthy animals; both were also perceived as tasty and appetizing. The tasty and appetizing appearance of VH and WR seem to be associated with the physical shape of the animals' body, i.e. bigger, well-shaped, stronger and more robust.

When associating the chickens with a specific type of use (e.g. meat or eggs), participants evaluated, just by looking at the color, white breeds (BG and WR) more suitable for meat and white egg production and brown breeds (VH and KM) more suitable for brown egg production. Despite of this, there is still a small group of consumers who see brown breeds as typical because it reminds them of the chickens they used to have or see when growing up.

Although each breed has unique characteristics, the lack of familiarity with them makes them be seen as either a "white or brown" or a "meat or egg" breed. We found that most consumers are, in general, not familiar with chicken breeds. However, when looking at pictures of breeds, they have associations to each one. Nonetheless, we can conclude that when looking at pictures of different chicken breeds, participants ignore the attribute of "breed" because of their unfamiliarity with it and make appearance-based, mostly feathering-based, associations. Therefore we confirm our first hypothesis: chicken breeds are perceived differently among consumers due to their different phenotypes.

4.3 Consumers' acceptance of animal pictures when buying meat (RQ3)

As expected, most participants are neither interested in seeing pictures of the animals on the meat package nor in seeing what animals looked like before slaughter. These participants try to dissociate chicken meat from a living animal significantly more than participants interested in seeing what the animal looked like. These results support previous findings where participants showed more empathy towards the animal and less willingness to eat its meat when a picture

was shown along with the product (Kunst and Hohle 2016). Our results also show that these participants consider it necessary that animals are kept for human consumption and feel that they cannot do anything about current animal husbandry systems. Hence, we confirm our second hypothesis: chicken meat, although usually perceived differently than red meat (Kubberød et al. 2002), suffers from the same "meat-paradox"-effect as red meat.

Our results also confirm our expectations that there is a smaller group of participants that is interested in seeing what the animal looked like before slaughter and interested in seeing pictures of animals on the meat packages. These participants consume less chicken meat than the rest and purchase more products with higher animal welfare standards and organic standards. This agrees with other studies where eating less meat was linked (in part) to a higher engagement of consumers to "green" goals, such as organic production methods (de Boer et al. 2016; Heerwagen et al. 2014) and animal concerns (Graca et al. 2015; de Boer et al. 2017; Rothgerber 2015). This sustainable behavior (e.g., consuming less meat, purchasing organic products, purchasing products with animal welfare label) demonstrates that some consumer segments are interested in production methods. Studies (Graca et al. 2015; de Boer et al. 2017) show that information regarding the environmental impacts of meat production and consumption increased consumers' willingness to reduce meat consumption. This shows that information may lead to a change in consumption behavior towards a more ethical and sustainable way.

Our results suggest that when these accepting consumers consider the "meat-animal origin", they react to the "meat-paradox" by reducing their meat consumption. This behavior has also been shown by other studies (Hoogland et al. 2005; Piazza et al. 2015). Similarly, when consumers consider that animals are being killed for human consumption some might react to it by preferring to purchase meat with higher animal welfare standards. This has also been revealed by Hoogland et al. (2005), Hölker et al. (2019), Rothgerber (2015), and Piazza et al. (2015). For this group of consumers, the use of pictures may add value to the product by providing easily understandable information about breeds and making the product more personal. These findings could also be relevant for companies in the organic market or those working with animal welfare labels. The presentation of pictures could fit into the "less but better" strategy in this consumer segment.

As participants were asked which picture came to their mind when remembering the last time they consumed chicken meat and eggs, both groups made more associations with a breed when thinking about eggs than meat. These results suggest that these participants also suffer from the

"meat-paradox" effect. Additionally, when associating the pictures with meat, those who accept pictures of the animals made more associations to breeds than those who reject pictures. This also confirms that participants interested in pictures try to think more about the animal they consume, while rejecting consumers avoid thinking about the animals.

5. Conclusion

This study is one of the first to evaluate consumers' attention and associations with pictures of traditional chicken breeds. Its importance relies in the need of communication tools to allow consumers to get acquainted with these breeds and the benefits of purchasing their products (e.g., no killing of day-old chicks, conservation of biodiversity). Results of this study show that consumers' knowledge and familiarity with chicken breeds is very low. In general, consumers mainly look at the body and face of animals and fixate on the brown chickens' body the longest, suggesting a longer attraction due to unfamiliarity. By looking at pictures, white breeds are considered better suited for meat and egg (particularly white egg) production, while brown breeds are considered to lay brown eggs.

Given the widespread ignorance of consumers of animal breeds, it is difficult to use biodiversity as a marketing tool. Very few consumers are able to recognize the special features of the traditional breeds. In this respect, our results are in line with the experiences of small-scale farmers who strive to preserve old breeds and are not very successful on the market, at least in Germany.

In general, using pictures of animals as a way to promote breeds in a mass market is not recommendable, as most consumers do not want to see pictures of living animals on packages of the meat products they consume. Nevertheless, pictures of traditional breeds could be used in smaller, alternative market segments to gain attention and to communicate in an effective way the type of breed reared and the benefits of this particular breed. Our results show that the consumer segment ready for this information purchases chicken meat with less frequency and products with animal welfare and organic standard more frequently than the rest of consumers, suggesting a higher engagement to sustainability issues. For this particular segment, the availability of these pictures and more information related to the animal breed (e.g., dual-purpose, traditional), its husbandry system (e.g., free range), the type of feed (e.g., regional cereals/legumes), and ethical conditions (e.g., no killing of day-old chicks) could be transferred.

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I.2 Who wants chicken? Uncovering consumer preferences for produce of alternative chicken product methods

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Abstract

As ethical and environmental concerns regarding current poultry production systems arise, consumers look for alternatives. This study assesses consumers' preferences for chicken meat of dual-purpose breeds (DPBs), regionally produced feedstuff, and specific breeds, along with attitudes and social norms that explain these preferences. We conducted an online survey (n = 934) including a discrete choice experiment and elements of the theory of planned behavior. Results show that after price, product and feedstuff origin are preferred by consumers, followed by breeding form and specific breed. Utilities for each attribute and level were calculated and consumer segments were created using latent class analysis. Three different consumer groups were identified: (1) price-sensitive consumers, (2) price-sensitive and origin-oriented consumers, and (3) origin-oriented consumers. We conclude that although consumers are interested in meat from DPBs, this attribute alone is not enough to influence the purchase decision, and geographical origin seems to be of crucial importance. However, by highlighting important attributes (i.e., animal welfare, regional/local production), DPB products could be introduced to the market. The consumption of these alternative products has economic implications, such as not relying on imports and promoting local production/consumption, along with social implications as refraining from killing day-old chicks.

Keywords

Bresse Gauloise; choice experiment; dual-purpose breeds; faba beans; Kollbecksmoor; theory of planned behavior; Vorwerkhuhn; White Rock

1. Introduction

Massive animal production methods started gaining popularity after World War II as these systems included specialized indoor environments and automation instead of manual labor. These methods increased the production of poultry meat worldwide, surpassing beef production [1]. In more recent years poultry production, and therefore consumption, has also increased worldwide. In the last 10 years, meat consumption in Germany has slightly decreased from approximately 61.6 kg per person to 59.5 kg [2]. However, poultry consumption in Germany has increased in from 17 kg (2006) to 20.9 kg (2017) per capita [3]. This increase in consumption has resulted in a production increase from 801,000 tons in 2000 to 1,537,000 tons in 2017 [3].

This fast increase in production and consumption has led to breeding of specialized chicken breeds to achieve a higher performance [4]. However, within these production schemes other animal welfare-related issues arose, such as the killing of day-old male chicks of the laying breeds. The killing of these male chicks is commonly practiced in the commercial production of eggs, in organic and conventional farming, since the males are not profitable [5]. In Germany, around 45 million male chicks are killed every year due to their non-profitability [6]. Consumers' complaints and requests to stop the killing of day-old chicks have led to the German government's decision to prohibit this practice starting January 2022 [7]. Consumers' increasing concern in this issue has led to the development of various alternatives to this practice. Among the different alternatives are: (1) in-ovo gender determination, i.e., looking into the egg to see the gender, (2) breeding of the brother, i.e., continue with specialized breeds but rear the male chicks of the laying breeds, and (3) the use of dual-purpose breeds [6]. This study focuses on the latter.

1.1. Dual-Purpose Breeds: Consumer Perspectives on an Alternative to Killing Day-Old Male Chicks

Dual-purpose breeds (DPBs) are chicken breeds that can be used for both laying eggs and producing meat; i.e., female chickens (hens) lay eggs and male chickens (cockerels) are fattened to produce meat [8]. DPBs are not able to compete with specialized fattening (meat-type) and laying breeds — DPB hens lay fewer eggs and DPB males produce less meat than specialized breeds, even if reared for a longer period of time. The main challenge is that these lower laying and fattening performances mean an increase in costs related to production, particularly with feed and housing, which should lead to higher product prices [9]. At the same time, DPBs could

produce better meat quality with regard to sensory profile, while also meeting consumer expectations on animal welfare. As consumers are searching for higher animal welfare standards, they might be willing to pay a higher price [4,10,11]. Hence, the DPB may be a very valuable transitory product line for sustainable food systems.

The importance of dual-purpose breeds does not rely solely on the ethical aspects of avoiding the culling of day-old chicks. The current specialized methods have created a loss of genetic variability of poultry; hence, by fostering DPBs, especially traditional breeds, breeders are contributing to the conservation of poultry genetic resources [12,13]. In Germany, traditional breeds such as Vorwerkhuhn (VH), a traditional breed from Germany, and Bresse Gauloise (BG), a traditional breed from France, have been used as DPB chickens by small-scale farmers. Additionally, commercial laying lines like White Rock (WR) could be bred with a dual-purpose traditional breed, in order to produce a DPB with a higher laying performance, such as Kollbecksmoor (KM) [14].

The impression that alternative poultry production systems provide healthier, tastier, and more environmentally friendly and more animal friendly products has led to consumers valuing these alternative systems and increasing their demand when com-pared to conventionally produced meat [15–17]. This shows that consumers are increasingly more interested in having more information about the products they purchase and consume. Additionally, Apostolidis and McLeay [18] show that some consumers who are not price driven are willing to pay more for sustainable-related attributes in meat products and consume less meat. Nonetheless, it is still unknown whether these consumers would be willing to pay a higher price for DPBs when other product attributes are compromised (e.g., product origin, feed origin) or whether consumers prefer the place of origin (of either production or feedstuff) versus attributes related to animal welfare, particularly DPBs. Additionally, the preference for a specific chicken breed has not been previously tested.

1.2. Faba Beans: An Alternative to Soy Imports for Protein Feedstuff

A further problem in the current poultry industry is that poultry farming requires a high amount of protein-rich feedstuff. When looking at the overall poultry farming system, feedstuff production accounts for a higher environmental impact than rearing the animals [19]. Soybeans are extensively used as a protein source in poultry diet formulations [20]. The problem with soybeans is that the European Union’s (EU) yield is not enough to cover the needs of its own poultry industry and there is a need to import soybean products from other countries [21,22].

These large imports cause problems in EU agriculture, mainly instability due to price volatility of soybeans on the global market [23] and EU consumers' concerns with genetic modified soy crops and deforestation of the Americas [22,24].

An alternative to soybean products is other protein crops like beans and peas, which are traditional European crops and suit the natural production surroundings well. Local agricultural industries could benefit from these crops by having a greater independency in their production and they could also benefit from these crops' environmental benefits like nitrogen fixation [23]. Faba beans (Vicia faba L.) are one of the oldest and most widely cultivated legumes [25]. They contain approximately 30% protein, which is complemented by a rich amino acid composition [25,26], making faba beans a good poultry feed protein source [26]. The use of faba beans in poultry diet has been challenged by anti-nutritional factors in the beans [20,27]. However, recent research has shown that there is no adverse effect in the chickens' health or in the carcass quality parameters when animals are fed with a faba bean-based diet compared to a soy-based diet [28]. Additionally, a recent study showed that meat quality parameters and sensory properties of chicken meat (of the abovementioned breeds) do not suffer a negative effect from a faba bean-based diet [29].

1.3. Study Aim and Research Questions

Food choice is a complex process that is influenced by different factors, e.g., situation, available information, previous experiences, personal preferences, lifestyle, and knowledge about the products [30,31]. Additionally, other aspects like attitudes regarding animal welfare issues and agricultural systems, and access to product information also determine purchase criteria of agricultural products [32,33]. Nowadays, consumers are confronted with abundant sustainability-related choices, such as fair trade products, organic products, animal products produced under animal-friendly conditions, and regional products. This abundancy of sustainable products can confuse consumers since an overload of information is delivered to them in different ways and for different, specific topics [34]. Often labeling is used to communicate specific characteristics of products, particularly credence attributes (attributes that cannot be evaluated by a consumer — e.g., animal-friendly); it is important to communicate particularly relevant information on the packaging so consumers use this information for decision making [35]. In this regard, one can distinguish different labeling strategies ranging from a binary to multilevel label — each containing a different level of abstract information [36]. Especially when it comes to the aspect of extrinsic food quality, it is the question of which information to communicate best, in order to reach the consumer successfully.

It is not known which altered product characteristics of alternative systems have the highest potential or which may be of interest to consumers. Thus, the objective of this study is to better understand which of the studied attributes (i.e., breed type, breeding form, product origin, feedstuff origin) are preferred by consumers. Additionally, this study aims to understand consumers' basic attitudes, beliefs, and motivations towards DPBs. Therefore, the following research questions were investigated:

- RQ1: What is consumers' preference for dual-purpose breeds, regionally and German produced feed, and specific breeds over other attributes when buying chicken meat?
- RQ2: How can these preferences be explained?

Our study aims to contribute to the missing literature regarding a socially accepted poultry production system, which takes into account the killing of day-old chicks, the use of dual-purpose breeds, the use of traditional breeds, and feeding chickens regional faba beans rather than soy imports.

The following section presents the concept of a discrete choice experiment (DCE) along with the different attributes and levels used in this study, as well as the theory of planned behavior (TPB) and the elements of it that were used to collect data. Section 3 then presents the main results of the study, including results from the latent class analysis used to create consumer segments based on their utilities for each attribute. Additionally, we further describe each class using the different elements of the TPB and sociodemographic information. In Section 4, we then discuss our findings with existing literature and present the major limitation for this study. Finally, in Section 5, we present our main conclusions and ideas for future research in this topic.

2. Materials and Methods

2.1. Conceptual Framework

The present study combines two methodological approaches. First, a DCE was conducted to detect participants' preferences regarding the different attributes they value the most when purchasing chicken meat. Then, in order to better describe the motivations behind these preferences, elements of the TPB were used and adapted since this method can trace attitudes, norms, and perceived behavioral control about a specific behavior [37]; in this case, a choice of purchase.

2.1.1. Discrete Choice Experiment

Thus far, chicken meat from DPBs is rarely found in the market, therefore there is little to no purchase data available. In order to simulate this market data, a DCE was implemented. In these experiments, respondents make choices from two or more alternatives with different varying attributes, allowing the elicitation of preferences and values for specific products that do not exist yet [38]. This also allows calculating consumers' willingness to pay (WTP) based on individuals' decision making [39].

The Lancastrian consumer theory assumes that different products have multiple characteristics which raise the utility of each product, and that each product will possess several characteristics which are shared by other products [40]. Thus, stating that consumers derive utility not from a product itself but from the combination of product at-tributes and levels. To measure these preferences or utilities, DCEs are applied. A DCE is a technique used to research consumer preferences by simulating a purchase situation in supermarkets, where different products are offered, and the consumer may choose any or none. These DCEs have been applied in a wide range of contexts, such as evaluating the impact of country-of-origin labeling and traceability in consumers' preferences [39] or evaluating preferences for animal-friendly foods [41]. These studies indicate that DCEs can be successfully implemented for calculating such preferences. In addition to the elicited preferences, data can be used to classify consumers based on latent or unobserved characteristics into segments via latent class analysis (LCA) [42].

For this study, we used five different attributes with four levels each. The attributes and levels selected for this study were those of interest to the authors and are mainly related to the animal from which the product comes from rather than to extrinsic characteristics (e.g., weight, color, fat). The attributes and levels used are the following:

1. Breeding form: The levels of this attribute were chosen to test consumers' preference for (1) dual-purpose breeds, (2) breeding of the brother — rearing brothers of laying hens despite their low fattening performance, (3) organic products, which consumers usually associate with higher animal welfare standards and show a higher WTP for these [43–46], and (4) no information, which resembles the current market situation where basic information regarding the husbandry system (barn raised, free range, organic) is provided.
2. Breed: The levels chosen for this attribute were four dual-purpose breeds currently used in Germany; (1) Bresse Gauloise (BG), a French native DPB commonly used due to its

good laying and fattening performance, (2) Vorwerkhuhn (VH), a German native DPB used mainly to preserve the genotype [14], (3) White Rock (WR), a commercial laying line with potential to be used as a DPB, and (4) Kollbecksmoor (KM), a crossbreed of VH and WR used due to its good laying and fattening performance. The name of each breed was presented along with a picture of the corresponding breed in order to increase consumers' exposure to each breed's appearance.

3. Price: The levels of this attribute were based on current market prices in Germany for breast fillets; the lowest level corresponds to the lowest market price, while the highest level to the highest market price. The levels in between are 9.64 EUR apart from the previous and following levels.
4. Product origin: The levels in this attribute were chosen to test consumers' preference for a regional product over (1) national (German) product, (2) product from the EU, since it is where Germany imports mostly from [3], and (3) product from outside the EU.
5. Feed origin: The levels in this attribute were chosen to test consumers' preference for regional faba beans over (1) German faba beans, (2) Brazilian soy, since it is the most common protein feedstuff [47,48] and the country where most imports to the EU come from [48], and (3) no information, which resembles the current market situation where no information regarding the feedstuff is provided.

The levels of the attribute "breeding form" are not mutually exclusive, i.e., they can be found combined with one another in the market (e.g., DPB or brother of laying hen reared organically). For this study, it was decided to test the preference for each of these levels individually. The objective was to better calculate the utilities of the specific wording "organic", "breeding of the brother", and "dual-purpose breed" and not a combination of these.

In order to make this experiment more realistic, we decided to prohibit eight combinations of attributes that could not possibly be found in the market. The lowest price level did not appear with organic or DPB levels since the cost production of these products does not allow such a price. Similarly, the lowest price level did not appear with BG since the current market price of this breed is comparable to organic (highest price). Non-EU product origin did not appear with regional nor German faba beans; moreover, it also did not appear with the highest price level. Finally, regional product origin and regional faba beans as feedstuff do not appear with the lowest price label since literature suggests that consumers are willing to pay more for regional

products [49,50]. Table 1 provides an overview of the different attributes, levels, and prohibitions included in the design.

The description of the CE reads as follows — participants were asked to imagine they want to buy chicken breast fillets. Next, they were presented with ten different choice sets. Each choice set had three options from which to choose plus a non-purchase option. The non-purchase option could be chosen if none of the other options met participants' preferences or WTP for their preference. Figure 1 shows an exemplary choice set. In this study, since the products are not in the market, each option was labeled as "Option 1", "Option 2", "Option 3", or "Option 4".

This experiment was prepared with Sawtooth Software (Version 9.5.3) as a balanced, fully randomized choice design.

2.1.2. Theory of Planned Behavior

Since food choice is a complex process, purchase behavior is not only affected by sociodemographic characteristics, or the product's price or attributes, but also by psychological characteristics of buyers, such as attitudes and beliefs [51]. Therefore, to measure these psychological characteristics, we employed elements of the TPB.

Based on the TPB, consumers' intention to behave in a certain way (e.g., purchase a product) is determined by their attitudes, social norms, and perceived behavioral control. These predicting intentions refer to the following: (1) "attitudes" (A) refers to the favorable or unfavorable attitude towards the behavior in question, (2) "subjective norms" (SN) refers to the social pressure consumers perceive to perform or not this behavior, (3) "perceived behavioral control" (PBC) refers to the perception consumers have of it being easy or hard to perform the behavior [37]. This theory has been widely used in different scenarios, such as predicting consumers' willingness to buy meat from a mobile slaughter unit [52], and to predict consumers' intention to purchase organic food [53]. Such studies show that the TPB can be successfully applied to predict food consumption behavior. Therefore, in this study, it is assumed that consumers who have a positive attitude to-wards buying DPB chicken meat, are influenced by their family, friends, and society approving DPBs, and believe they are able to buy DPB chicken meat should have a stronger intention to buy the product.

Table 1. Attributes, levels, and prohibitions included in the design of the choice sets.

Attributes	Levels	Prohibitions
Breeding form	Organic	5.98 EUR/kg
	Breeding of the brother	
	Dual-purpose breed	5.98 EUR/kg
	No information	
Breed	Bresse Gauloise	5.98 EUR/kg
	Vorwerkhuhn	
	White Rock	
	Kollbecksmoor	
Price	5.98 EUR/kg	Regional product
	15.62 EUR/kg	
	25.26 EUR/kg	
	34.90 EUR/kg	Non-EU product origin
Product origin	Regional	
	Germany	
	EU	
	Non-EU	Regional faba beans, German faba beans
Feed origin	Regional faba beans	5.98 EUR/kg
	German faba beans	
	Brazilian soy	
	No information	

Source: authors' own.

Although the TPB has been widely used and has received empirical support, other research, e.g., [54,55] has used the value belief norm (VBN) theory which links factors to predict pro-environmental behavior [56]. Nonetheless, the aim of this study is not solely guided by an environmentally friendly preference, but by several dimensions of sustainability (e.g., purchase of local products, animal welfare, and diversity of genotype — biodiversity). Therefore, for the purpose of this study, the elements of the TPB were extended with moral elements of the VBN theory to consider other attributes that would help better understand consumers' purchase intention of DPB products. Other studies, e.g., [52,57–59] have also combined both theories to better explain specific behaviors. Hoeksma et al. [52] tested the VBN theory versus the TPB and the extended TPB (combination of TPB with VBN) to predict consumers' willingness to buy meat that was not available in the market yet; they found that the combination of both theories explained a higher percentage of variance in the models than the theories by themselves. From the VBN theory, personal norms (PN) were included since these reflect people's sense of obligation to act in a certain way. Since the topic of DPB is related to animal welfare concerns, personal norms on animal welfare (PNAW) were added. Additionally, since the topic of regional/German faba beans as feedstuff is also a research point, personal norms to address consumption of regional products (PNR) were included.

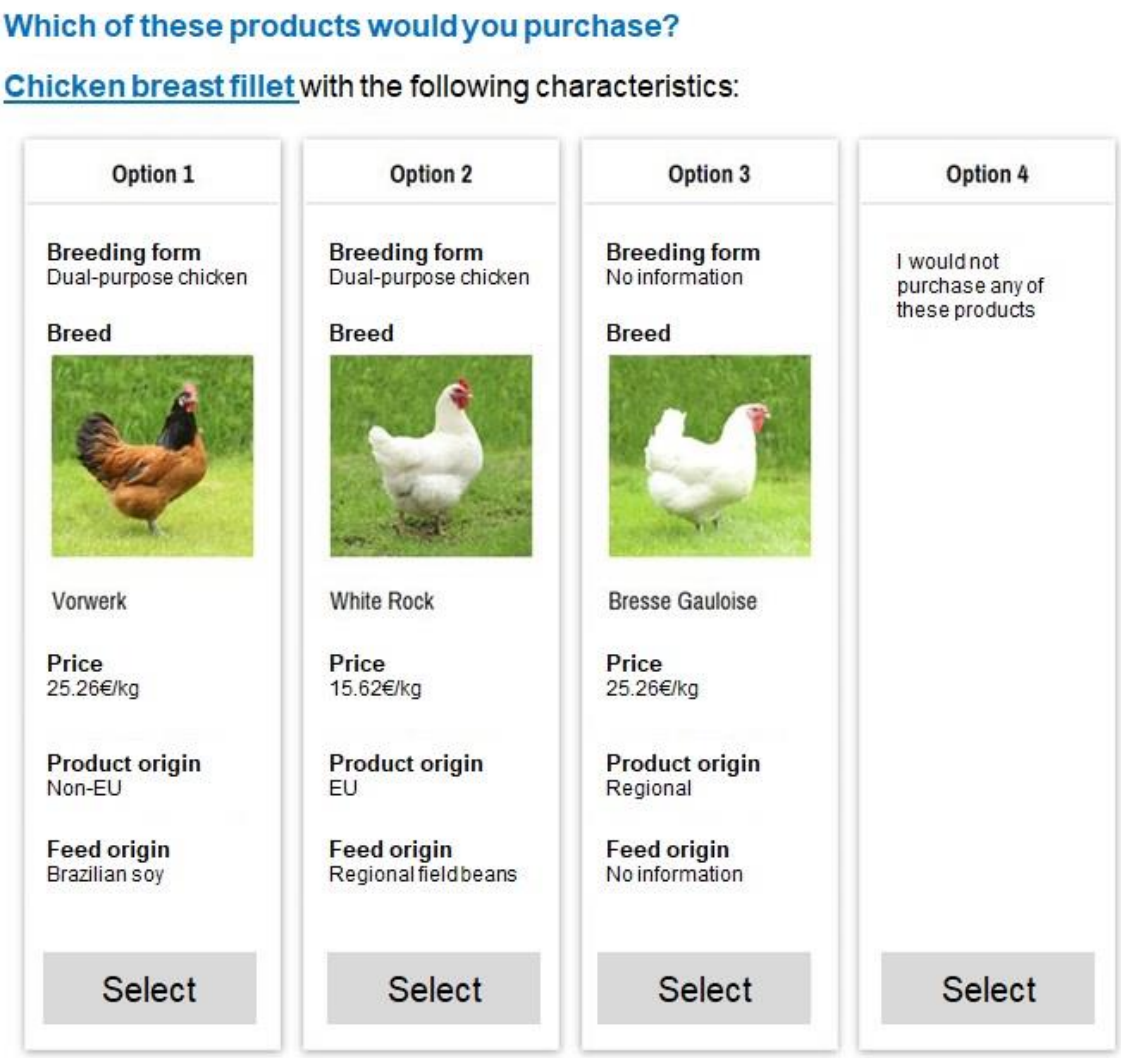

Figure 1. Example of a choice set (translated from German).

Items related to the attitude towards DPB, SN, PBC, PNAW, and PNR were measured using a 7-point Likert-scale, from 1 "totally agree" to 7 "totally disagree". Statements were adapted from [53,60–62]. Table A1 (Appendix) shows the statements used to evaluate each predictor of the extended TPB. All statements were randomized to prevent systematic order effects.

2.2. Survey Design

A sample of 1100 participants was recruited via a professional online panel (Respondi AG) in July and August 2018 in Germany. The sample was selected by a quota sampling procedure with gender, age, education, and income, to achieve representativeness of the German population. Additionally, participants were asked in which state of Germany they currently lived in. In this study, all participants gave written informed consent to take part in the study before the survey started. This study was conducted in accordance with the Declaration of

Helsinki, and the protocol was approved by the Ethics Committee of the University of Goettingen.

First, participants were screened to select only those who consume chicken meat. Additional questions related to participants' consuming and buying patterns were asked: consuming frequency of chicken meat and eggs, and buying frequency of chicken meat, eggs, regional products, organic products, and animal products with animal welfare labels. Next, to ensure all participants had the same basic knowledge about the topic and could make an informed decision, all participants were shown a text with information about the current poultry farming system, dual-purpose breeds, and the current poultry feed situation (see Table A2, Appendix). Participants were then asked if they were aware of these specific issues: killing of one-day-old male chicks and soy import for animal feedstuff. The DCE was next; here, participants were presented with 10 choice sets consisting of 3 products plus the option "I would not purchase any of these products", as shown in Figure 1. Finally, elements of the extended TPB were used to measure the relationship between respondents' attitudes and purchase behavior.

2.3. Data Analysis

A total of 977 participants completed the survey. After data cleaning (participants who needed less than half of the average response time or more than twice the average response time were removed) the total sample was reduced to 934 participants. All descriptive statistics were calculated using IBM SPSS, Version 26.

The analyses of the DCE were calculated using Sawtooth Software Lighthouse Studio (Version 9.5.3). First, the hierarchical Bayes multinomial logit model was used to estimate attribute preferences and part-worth utilities, utility values for each level of every attribute of a product of each level, for each respondent [42].

Next, in order to narrow down the statement batteries of the extended TPB to the core of each concept, a confirmatory factor analysis (CFA) set on five factors was performed. The requested five factors account for each of the extended TPB predictors (see Table A1, Appendix). The principle components analysis method was used for the extraction of the factors with an orthogonal (varimax) rotation. To optimize each factor, variables with loadings <0.4 were suppressed [63] from the final item list of each factor in order to better display principal elements for each factor. The quality was tested using the Kaiser–Meyer–Olkin (KMO) test and

the Bartlett's test for sphericity. To measure the internal reliability of each factor, Cronbach's alpha (Cα) was calculated. These analyses were calculated using IBM SPSS (Version 26).

Since consumer heterogeneity was found in responses of the extended TPB as well as utilities for some attributes of the DCE, we decided to further segment consumers into groups based on their responses in the DCE. Therefore, a latent class analysis was per-formed to determine different segments of consumers. In an LCA, each participant gets a utility for each attribute in the choice experiment; however, this utility is determined by the latent, or unobservable, class membership [42]. This analysis was calculated using Saw-tooth Software Lighthouse Studio (Version 9.5.3).

Finally, each factor was used to further characterize each consumer segment along with sociodemographic data and purchase frequencies of chicken meat, organic products, regional products, and products with an animal welfare label. To analyze the differences of the describing variables between groups, an ANOVA with post-hoc tests Tukey for variance homogeneity and Games–Howell for variance heterogeneity was calculated using IBM SPSS (Version 26).

3. Results

The sociodemographic characteristics of the sample are described in Table 2. Gender, age, and income fairly represent the German population, while education is slightly under- or overrepresented in certain categories. Nearly half (53%) of the participants lived in northern Germany (Berlin, Brandenburg, Bremen, Hamburg, Lower Saxony, Mecklenburg-West Pomerania, North Rhine-Westphalia, Saxony-Anhalt, and Schleswig-Holstein), while 46% lived in the southern states (Baden-Württemberg, Bavaria, Hesse, Rhineland-Palatinate, Saarland, Saxony, and Thuringia).

Table 2. Sociodemographic characteristics of the sample (n = 934) and the German population.

	Sample (%)	Population (%)		Sample (%)	Population (%)
Gender			Education		
Female	50.9	50.7	No education	0.5	4.0
Male	49.1	49.3	Lower secondary education	34.3	31.4
Age			High school diploma	30.8	29.4
18–24 years old	8.8	9.1	Technical college	15.3	13.7
25–39 years old	20.8	22.6	University degree	19.1	17.1
40–64 years old	43.5	43.1	Income (net/month)		
65 or more years old	27.0	25.2	Less than 1300 EUR	25.1	26.3
			1300–2599 EUR	39.3	39.6
			2600–4999 EUR	28.1	27.1
			5000 EUR or more	7.6	6.5

Source: authors' own data for sample, German population based on data from the Federal statistical office [64].

Most participants (56%) consume chicken meat at least once a week, while 50% of participants purchase chicken meat with the same frequency. Chicken meat is mostly purchased in supermarkets (46.4%) and discounters (36.7%), while only 2% is directly from the farmer.

After participants read the provided information regarding the current poultry farming situation, they were asked if they were aware of the killing of one-day chicks, to which 85.4% responded "yes", 12.4% "no", and 2.1% "I do not know". Respondents were also asked if they were aware of the imports of protein feed for animals, 26.1% responded "yes", 66.4% "no", and 7.5% "I do not know".

3.1. Discrete Choice Experiment

3.1.1. Hierarchical Bayes

Aside from the part-worth utilities, the average importance of the hierarchical Bayes estimates for each attribute was calculated. These averages showed a general overview of how each attribute influenced the overall utility of a product. The presented average importance of attributes and utilities of levels are only valid for this specific combination of attributes.

Results indicated that after price (38.63%), the attributes "feed origin" and "product origin" had the highest importance, with 21.11% and 20.19%, respectively. The breeding form only accounted for 13.47% of the preference, while the breed had the lowest preference (6.58%).

3.1.2. Latent Class Analysis

In an LCA, it is important to decide the number of groups, or classes, needed for further analysis or interpretation. The optimal number of classes is usually determined by the Akaike information criterion (AIC), consistent AIC (CAIC), and Bayesian information criterion (BIC) [65]. By looking at the higher decrease in AIC, CAIC, and BIC in three groups and by interpreting the group sizes and characteristics of the different class solutions, we selected three classes. Table 3 shows the model fit criteria.

Table 3. Criteria for number of groups in latent class analysis.

Groups	Log-likelihood	AIC	CAIC	BIC	Chi-square
2	−9242.67	18551.35	18820.04	18787.04	7410.62
3	*−8749.21*	*17598.42*	*18005.52*	*17955.52*	*8397.55*
4	−8440.82	17015.64	17561.16	17494.16	9014.33
5	−8268.78	16705.56	17389.50	17305.50	9358.40

AIC: Akaike information criterion; CAIC: consistent AIC; BIC: Bayesian information criterion. *Italics:* Selected number of groups and its criteria. Source: authors' own calculations.

The attribute importance reveals which attributes are more important to consumer classes (from hereon also referred to as segments) while the part-worth utilities show the preference of each level for each particular attribute. Higher values represent a higher importance or preference of each attribute or level. Table 4 shows the attribute importance and part-worth utilities for each attribute and level in detail.

The first class accounted for 22.8% (n = 213) of the sample. This group of participants gave the highest importance to price (70.27%), particularly to the lowest level (5.98 EUR/kg), followed by product (11.30%) and feed origin (10.73%), particularly regional and German origin. Breeding form and breed accounted for less than 6% of attribute importance each. Breeding of the brother and DPB had the highest utilities in this attribute. Bresse Gauloise was the breed with the highest utilities from the attribute breeds. The second group consisted of 20% (n = 184) of participants and also gave the highest importance to price (62.13%), particularly the lowest level. However, this group allocated around 30% of importance to origin (product and feed, 20.52% and 9.76%, respectively), particularly regional and German. Breeding form and breed only accounted for less than 8% importance for this group. Breeding of the brother and organic showed the highest utilities for this class when referring to breeding type. The third, and largest, class consisted of 57.2% (n = 537) participants. Contrary to the other groups, this

group allocated a higher importance to feed (32.33%) and product origin (27.63%), specifically regional and German. Price showed an importance of 18.76%, and contrary to the other groups, the highest utilities were on the second and third levels (15.62 EUR/kg and 25.26 EUR/kg). For this group, breeding form was more important (17.09%); here, DPB and breeding of the brother showed the highest utilities. Similar to the other groups, the attribute importance of the attribute "breed" accounts for less than 5%.

3.2. Extended Theory of Planned Behavior

The five factors obtained by the CFA accounted for 77.27% of explained variance and the KMO value was 0.906, which is generally seen as a very good value [63,66]. The internal reliability of each factor was tested with Cα, and the values obtained ranged from 0.689 to 0.909.

Table 5 shows each obtained factor in detail along with individual loadings, means, and standard deviations for each item. Factor 1 (Cα: 0.882) resulted in six items related to the participants' attitude towards DPB. The highest loadings were those of items related to the general idea of purchasing the products; however, when talking about the confidence of the purchase the loading decreased. Factor 2 (Cα: 0.870) resulted in six items related to personal norms on animal welfare. While most items were directly related to animal welfare, elements of PBC and PNR were also found. Factor 3 (Cα: 0.909) consisted of four items related to social norms that influence participants' attitude towards purchasing DPB. All items showed similar loadings. Factor 4 (Cα: 0.855) resulted in four statements related to personal moral norms on regional products influencing consumers' purchase. The loadings obtained were similar for three items, while the statement related to guilt from purchasing products from different regions or countries obtained a lower loading. Finally, Factor 5 (Cα: 0.689) resulted in three items related to participants' perceived behavioral control, specifically to participants' knowledge or ability to purchase these products.

Table 4. Attribute importance and part-worth utilities for each class.

	Class 1	Class 2	Class 3
Size (%)	22.8	20.0	57.2
Attribute importance (%)			
Breeding form***	5.10	5.09	17.09
Breed***	2.57	2.44	4.16
Price***	70.27	62.13	18.76
Product origin***	11.30	20.52	27.63
Feed origin***	10.73	9.76	32.33
Part-worth utilities			
Breeding form			
Dual-purpose breed	9.44	−5.80	31.16
Breeding of the brother	10.06	10.95	26.38
Organic	−4.38	9.52	−3.30
No information	−15.13	−14.68	−54.28
Breed			
Vorwerkhuhn	−6.40	−7.50	0.17
White Rock	6.36	2.60	8.12
Bresse Gauloise	3.78	4.77	4.44
Kollbecksmoor	−3.73	0.11	−12.73
Price			
5.98 EUR/kg	171.41	181.68	−0.21
15.62 EUR/kg	68.11	28.45	43.67
25.26 EUR/kg	−58.60	−80.85	6.99
34.90 EUR/kg	−180.92	−129.29	−50.45
Product origin			
Regional	16.29	36.37	55.93
Germany	17.67	30.83	49.48
European Union	3.93	−1.68	−23.19
Non-EU	−37.90	−65.52	−82.22
Feed origin			
Regional field beans	21.71	12.94	72.00
German field beans	21.39	19.22	71.58
Brazilian soy	−32.40	−2.19	−89.43
No information	−10.70	−29.97	−54.15
None	−143.76	120.14	−104.11

*** $p \leq 0.001$. Source: authors' own calculations.

Table 5. Factors obtained of extended theory of planned behavior statements (n=934).

Wording	Factor Loading	Mean | SD
Factor 1: "Attitude towards DPB" (Cα: 0.882)		
It is a good idea to buy products from DPB (eggs and meat).	0.911	2.02 | 1.21
The purchase of products from DPB (meat and eggs) is good.	0.887	2.11 | 1.19
The purchase of products from DPB (eggs and meat) is interesting for me.	0.870	2.29 | 1.34
It is important for me to buy products from DPB (eggs and meat).	0.680	2.80 | 1.39
I am confident that I will buy chicken meat and eggs from DPB.	0.615	2.77 | 1.47
I see myself in a position to buy chicken meat and eggs from DPB in the future.	0.428	2.99 | 1.61
Factor 2: "Personal norms on animal welfare" (Cα: 0.870)		
I feel morally obliged to consider animal welfare in my daily behavior.	0.811	2.65 | 1.50
I feel guilty buying meat and eggs where the day-old chicks were killed.	0.807	3.59 | 2.00
People should do everything to improve animal welfare.	0.719	2.00 | 1.25
I feel a moral obligation to buy DPB products (meat and eggs) regardless of what others do.	0.682	3.09 | 1.69
I am ready to invest more time and money in purchasing chicken meat and eggs from DPB.	0.522	3.22 | 1.75
I feel guilty if I buy chicken meat and eggs from other countries or regions.	0.509	4.03 | 1.91
Factor 3: "Subjective norms" (Cα: 0.909)		
People who are important to me want me to buy products from DPB (eggs and meat).	0.892	4.24 | 1.70
People who are important to me think that I should buy products from DPB (eggs and meat).	0.884	4.08 | 1.67
People whose opinions I value would prefer that I buy chicken and eggs from DPB.	0.873	3.81 | 1.72
The positive opinion of my friends influences me to buy products from DPB (meat and eggs).	0.763	4.25 |1.74
Factor 4: "Personal norms on regional products" (Cα: 0.855)		
People should do everything possible to increase the consumption of regional products.	0.810	2.22 |1.29
I feel obliged to consider regional consumption in my daily behavior.	0.803	2.69 | 1.60
I feel a moral obligation to buy products from this region, regardless of what others do.	0.788	2.93 | 1.76
I feel guilty if I buy chicken meat and eggs from other countries or regions.	0.521	4.03 | 1.91
Factor 5 "Perceived behavioral control" (Cα: 0.689)		
I know where I can buy chicken meat and eggs from DPB.	0.840	5.11 | 1.95
Products from DPB (meat and eggs) are available in the shops where I usually go shopping.	0.840	4.39 | 1.74
I see myself in a position to buy chicken meat and eggs from DPB in the future.	0.522	2.99 | 1.61

Cα: Cronbach's alpha, DPB: dual-purpose breed. Explained variance: 77.27%; KMO: 0.906; Bartlett's test: Chi-square: 13,498.96, sig.: 0.000. Likert-scale: 1 "I fully agree" to 7 "I fully disagree". Source: authors' own calculations.

3.3. Characterization of Classes

To further describe each obtained class, sociodemographic data, purchase frequencies (organic products, regional products, and products labeled with animal welfare, purchase place) and the extended theory of planned behavior were used. Table 6 shows the results of consumer segmentation with respect to the abovementioned (significant) describing variables.

Segment 1: Price-conscious consumers (23%). Consumers in this group were mostly men (60%) with a monthly net income of up to 2599 EUR (67%). Participants in this group mostly purchase their chicken meat at discounter stores. The attribute they valued most was price, and within the price the lowest level (5.98 EUR/kg) obtained the highest utilities. In this group, product and feed origin had a similar importance (11%), especially the regional and German levels. Breeding form and animal breed were not highly important (5% and 2%, respectively); however, the levels of breeding of the brother and dual-purpose breed were preferred in this group. This group also shows a more positive attitude towards DPBs (attitude towards the behavior—ATB), which can also be observed in the utilities of DPB, and a higher PBC versus Segment 2.

Segment 2: Price-sensitive and origin-oriented consumers (20%). This group consisted of a similar percentage of male and female participants. Most consumers (55%) were between 40 and 64 years old and most (73%) had a monthly net income of up to 2599 EUR. Participants in this group purchase chicken meat mostly in supermarkets and discounters. The most important attribute for this consumer segment was also price (62%), specifically the lowest level. However, contrary to Segment 1, this group places more importance (almost twice as much, i.e., 20%) on the product origin, particularly in regional origin. The importance of the breeding form and animal breed for this group were also very small (5% and 2%, respectively); however, the breeding of the brother and organic were preferred, rather than dual-purpose breed (as opposed to Segment 1). The lower preference for DPB can also be observed in the attitude towards DPB (ATB), where Segment 1 reported a more positive attitude towards dual-purpose breeds. Results also showed that subjective norms had a significantly lower impact in this group than in Segments 1 and 3.

Segment 3: Origin-oriented consumers (57%). Women make up the majority (56%) of this group, and 39.5% of participants reported a monthly net income of at least 2600 EUR. Similar to Group 2, participants in this group purchase chicken meat mostly in super-markets and

discounters. Nonetheless, 21.9% members of this segment purchase chicken meat from either a butcher, directly from the farmer, in organic shops, or at the farmer's market, while only 7.4% in Group 1 and 5.4% in Group 2 do so. Contrary to the other two segments, this group valued feed and product origin (regional and German) more than other attributes such as price. This was also reflected in the group's reported purchase frequency of regional products and on their personal norms regarding regional products. For consumers in this group, price and breeding type obtained almost the same importance. Participants were willing to pay more for their products (15.62 EUR/kg and 25.26 EUR/kg), which can be related to 40% of participants earning at least 2600 EUR (net) per month. As opposed to Segments 1 and 2, the utilities of consumers in this group were higher for dual-purpose breeds. This was also observed in the describing variables where the attitude towards dual-purpose breeds (ATB) and personal norms on animal welfare (PNAW) were more positive in Segment 3 when compared to the other groups. Similarly, Group 3 reported purchasing products with an "animal welfare" label with a higher frequency than the other two groups. A similar difference was observed in the PBC, where Class 3 felt a higher control to purchase DPB products when compared to the other two classes.

4. Discussion

Our results showed that 85% of the participants were aware of the killing of day-old chicks. This high awareness has also been confirmed in previous studies with European consumers [4,10,67]. As this practice will be forbidden in Germany starting January 2022, current animal friendly alternatives such as using dual-purpose chicken breeds and how to market these products need to be researched extensively.

Table 6. Description of each class based on significant describing variables.

	Class 1	Class 2	Class 3
Size (%)	22.8	20.0	57.2
Describing variables: Sociodemographic (%)			
Gender ***			
Female	40.4	48.4	55.9
Male	59.6	51.6	44.1
Age *			
18–24 years old	8.5	6.0	9.9
25–39 years old	27.2	10.3	21.8
40–64 years old	38.0	55.4	41.5
65 or more years old	26.3	28.3	26.8
Net income per month **			
Less than 1300 EUR	30.5	27.7	22.0
1300–2599 EUR	36.2	45.1	38.5
2600–4999 EUR	23.9	23.9	31.1
5000 EUR or more	9.4	3.3	8.4
Describing variables: Purchase frequencies [1] (μ|σ)			
Organic products ***	3.46^{a}|1.00	3.61^{a}|0.97	2.85^{b}|1.05
Regional products ***	2.41^{a}|0.76	2.38^{a}|0.89	2.00^{b}|0.78
Products with "animal welfare" label ***	3.06^{a}|0.91	3.23^{a}|0.94	2.66^{b}|0.93
Describing variables: Place of purchase (%)			
Discounter	57.3	42.4	26.6
Supermarket	35.2	47.8	50.3
Butcher	2.3	2.2	8.6
Directly from the farmer	0.9	0.5	3.2
Organic shop	1.9	0	4.3
Farmer's market	2.3	2.7	5.8
Other	0	4.3	1.3
Describing variables: Factors [2] (μ|σ)			
ATB ***	2.57 [a] | 0.93	3.01 [b] | 1.22	2.28 [c] | 1.04
PNAW ***	3.70 [a] | 1.26	3.72 [a] | 1.32	2.63 [b] | 1.15
SN ***	4.13 [a] | 1.49	4.60 [b] | 1.46	3.90 [a] | 1.50
PNR ***	3.56 [a] | 1.41	3.47 [a] | 1.48	2.55 [b] | 1.18
PBC ***	4.29 [a] | 1.23	4.70 [b] | 1.32	3.92 [c] | 1.42

[1] Scale: 1 "Very often" to 5 "Never", [2] Scale (for items in each factor): 1 "I fully agree" to 7 "I fully disagree". * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$. [a,b,c] values with different superscript letters are statistically significant different ($\alpha = 0.05$) according to Games–Howell or Tukey. ATB: attitude towards the behavior, PNAW: personal norms on animal welfare, SN: subjective norms, PNR: personal norms on regional products, PBC: perceived behavioral control.

Source: authors' own calculations.

4.1. Consumers' Preference for Each Attribute

In this study, the importance of each attribute is only valid with the particular combination of attributes and levels used here. Results of the present study show that, in the whole sample, price was the most important attribute considered when purchasing chicken meat. Price has been shown to play a major role in a consumer's purchase decision [68,69]. After price, feed origin and product origin had an important weight when purchasing chicken meat, particularly when the feed or product origin was regional or German. Studies have shown that consumers prefer and are usually willing to pay more for local products [49,70–72]. Schnettler et al. [73]

show that consumers prefer and have a higher WTP for beef products of local origin than non-local origin. However, Rahbauer et al. [74] show that the elasticity in German consumers' WTP for meat products varies depending on the type of meat—beef shows a higher elasticity, while poultry and pork show a lower elasticity, suggesting consumers would still purchase chicken meat if prices increase slightly. Additionally, Feldmann and Hamm [49] find that consumers' preference and WTP for local products depends on the type of product—higher for plant products than for animal products. Similarly, Becker et al. [75] show that the country of origin is more important for beef than for pork and chicken.

The type of breeding only accounted for a small percentage of importance when purchasing chicken meat. Finally, the type of breed played a minor role in consumers' preferences when purchasing meat. This could be attributed to consumers' lack of familiarity with different chicken breeds [76]. Additionally, the "meat-paradox" (i.e., liking meat but disliking killing an animal for food) could have an important effect in this attitude, since research has shown that consumers do not like to associate any living animal to food, especially meat [77,78].

4.2. Preferences of Each Consumer Segment

While the theory of planned behavior is usually employed to predict consumers' intention to carry out a certain action, in this case we used it to explain what motivates consumers to carry out the specific action. It is suggested that consumers which have a positive ATB, SN, and PBC have a stronger intention to purchase a product; however, this decision making process takes into account additional product attributes (e.g., price, quality) that can hinder this intention. Therefore, by combining the motivations behind a purchase and actual product attributes, we can better understand what our target group values most. As we see from these results, the TPB would not have been enough to de-scribe the purchasing motivations behind the purchase of our specific products. Although this theory helps understand how society influences consumers' decisions and how the attitudes towards a specific behavior in question influence the purchasing decision, this theory lacked the elements of animal welfare and regional products that this particular research question needed. Therefore, the use of an extended TPB seems like a suitable option to understand motivations and/or values beyond the usually employed.

Although, for the sample as a whole, price was the most important attribute, and this differed between consumer segments. Price was the attribute with the highest importance for two consumer segments, while (feed and product) origin was the most important attribute for the

third segment. Our results confirm that although the price of a product usually plays a major role in a consumer's purchase decision [68], consumers' willingness to pay might be affected when involving credence attributes such as animal welfare [79–81] and place of origin [73].

The origin of either the product or feedstuff was a valued attribute for all consumer segments in this study. This has also been tested in other studies [41,82] where local or regional food is preferred to other attributes. In our study, while Class 1 preferred German product and feed origin, Classes 2 and 3 preferred regional over German origin. This was also reflected in each segment's personal norms on regional products (PNR) and on their claimed purchase behavior of regional products. These results showed a slight difference between the behavior of Class 1 and 2, but a clear difference between Class 3 and the other two classes. Consumers' preference for local foods has been related to positive attitudes towards environmental, social, and quality motives [49,70]. This was also reflected in this study, where "origin-oriented consumers" (Class 3) also shows a more positive result towards animal welfare (PNAW), has a more positive attitude towards dual-purpose breeds (ATB), and consumes organic products and products with "animal welfare" labels more frequently than the rest.

The role of the breeding form in the purchase of chicken meat was less important than origin of the product or feed. "Price-sensitive and product origin-oriented consumers" (Class 2) preferred the breeding of the brother and organic over DPB. The ATB of this consumer segment also reflected this preference, as this segment has the less positive attitude towards DPB. Although "price-conscious consumers" (Class 1) showed a positive attitude towards dual-purpose breeds (ATB) and the utilities for this breeding form were the second highest, other product attributes (such as price) had a higher weight on their purchase decision. This supports related research [4,10], which indicates that although consumers are interested in DPB, attributes like price influence their final decision. On the other hand, Class 3 showed a higher preference towards dual-purpose breeds versus Segments 1 and 2. This engagement with DPB was also seen in the factors obtained from the TPB, where Class 3 had the most positive attitude towards DPB, the highest personal norms on animal welfare, and their stated purchase frequency of animal products with an "animal welfare" label. Since consumers have evaluated the breeding of dual-purpose chickens as an "animal-friendly" practice [4], our study showed that there was a group of consumers willing to pay a higher price for chicken meat where animals were raised under animal-friendly standards. Even though, in general, consumers' attitude towards DPB is positive, many consumers are not willing to pay more for meat and

eggs from this production system [4,67], while others would also have to consider other product attributes when purchasing these products [4,10,67].

Other elements of the extended TPB also show significant differences between groups. Subjective norms (SN) have a lower influence in Class 2 when compared to Classes 1 and 3. This could also contribute to the lower preference of DPB, more negative ATB, and in general a lower purchase frequency of animal products with an "animal welfare" label. Additionally, perceived behavioral control (PBC) also shows differences between groups, which can also influence the overall preference for DPB. Class 3 showed a higher utility for DPB, which is also reflected in their PBC; this can also be associated to the place of purchase of chicken meat as about 25% of participants in this group usually purchase their chicken meat in "non-typical" (i.e., supermarket or discounter) venues.

Segments for potential consumers of dual-purpose chicken breeds have also been created by Busse et al. [67]. However, the approach used in that study involved conditions for a potential purchase of these products; among the conditions included were knowledge of the product, regular availability, price, regional origin, and taste. That particular study showed that various aspects contribute to determining purchase criteria, such as access to information and trust in the given information. However, although their most promising cluster stated a higher willingness to pay for DPB products, it is still unknown how much more they would pay and which compromises or under which conditions this price would be paid. Our study did that by showing that although consumers might be willing to pay a premium price for certain attributes such as animal welfare conditions, other attributes are equally or more important. In our case, the most promising consumer class gives a higher importance to the origin of the product and feed than to other attributes.

The overall low preference for DPB products could be associated to the fact that this topic (dual-purpose chicken breeds) is unknown to most European consumers [10,67,83]. Therefore, for this particular alternative production system (dual-purpose breeds fed with German field beans), it is necessary to communicate what dual-purpose breeds are and to specifically market the regional origin of the feedstuff, along with the sustainability and ethical advantages of this product when compared to conventional chicken meat. A proper communication of the advantages of these products could justify a higher price and more consumer engagement in these topics. By increasing communication of these particular products, consumers would be more aware of their decisions and the impact these have on sustainability issues like animal

welfare (e.g., killing of day-old chicks), sustainability (e.g., supporting local economy, conserving biodiversity through the use of traditional chicken breeds), and environmental issues (e.g., avoiding imports of protein feedstuff for animals).

The major limitation of the present study is that since this product is still not avail-able in a mainstream market, consumers had to make their choices assuming the product was available without having prior experience. Although potential consumers of DPBs show a higher engagement towards DPBs, and a higher engagement to animal welfare and regional origin, important aspects such as organoleptic properties and availability can heavily influence the final behavior. This study is also limited by the use of a method that indirectly measures consumers' WTP. As participants do not have to actually pay for the products they are selecting, there are no actual financial consequences for their decisions. This lack of financial consequences creates a hypothetical willingness to pay [84].

5. Conclusions

In order to create a successful marketing strategy for alternative production methods for poultry, it is necessary to understand which product characteristics consumers value the most. From this study it can be concluded that, after price, consumers value most the information about the origin of the product and origin of the animal feedstuff. Three classes were obtained from the latent class analysis based on their preferences for certain attributes: (1) price-conscious consumers (where price is the most important attribute), (2) price-sensitive and origin-oriented consumers (where price and origin are of importance), and (3) origin-oriented consumers (where origin importance is the highest). We conclude that the target consumer for meat of DPB fed with German field beans is Class 3 "origin-oriented consumers". Although consumers in this segment are interested in the idea of dual-purpose breeds, this attribute alone is not enough to influence their purchase behavior. Since animal welfare standards and region of origin are important to them, an approach to promote dual-purpose breeds could highlight these particular attributes rather than the specifics of the breeding.

The results of this study support the idea of using alternative production methods in the poultry industry. This is of particular relevance to this industry since the killing of day-old chicks will be prohibited in Germany starting 2022 and alternatives have to be implemented. Moreover, these results are also relevant to breeders of DPBs and growers of faba beans in Germany as consumers showed interest in these products.

Further research should test how to integrate and communicate different concepts related to these accepted attributes in chicken meat. Additionally, future studies could research organoleptic acceptance (sensory testing) with consumers along with an experimental auction, where consumers actually have to purchase the product, as this could show a real WTP and preference for these products when including experience and credence attributes.

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Appendix

Table A1. Statements used to measure the extended TPB (translated from German).

Predictors		Wording
ATB [53]	1	The purchase of products from DPB (eggs and meat) is interesting for me.
	2	It is a good idea to buy products from DPB (eggs and meat).
	3	It is important for me to buy products from DPB (eggs and meat).
	4	The purchase of products from DPB (meat and eggs) is good.
SN [53,60,62]	1	People who are important to me think that I should buy products from DPB (eggs and meat).
	2	People who are important to me want me to buy products from DPB (eggs and meat).
	3	People whose opinions I value would prefer that I buy chicken and eggs from DPB.
	4	The positive opinion of my friends influences me to buy products from DPB (meat and eggs).
PBC [62]	1	I know where I can buy chicken and eggs from DPB.
	2	I am confident that I will buy chicken meat and eggs from DPB.
	3	I see myself in a position to buy chicken meat and eggs from DPB in the future.
	4	I am ready to invest more time and money in purchasing chicken meat and eggs from DPB.
	5	Products from DPB (meat and eggs) are available in the shops where I usually go shopping.
PNAW [61]	1	People should do everything to improve animal welfare.
	2	I feel a moral obligation to buy DPB products (meat and eggs) regardless of what others do.
	3	I feel guilty buying meat and eggs where the day-old chicks were killed.
	4	I feel morally obliged to consider animal welfare in my daily behavior.
PNR [61]	1	People should do everything possible to increase the consumption of regional products.
	2	I feel a moral obligation to buy products from this region, regardless of what others do.
	3	I feel guilty if I buy chicken and eggs from other countries or regions.
	4	I feel obliged to consider regional consumption in my daily behavior.

ATB: attitude towards the behavior, SN: subjective norms, PBC: perceived behavioral control, PNAW: personal norms on animal welfare, PNR: personal norms on regional products; DPB: dual-purpose breeds. Source: adapted from [53,60–62].

Table A2. Information provided to participants prior to the choice experiment (translated from German).

Current poultry farming system
"The intensive poultry husbandry of chickens is characterized by specialized laying breeds (egg production) and fattening breeds (meat production). For modern meat production, specialized fattening breeds are used, which reach a weight of 2.6 kg within 6 weeks and can then be slaughtered. Specialized laying breeds are used in egg production, which lay up to 330 eggs in a laying period of 56 weeks. These laying breeds are thin and do not produce much meat, even when fully grown. The problem with the laying breeds is that only the female animals can lay eggs. Since this breed produces little meat and the male chicks do not lay eggs, these (male chicks) are generally killed today on the first day of life. This practice is carried out today by almost all farmers in conventional farming and by the vast majority in organic farming."
Dual-purpose breeds
"A possible solution to avoid the direct killing of male chicks is the use of "brother cocks". These are the male siblings of the laying hens, which are reared as broilers. However, the use of brother cocks is regarded as a transitional solution until there are solid dual-purpose breeds, because these chickens are relatively expensive. A dual-purpose breed is a breed that can be used for both production systems (eggs and meat). This means that the female hens lay relatively many eggs, the male hens gain weight relatively well. Both are not as good as the specialized breeds, but they can do both, which also explains the name "dual-purpose breed". Since these breeds are not only for egg production, chicks do not have to be killed and can be used for meat production. This prevents the male chicks from being killed directly and then new chickens from being bought for meat production only. At the moment it is possible to buy products from dual-purpose chickens. However, these products are not very common as they are only available in certain regions and shops."
Current poultry feed situation
"Another current problem with chicken production is that many farmers in Germany produce only a small part of the feed for their animals themselves. In most cases, this is purchased from feed manufacturers. A supply bottleneck (i.e., less produced than used) exists throughout the EU, especially for protein feed (protein). For the protein supply of livestock in Germany, 27% of this feed component must be imported. Most of the imported raw protein is in the form of soybeans and soy extraction meal, which are mainly produced in the USA or South America (e.g., Brazil). In the public debate, some interest groups are calling for the import of protein feed to be reduced and for only domestic raw materials to be used. One reason for this is, for example, the criticism of genetically modified varieties. In order to solve this problem, farmers and scientists are looking for other protein sources with correspondingly available protein quantity and quality."

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I.3 Consumers' opinions and expectations of an "ideal chicken farm" and their willingness to purchase a whole chicken from this farm

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Abstract

As poultry production and consumption have increased in the last decade, so have consumers' concerns about intensified production methods and the impacts they have on animal welfare. At the same time, poultry consumption has increased and enjoys great popularity. Also, a shift in consumers' consumption behavior can be observed as nowadays most consumers purchase chicken cuts, especially breast filets, rather than whole animals, mostly due to convenience and taste. Although consumer concerns have increased, market shares of alternative poultry products, i.e., those that are produced under higher standards compared to conventional products, remain comparably low. One of the main reasons are the large differences in prices. The higher prices for alternative chicken products such as organic result partly from increased production costs on farm level. Besides, consumer preferences for chicken cuts intensify cost differences. While alternative chicken breasts (e.g., organically produced) might be valued by some consumers, other cuts such as wings or thighs are not and are therefore sent into the conventional market. In these cases, the breasts need to remunerate all additional costs. Analyzing consumers' concerns about production methods and learning about consumers' obstacles to buy whole chickens might offer farmers greater possibilities to succeed in alternative markets. Therefore, the purpose of this study was to gain insights into consumers' chicken consumption behaviors, how consumers imagine an ideal chicken farm and whether they would be willing to purchase a whole chicken from this ideal farm. Three focus group discussions (total n = 30) with German consumers were held online in June 2020. The results show that participants associate the ideal chicken farm with four main characteristics: good husbandry system, positive economic impact for the farmer, high transparency, and proximate location of the farm in the same geographical region. However, willingness to purchase a whole chicken, even from the ideal farm, remains low due to mainly convenience reasons and daily routines.

Keywords

animal welfare, poultry production, consumer preference, whole chicken, chicken cuts, focus groups

1. Introduction

The poultry meat sector has grown worldwide for years, focused on indoor environments and automated production systems and processes (Fraser, 2008). In Germany, more than 620 million broilers have been slaughtered in 2019 (Statistisches Bundesamt, 2021). As poultry production grows, worldwide consumption of poultry meat also rises. In Germany, although meat consumption has decreased ~2.2 kg per capita between 2009 and 2019 (Statista, 2020), poultry consumption has increased by 4.12 kg per capita in the last decade (Bundesinformationszentrum Landwirtschaft, 2020). This increase in poultry consumption has been related to consumers' association of this type of meat with a healthier diet (less fat content) when compared to other types of meat, particularly red meat (Kennedy et al., 2004; Spiller et al., 2010).

In production, also animal genetics changed and chickens have been selected based on their performance to obtain a greater muscular growth in a short period of time. Before the industrialization of poultry production took place, a broiler (i.e., chicken for meat production) needed around 120 days to reach a weight of 1.5 kg while nowadays this is achieved in 30 days only [Bundesanstalt für Landwirtschaft und Ernährung (BLE), 2020].

Moreover, with these intensified production schemes farm structures changed. The number of small poultry farms (<10,000 animals) in Germany decreased significantly from 1999 to 2016 while the number of big poultry farms (>50,000 animals) increased [Bundesanstalt für Landwirtschaft und Ernährung (BLE), 2020]. These big farms account today for 80% of all broilers produced in Germany [Bundesanstalt für Landwirtschaft und Ernährung (BLE), 2020]. However, along with these production schemes, public criticism, and concerns toward farm animal welfare in these systems have grown (Vanhonacker et al., 2008; Martelli, 2009; Nocella et al., 2010; De Jonge and van Trijp, 2013), particularly for broiler production and laying hens (Verbeke and Viaene, 2000; Martelli, 2009; Vanhonacker and Verbeke, 2009; Heng et al., 2013). Among the concerns related to the welfare of broilers are high stocking densities in barns (Halle and Sandilands, 2006), a lack of outdoor access (Busch and Spiller, 2018), and leg weakness due to the lack of activity (Bessel, 2006). In laying hens, the killing of day-old male chicks (Brümmer et al., 2017; Busse et al., 2019), and beak trimming (Heng et al., 2013) are additional sources of concern. Further, the use of antibiotics in animal production is negatively perceived by consumers due to their association with antibiotic resistances and residuals causing health problems in humans (Bernard et al., 2005; Yang et al., 2009; Busch et al., 2020).

As the term “animal welfare” has become increasingly debated by the public (Deemer and Lobao, 2011; Lagerkvist and Hess, 2011) and public criticism and concerns regarding the abovementioned topics have increased, it is necessary to understand what regular consumers (i.e., not experts on the topic) consider ideal characteristics of a farm where chickens are reared for human consumption. Although literature shows that animal welfare and type of husbandry system are important attributes for consumers (Tonsor et al., 2009; Vanhonacker and Verbeke, 2014), it is still unknown whether other characteristics are also of relevance to consumers when imagining an “ideal” production method. Although there has been research related to ideal pig (Sato et al., 2017), beef (Kühl et al., 2020), and dairy (Cardoso et al., 2016) farms, to the best of our knowledge there is still a gap regarding chicken farms.

Consumers buying decisions for chicken meat are impacted by several aspects, depending on the information available. Price is certainly among the most important attributes when making buying decisions for meat (Clark et al., 2017; Escobedo del Bosque et al., 2021) but animal welfare attributes are of importance, too. Increased willingness-to-pay for broiler chicken with higher welfare levels is generally given but is lower compared to other animal products such as dairy (Clark et al., 2017). People with higher levels of animal welfare concerns have found to eat less animal products and to pay more attention to welfare labels when buying animal products (Clark et al., 2016). Feed and product origin also influence buying decisions in broiler chicken and are of higher importance compared to breeds (Escobedo del Bosque et al., 2021).

Besides animal welfare concerns and an increase in consumption quantity, the intensive production methods of the poultry industry also allowed for a change in consumers' consumption behavior of poultry. Nowadays, it is possible for consumers to purchase only those cuts which they desire, e.g., breast filets, instead of whole animals. This increasing trend of purchasing specific chicken cuts (e.g., breast filets, thighs) (Birzele and Stetter, 2018) occurs since many consumers see convenience as the most important motive for purchasing specific cuts rather than a whole chicken (Kennedy et al., 2004; Ripoll et al., 2015). Additionally, consumers usually try to avoid associating meat with an animal (Kubberød et al., 2002) in order to feel less guilt (Te Velde et al., 2002; Hopkins and Dacey, 2008) or disgust (Kubberød et al., 2002; Hamilton, 2006; Hopkins and Dacey, 2008). Te Velde et al. (2002) suggest that the unrecognizability of the cuts (e.g., breast filets cannot be as easily recognized as a part of a chicken compared to a whole carcass) also influences the preference for cuts. Nonetheless, the changed genetics and the trend of purchasing only cuts has contributed to a decrease in the number of whole animals being sold (Birzele and Stetter, 2018) and therefore reducing the

market segment of whole chicken consumption, which also impacts the production side. Consumers' increasing preference for chicken cuts also led to a shift from “short” (i.e., rearing for ~33 days to achieve a weight of 1.5 kg) to “heavy” (i.e., rearing for ~40 days to achieve a weight of 2 kg) fattening production methods in order to obtain larger and heavier cuts, particularly breasts (Bundschuh and Henning, 2016). Additionally, those cuts that are not consumed in European countries (i.e., wings, thighs, feet, organs) are exported to countries in Africa (e.g., South Africa, Benin, Ghana) and Asia (e.g., Saudi Arabia, Philippines, Hong Kong) (Bundschuh and Henning, 2016) often at low prices (Fourie, 2013; Banson et al., 2015; Bioland, 2020). For small producers of alternative markets in Germany, these developments are challenging. For them, exporting cuts is not economically viable. Selling whole chickens is therefore often an economic decision that is contrasting current consumer trends and challenging small and alternative production with e.g., increased farm animal welfare. The topic of consumers' willingness to purchase a whole chicken as well as the advantages and disadvantages of this product from consumers' perspectives has not been studied, to the best of our knowledge. Especially in combination with linking the consumption behavior to the impacts on the famer and the animals.

Since most consumers' knowledge about production systems in the poultry industry is limited (Erian and Phillips, 2017), the aim of this study was 2-fold: (1) to gain insights into how an ideal production of chicken meat looks like from a consumers' point of view; and, since it is known that consumers generally prefer cuts our aim was also (2) to assess the potential for marketing whole animals vs. cuts if the whole animal comes from such an ideal farm. The results of this study help understand consumer trade-offs between convenient consumption habits and support for preferred production methods. It indicates whether, and to what extent, consumers are willing to change consumption and preparation habits for the sake of production methods and farms that are in line with their values. In addition, results are relevant to chicken farmers in alternative (e.g., organic or animal welfare) markets in order to better understand what consumers expect from their practices and adapt these to their strategies in order to make chicken production more diverse and sustainable.

2. Materials and Methods

To generate information addressing our research questions, we gathered qualitative data through online focus groups. As defined by Morgan (1996), focus groups are a research method to collect information on a preset topic through interactions in a group. According to this definition, focus groups have three main characteristics: collecting data, interaction in a group

as source of data and an active role of the researcher in creating the group discussions. Focus groups allow creating an almost natural atmosphere that resembles a conversation setting with different opinions (Lamnek, 2005). This difference in opinions also allows participants to respond to and discuss with other participants and therefore generating further insights in the topic and reflect own views. As we did not know in advance all possible aspects that might contribute to an "ideal" broiler farm from a consumers' point of view as well as the drivers of consumer behavior regarding chicken cuts, we decided to choose focus groups as research mode. In addition to this exploratory approach we added some confirmatory elements in the focus group protocols for those cases in which respondents do not come up with topics for discussion by themselves.

In this study, all participants gave informed consent to take part in the study before the discussions started. This study was conducted in accordance with the Declaration of Helsinki, and the protocol including the leading interview questions for the focus groups was approved by the Ethics Committee of the University of Göttingen before data collection.

Three focus group discussions with German residents were held online in June 2020, using a virtual meeting room with audio and video sequences. Each discussion was scheduled for 90 min and moderated by a professional facilitator. Participants were recruited through an agency (Forester&Thelen Teststudio GmbH) in Hanover, Germany. The prerequisites for taking part in the discussions were consuming chicken meat at least once a month, consuming organic animal products and animal products with an animal welfare label at least once every 2 weeks or being responsible for cooking chicken for the family. The latter was the case for one of the participants in the group discussions (vegetarian that purchases and cooks chicken for the family), while all others were chicken eaters themselves. The age range for participants was set from 25 to 70 years. In each focus group discussion, 10 participants that live in Hanover, a city with ~500,000 inhabitants in Northern Germany (and its suburban area) took part. Hanover was selected for the discussion groups as it is the capital of Lower Saxony, the state with the highest poultry production in Germany.

Accordingly, the questioning order was semi-structured in order to stay flexible within the discussion but also to have comparable results (Lamnek, 2005). The moderator followed the script of questions (see Supplementary Table 1) which was divided in five main parts and started with (1) a warm-up phase in which the rules for the discussion were explained and each participant introduced him/herself to the group (10 min). Next, in order to introduce participants to the topic of preferences for chicken meat, participants were asked in part (2) to describe their

buying behavior of chicken meat (frequencies, point of purchases and determinants of buying decisions) and to rank the attributes that are of importance when buying chicken meat (20 min). These results will show a first glance at attributes that consumers value when purchasing chicken meat. Therefore, we then centered the discussion on our main research focus in parts 3 and 4. In part (3), participants were asked to describe an ideal chicken farm, according to their expectations. Included were questions about how relevant the farm is for consumers when purchasing chicken meat and which information about the farm would be wished to encounter at the point of sale (30 min). Part (4) of the focus group discussion was dedicated to the question whether participants prefer buying a whole chicken or cuts and for what occasions they buy each of these. In addition, participants were asked whether they would accept buying whole animals that originate from the ideal farm that they described before and how they rate the success of the approach of marketing whole animals. Advantages and disadvantages of marketing whole animals vs. cuts were discussed. Finally, the group discussions ended with (5) a closing question in which participants were asked to comment on the statement of eating less but better meat (25 min) followed by a summary and feedback section (5 min).

The discussions were recorded and transcribed by the recruiting agency and facilitated to the researchers. The transcripts were then revised and compared to the audio by two researchers independently. Next, the transcripts were analyzed following Knodel (1993) in two steps: (1) organizing and subdividing the data into segments: in this step, the collected data were looked at to determine where each topic started and ended; next, the data was divided into the four main questions asked in this study and (2) coding the material by determining criteria for converting it into analytically useful data. The coding of the transcripts was done in the following way (based on Knodel, 1993):

1. Development of codes that corresponded to each item in the discussion guideline: numerical codes were assigned to each research topic: 1 = “determinants of purchase,” 2 = “ideal chicken farm,” 3 = “whole animal vs. cuts,” and 4 = “less but better meat.” For each of these four major topics, subtopics were identified and statements were classified accordingly. For example, the topic of “whole chickens” was coded 3.1 and “cuts” was coded as 3.2 since they belonged to the topic coded with 3.
2. Creation of additional codes for topics that arose and were of special interest for the researchers: for instance, topics such as missing information from chicken meat packages or ideas on how to market whole chickens were mentioned. These were then allocated under a major topic and then coded differently than the subtopics included in

the guidelines. For instance, "missing information" was coded 1.A as a subtopic of determinants of purchase (code 1).

3. Development of non-substantive codes that helped in the writing phase: statements that could be used as illustrative quotations when reporting the results of the study were marked with asterisks and italics font while subtopics or additional topics had numerical coding.

The coding of the material was done by two researchers independently, and then themes were compared and adjusted. Since different topics and subtopics were covered in this study, the analysis was done individually for each major category.

3. Results

A total of 30 participants took part in the group discussions. The average age was 43 years, with the youngest participant being 25 and the oldest 64. A total of 15 men and 15 women participated and they were equally distributed in each session. In total, Six participants stated that they purchase and consume chicken meat more than once a week, while 13 participants do so only once a week and 11 once every 2 weeks.

Determinants of Purchase

At the beginning of each group discussion participants shared their purchase criteria regarding chicken meat. Fourteen participants purchased chicken meat in supermarkets 10 in discounter stores while only three participants purchased directly from a farmer, two in a weekly market, one in an organic shop and one purchased chicken meat online. When purchasing chicken meat, 63% of participants stated to mainly consider the price of the product. However, for some this meant "not the cheapest" product but included also the weighing with some quality criteria. When referring to a quality-price performance it was mentioned that "if the other criteria are met, I buy the cheapest." For 63% of participants, the type of husbandry system was as important as price Statements such as "having a good conscience" and "if I must eat it, then it (the chicken) should also had run around" were mentioned when referring to the importance of the type of husbandry system.

Further aspects that were of importance at the moment of purchase were: product origin (30%) — specifically regional origin, freshness (30%) — particularly the "best-before date," labels (30%), appearance (23%) — including color, paleness, leanness, and texture, and preparation (i.e., marinated or "pure") (23%). Other aspects that were, although less often, mentioned were:

type of packaging (13%), amount of product (e.g., 500 g) (10%), cut (e.g., breast filets) (7%), brand (3%), sustainability (3%), age/size of the animal (3%), and spontaneous decision (3%).

Nonetheless, 20% of consumers stated to not find all necessary information they desire on the products at the point of sale. One participant said that "in the counter no answer about origin" could be given, referring to the salesperson not being able to provide information regarding the origin of the animal; two other participants agreed with this specific comment. Similarly, while discussing missing information, one participant mentioned that "feedstuff is missing" or "one can hardly recognize" referring to animal feedstuff. Additionally, when discussing the information on husbandry system labels participants stated "what is behind it?" showing that this type of information is not easily understandable for all consumers. Although the abovementioned attributes were of importance for participants when purchasing chicken meat, additional attributes that might also be of relevance—particularly those which are not mentioned on the product packaging, remain unknown. Therefore, we asked next, what an ideal chicken farm looks like for these participants.

The Ideal Chicken Farm

The ideal chicken farm, as described by participants in the focus group discussions, has four main characteristics. These categories were built from the different topics mentioned during the discussions. Table 1 shows the topics discussed with regard to the ideal chicken farm and the counts how often the sub-topics have been mentioned by participants.

Table 1. Topics and sub-topics built from the group discussions of the 'ideal chicken farm'.

Topic	Sub-topic	Number of mentions
Husbandry	Free-range	9
	Green fields	6
	Space	3
	Weather protection	1
	No mass production	2
	Large farm	1
	Nice building	1
	Mobile housing	2
	Tents	1
Economics and Production	Development of the farm	1
	Pre-ordering of meat	2
	Idyllic farm	2
	Cycle farming	12
	Utilization of everything	1
	Fair pricing	3
	Production of egg and meat	3
Animals and their lives	Balanced nutrition	3
	Species-appropriate behavior	12
	No shredding of chicks	4
	Animals live longer	1
	Transparency	14
	No antibiotics	2
	No growth hormones	1
	Antibiotics only when needed	3
Origin	From the region	5
	Regional feedstuff	8
	Farmers grow their own feedstuff	2
Definition of regional	Radius 50km	3
	Lower Saxony	5
	Region of Hanover	2
	Under 100km	3
	Germany	1
	Production not possible everywhere	1
	Nord Germany	1
	200km	1
	300km	1
	200-300km	1
Farm size	Small	12
	Irrelevant if animals have enough space	7
	Irrelevant	6
	No mass production	3

First of all, when consumers thought of the ideal husbandry system, free-ranging was mentioned by 30% of participants, while 20% of participants emphasized the importance of chickens walking on green fields with sufficient space. A smaller number of participants also mentioned "no mass production" (7%), "nice building" (3%), as well as the use of mobile chicken housing (7%) as part of the ideal farm.

Second, they mentioned the economic aspect for the farmer. Participants expected from the ideal chicken farm that the farmer practices circular farming, i.e., that all steps of production,

from feed production to slaughtering, are done on the farm. In addition, three participants suggested that ideally the farm produces both, eggs and meat. Similarly, three participants mentioned that in an ideal scenario consumers pay more for the products, resulting in higher prices for the farmers; when referring to this topic one participant stated that farmers "do not participate in the price war and do not go bankrupt."

The third aspect that constituted an ideal chicken farm is transparency of production and species-appropriate conditions for the animals. While 14 participants mentioned transparency as an important part of the ideal farm, only a few gave specific examples of what they expected. For instance, two participants stated to want information about the farm with "realistic pictures" on a website and to be accessible through Quick Response (QR) codes on the products. Participants were also interested in seeing how and where the animals are raised; statements such as "petting chickens and feeding them yourself," "know the farm owners, see where the animals live," and "guided tour for children" were mentioned by four participants as ways to see how the farm works. Regarding transparency, two participants also mentioned "where you can see feeding conditions" as an important aspect of the ideal chicken farm. Additionally, two participants wished to know how much space chickens have while 12 of them wanted to see that the animals are reared in a species-appropriate way. The use of antibiotics was mentioned, however the opinion seemed divided into two groups: the first wished no antibiotics in the production at all and the other group agreed with the application of antibiotics only when necessary. With regard to size of the farms, perceptions differed: 40% of participants clearly expected an ideal farm to be rather small, whereas 23% stated being indifferent on farm size as long as chickens are kept and treated in a good way or "if there is enough staff and space." For instance, first participant mentioned that even on an ideal farm "there can be 39,000 animals, but in small groups and kept in such a way that they get along."

As a fourth point, participants wanted the ideal farm to be located in their region in order to reduce transportation distances. Additionally, 27% of participants mentioned that the ideal chicken farm should use regional feedstuff, preferably grown on the same farm. Although most participants were not aware of which type of feedstuff is fed to chickens, 23% of participants highlighted that the feedstuff should "not be imported," "not come from South America," and "not be genetically modified." The question of what regional production means was also discussed. It was clear that consumers have different ideas: for 30%, regional was measured in a radius of 50, 100, 200, 300 km around place of residence while for others it meant a city (Hanover) (7%), a state (Lower Saxony) (17%), or even a country (Germany) (3%). As

consumers have different ideas about what regional production means, one participant suggested indicating the distance between farm and point of sale on the product, which was supported by other participants in the group.

When consumers were asked to state, if they take all of the above mentioned aspects into account when purchasing chicken meat, only two claimed to do so while 10 stated that they only focus on one or two points (e.g., origin, animal husbandry).

Whole Chicken vs. Cuts

A higher share of participants (43%) in the focus groups stated to buy chicken cuts (e.g., breast, thighs, wings) instead of whole chickens. The 33% of participants who purchase whole chickens stated to do so mainly for special occasions like barbecue, when guests are visiting or when more time for cooking is available (e.g., weekend or holidays). The high time requirement was mentioned by six participants as the main disadvantage associated with the preparation of whole chickens. Additional obstacles of buying whole chickens were the need of "specific tools" such as cutting scissors, the large quantity of chicken meat that needs to be eaten and the problems associated to storing this large amount of meat. Among the advantages of purchasing a whole chicken "less food waste," "better taste," and quality ("I see what I purchase") were mentioned by eight participants.

On the other hand, four participants stated that the main advantage of cooking chicken cuts was also less food waste on the household level as well as the ability to cook the desired amount of meat rapidly. Additional advantages such as less workload, less time needed and easy recognition of quality were mentioned by six participants. The main disadvantages of cuts, mentioned by three participants, were seen in more food waste in the chicken industry as well as the lack of sustainability when purchasing only chicken breasts.

When confronted with the idea that the ideal chicken farm only sells whole broilers, the groups' opinions were again divided. Three participants said it was a bad idea. Three participants stated that the "idea is good but I would not do it" and one that it was "unrealistic" since some households consist of only one or two members. On the other hand, five participants thought it was a good idea and would purchase the product; however, three participants who would purchase the whole chicken stated to still prefer buying cuts (i.e., purchasing the whole chicken disassembled).

In order to generate demand for a whole chicken from this ideal farm, three participants stated that if the positive aspects of production (e.g., sustainability, animal welfare, regional

production) were highlighted this could be possible. Other ideas that were mentioned to generate demand for this product included: “associate a whole chicken with an occasion, for example a Sunday grill,” to reach a compromise by selling half chickens, to sell these whole animals to grillers, “education—explain good criteria for a whole chicken,” to sell in one particular supermarket store and “he must make himself known there” (he refers to the farmer).

Finally, participants discussed under which circumstances their willingness to purchase a whole chicken would increase. Three participants suggested that including recipes on how to prepare the chicken would increase their interest. The idea of farmers offering a “package” with a “perfect meal” (i.e., vegetables to accompany a specific dish) was also suggested by one participant. When asked about purchasing smaller breeds which result in smaller animals three participants thought it was a good idea and could be an option to increase consumer interest since the amount of meat would be less and therefore more adequate for smaller households. However, three others argued against this point by saying “if I have to do the cutting, I prefer to have more,” and one mentioned that it is not a good idea if it costs more.

Eating Less but Better Meat?

Finally, when responding to the statement eating “less but better meat,” 13 participants thought this was a good idea, whereas six others asked why not eating “more better meat” or “paying more for meat,” denying the reduction component of the statement. The question of what better meat meant was answered with higher quality (20%), animal friendliness (7%), and regional production (7%) as quality indicators by participants.

4. Discussion

The Ideal Chicken Farm

When thinking about the ideal chicken farm, participants in our study mentioned a good husbandry system including free-ranging as an important criterion. This is in line with what others found (Martínez Michel et al., 2011), also holding true for pigs (Weible et al., 2016; Sato et al., 2017) and dairy cows (Cardoso et al., 2016). Outdoor access is often acting as a key indicator for an animal welfare friendly system in the consumers' perception (Busch and Spiller, 2018). Husbandry system has also been mentioned as important for making purchase decisions by participants in the focus groups (together with price). The importance of animal husbandry systems could be a consequence of the negative associations consumers have with animal rearing (Te Velde et al., 2002; Weible et al., 2016), mostly gathered from different sources such as television, newspapers, stories heard from other people, or visiting farms (Te Velde et al.,

2002; Tonsor and Olynk, 2011; Weible et al., 2016; Erian and Phillips, 2017). Since consumers' definitions of animal welfare are usually different than farmers' definitions (Te Velde et al., 2002), it is important to understand what consumers expect. Consumers usually focus on housing conditions since these are strongly associated to the ability of animals to express their behavior, resembling their natural environment (Van Poucke et al., 2006; Sato et al., 2017). Consumers usually associate housing conditions to animal welfare (Sato et al., 2017; Vigors, 2019), and when thinking about positive animal welfare they think of small farms with animals living outdoors in a natural environment (Vigors, 2019). However, products of animals with a more animal-friendly husbandry system usually come with a higher price associated to a lower stocking density, more feedstuff needed, more space needed, etc. (Bornett et al., 2003; Lusk and Norwood, 2011). Nonetheless, many consumers state that they are willing to pay a higher price for animal products produces under higher animal welfare standards (Vanhonacker and Verbeke, 2009; Napolitano et al., 2010; Nocella et al., 2010; Clark et al., 2017). Even so, there is still a gap between the attitude (i.e., concern for farm animal welfare) and the actual behavior (i.e., purchasing a product with higher animal welfare standards) (Te Velde et al., 2002; Vanhonacker et al., 2008; Vanhonacker and Verbeke, 2009). This suggests that although many consumers might have concerns about animal welfare and have intentions of purchasing products with higher animal welfare standards, they might actually not purchase the product due to different and diverse reasons, also including the weight of a higher price (De Jonge and van Trijp, 2013). This is discussed as attitude-behavior or consumer-citizen gap (e.g., Ajzen, 2005; Vermeir and Verbeke, 2006). Also farmers have expressed doubt in consumers' and retailers' willingness to pay a fair price that would cover their expenses for implementing higher animal welfare standards (Bock and van Huik, 2007) and participants in the research presented herein valued price as equally important than husbandry system. Price has already been identified as the most important attribute when buying meat by others (Clark et al., 2017). In the focus groups presented herein, price as a purchase determinant did not necessarily mean purchasing the cheapest product but considering the price quality ratio. In the case of broilers, studies reveal that many people are concerned about animal welfare but there is a lower willingness to pay for it compared to e.g., beef (Clark et al., 2017). This challenges the selling of alternative chicken products and emphasizes the importance of good communication and available information about product quality.

A lack of information and availability of information on husbandry and welfare conditions is also an important factor that has been mentioned by our study participants and acts as a barrier

in buying according to welfare attitudes ad preferences. Only few countries have specific welfare labels or labeling of husbandry systems on products, making it hard for consumers to get information. In Germany, for example, the labeling of husbandry systems on conventional meat has only been introduced by some retailers into the market in 2019. Even in the latter case of Germany, the meaning of such labeling is not necessarily self-explaining for consumers—as it has been stated by study participants.

As part of the ideal chicken farm, participants consider important that farmers are paid fair prices for their products. Other studies have shown that consumers' desire to support (local) farmers (Chambers et al., 2007) and are in favor of paying farmers fair and higher prices for their products (Padel et al., 2010; Busch and Spiller, 2016). Additionally, on an ideal farm they expect farmers to carry out all production steps on farm, including slaughter and feed production. This is rarely the case since protein feedstuff, particularly soy for poultry production, is imported from countries outside the EU [De Visser et al., 2014; Deutscher Bauernverband (DBV), 2016]. Additionally, animals are born in hatcheries and then transported to fattening farms and animals are not slaughtered on farm but rather at a slaughterhouse. Moreover, the slaughter of animals also implicates much more work for farmers and, even more importantly, the need of facilities designed and legally approved for slaughter. Therefore, carrying out all steps of broiler production on farm seems not realistic for the large majority of farmers. A compromise for this could be the use of mobile slaughterhouses as consumers have expressed an interest and a higher willingness to pay for mobile slaughtered animals (Carlsson et al., 2007; Hoeksma et al., 2017).

As urbanization has grown, consumers' distancing from agriculture has also increased (Albersmeier and Spiller, 2008; Böhm et al., 2009; Olynk, 2012). This disconnect from agriculture along with food scandals, have generated a lack of trust in agricultural production systems (Kubberød et al., 2002; Spiller et al., 2010; Berk, 2012). This distancing and lack of trust have increased consumers' demand for transparency in production processes over the last few years (Olynk, 2012). Our results confirm this, as participants indicated transparency as an important part of an ideal chicken farm, particularly regarding how and where the animals are raised. Nowadays consumers can find meat products with labels related to different topics such as: organic and sometimes husbandry systems, regional origin, and animal welfare. Although these labeling schemes have aimed to inform consumers and increase transparency of the production methods (Olynk, 2012), they are not extensively available and, apart from the organic label, well-known. Many consumers do not trust the information, are confused and do

not know what each label means, or feel like there is an overload of information (Martelli, 2009; Vanhonacker and Verbeke, 2014). This was also reflected in our discussions, where participants revealed that when purchasing chicken meat, the information available was not always clear to them. Additionally, not all information (e.g., region of production, husbandry system, farm size, animal welfare conditions) is made available, particularly when purchasing meat at the counter. This problem was also mentioned by participants in this study who revealed that when purchasing meat at the counter the employee could not answer questions regarding the animal origin. This suggests the need for a consistent, clearer, and more transparent communication system when marketing such products, including the training of sales persons.

Product origin (i.e., farm location for animal products) is of high importance to many consumers as geographical proximity is usually associated to a high product quality, including freshness and better taste (Chambers et al., 2007; Grebitus et al., 2013; Feldmann and Hamm, 2015). Preference for local agricultural products such as fruits and vegetables and products of animal origin has been previously tested in several studies (Zepeda and Leviten-Reid, 2004; Chambers et al., 2007; Brown et al., 2009; Grebitus et al., 2013; Marcoz et al., 2014). In this study, participants mentioned the preference for regional products in order to reduce transportation distances. The preference for regional products due to the environmental friendliness of the production process, including transportation has also been found in other studies (Brown et al., 2009; Yue and Tong, 2009). Although most consumers were not aware of what chickens eat or where the feedstuff comes from, participants in this study mentioned the use of regional feedstuff as part of the ideal chicken farm's process. However, little is known about consumers' preference for animal feedstuff, including its origin. A few studies (Wägeli et al., 2015; Profeta and Hamm, 2018) show that there is potential for animal products produced with local feed as consumers would be willing to pay more for such products. Although most participants in this study prefer “regional” products, the definition of regional is still very ambiguous as each participant had its own criteria. This difference in perception of what regional entails can be attributed to the lack of an official definition and regulation (Feldmann and Hamm, 2015). Indicating the distance between the farm and point of sale, as suggested by participants in this study, seems like an easy and understandable way for consumers to determine themselves whether they are purchasing a regional product or not. The preference for labeling products with specific distances in miles/kilometers has also been elicited by consumers in Grebitus et al. (2013), although such labeling might be challenging for producers selling into different channels.

Whole Chicken vs. Cuts

Consumers' readiness to purchase a whole chicken (rather than cuts) from their ideal farm was divided, although it was seen as a good idea in general. Consumers resisting purchasing a whole animal stated that the amount of meat and work was too much for a household with one or two people. Especially when prices are higher for these whole chickens, these consumers will not be willing to switch to buying whole chickens as price play a predominant role in the buying decision (Clark et al., 2017). Ripoll et al. (2015) and Kennedy et al. (2004) found that consumers' main motivation to purchase cuts was the convenience of these pieces which is in line with our findings. Participants' interest in a product's convenience shows that consumers' lifestyles play a big role in purchasing behavior, even though they might compromise the "ideal" production method. As participants in this study suggested, the demand for whole chickens from the "ideal chicken farm" could be increased by focusing on promoting the sustainability, animal welfare, and regional production aspects of the products. This might be a good strategy as some consumers exhibit an increased willingness-to-pay for these aspects (Janssen et al., 2016). However, Vanhonacker and Verbeke (2014) suggest that rather than highlighting the benefits of higher welfare products, informing consumers about the current practices and their disadvantages might be a more efficient way to market products. In the case of marketing whole chickens it remains unclear how increased prices would further decrease consumers' acceptance compared to buying the more convenient cuts.

Not all consumers know how to prepare a whole chicken. The inclusion of cooking recipes as well as instructions for cutting the whole chicken (or selling a whole chicken already cut) were seen as good motivators to increase consumer's willingness to purchase a whole chicken. The inclusion of cooking recipes could help farmers to sell their products as a greater involvement in preparing and cooking food usually leads to purchasing local products (Cranfield et al., 2012; Zepeda and Nie, 2012).

Due to the obstacle many consumers have in purchasing a whole animal, an alternative for small-scale farmers could be offering a whole animal but already cut into the different pieces. In this way, consumers can have a whole animal without losing the convenience of individual storage and preparation of individual cuts. This system is currently used by Crowdbutching GmbH, were the animals (e.g., cows, pigs, chickens) are slaughtered only when all pieces have been sold. In the case of chicken meat, their website (http://www.kaufeinhuhn.de) allows consumers to choose from different packages of either cuts (including breast filets, wings, thighs, and drumsticks) or whole animals (mainly used for soups). Others are also using similar

systems in solidary agriculture. Although such system implies more work for farmers or slaughterhouses/cutting facilities (slaughter, disassembling/cutting, and packaging), it also provides an opportunity to attract consumers and expand markets.

Eating Less but Better Meat?

A high consumption, and therefore production, of meat is associated with environmental issues such as high greenhouse gas emissions, water and soil contamination and a loss of biodiversity (Deckers, 2010; De Vries and De Boer, 2010; Lesschen et al., 2011). However, only few consumers have an idea of the environmental impact of meat production and consumption, and they usually underestimate this impact (Macdiarmid et al., 2016; Hartmann and Siegrist, 2017). Accordingly, many consumers are not willing to reduce their meat consumption or substitute meat for other protein sources (Rothgerber, 2012; Macdiarmid et al., 2016; Hartmann and Siegrist, 2017). This behavior is justified with satisfaction-related (e.g., taste, satiety) or health-related (e.g., necessary for strong muscles, need for animal protein) arguments (Rothgerber, 2012; Macdiarmid et al., 2016). This is also reflected in our study, where only a third of participants agreed with the phrase "eat less but better meat," while the other participants questioned why "less meat" and not "more."

5. Conclusions

In this study, eliciting what consumers perceive an ideal chicken farm was the main research goal. Four main aspects could be found to be of importance for many: (1) husbandry systems with much space for the animals including free-ranging, (2) circular farming (all is done on the farm, from fodder production to slaughtering) with adequate remuneration of farmers for their efforts, (3) transparency about good animal conditions for consumers and (4) geographical proximity between place of production and consumption. In summing up these results, the "ideal" chicken farm from a consumer's point of view is quite different from common conventional production systems that usually produce intensively indoors, buy the animal feed that is internationally produced and traded, and sell the products into anonymous markets where consumer cannot easily trace the product back to single farms. Although these mentioned aspects constitute the ideal chicken farm, many participants only take a few attributes into account when making a purchase decision at the point of sale. This finding supports the phenomena frequently discussed as consumer-citizen or attitude-behavior gap. In order to let this gap shrink and to support consumers behaving according to their attitudes, there is a need for improved communication when selling products with improved production methods,

especially improved welfare. The information needs to be available in an easy, recognizable and independent way at the point of sale. The strong preference for purchasing cuts instead of whole chickens might be a challenge for producers with high welfare and sustainability standards. In order to get their efforts remunerated, those farmers need to make all information and processes transparent and invest in good communication to highlight the advantages of their products. Nevertheless, market segments for whole chicken, although produced on an "ideal" farm might remain a niche segment.

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Section II – Intrinsic characteristics

II.1 Meat quality parameters and sensory properties of one high-performing and two local chicken breeds fed with *Vicia faba*

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Abstract

The current practices of the poultry industry have raised concerns among consumers. Among these is the culling of day-old male chicks of laying hybrids; a suitable alternative for this could be the use of dual-purpose breeds where both sexes are used. Another practice that causes concern is the import of large quantities of soybeans for feedstuff production. Substitutes for these soybean-based products are regional protein crops, such as faba beans (Vicia faba L.; FBs). The objective of this study was to test the suitability of FB as a locally produced soybean meal replacement for two local dual-purpose chicken breeds and one high-performing layer line. The breast and leg meat of male Bresse Gauloise (BG), Vorwerkhuhn (VH), and White Rock (WR) animals was evaluated for different meat quality parameters: pH, color, water holding capacity, and tenderness. Sensory properties of the samples were evaluated by a trained panel with a conventional descriptive analysis. Results show different effects of FB diets on meat quality parameters in the different breeds. The attributes mostly affected by the diet are related to aroma, flavor, and texture, particularly in VH and WR. Overall, faba beans appear to be an acceptable dietary protein source for rearing these breeds for meat production.

Keywords

Alternative protein source; Bresse Gauloise; chick culling; faba bean; fava bean; meat-type chicken; slow-growing; Vorwerkhuhn; White Rock

1. Introduction

Nowadays, commercial poultry breeding is characterized by specialized fattening (meat-type) and laying lines (egg-type), i.e., meat-type genotypes are not used for egg production and laying genotypes are managed for efficient egg production where carcasses of culled hens are considered a by-product. Contrary to meat-type genotypes, where both sexes are used, in laying hybrids, only hens are used for egg production. Since male offspring of layers do not produce enough meat, they are not used for fattening and are culled on their first day of life, in both organic and conventional farming. This practice has raised ethical concerns in some European Union (EU) countries, including Germany [1,2], leading to research into alternatives. One alternative to killing day-old male chicks is the use of dual-purpose breeds: breeds that produce meat (males) and lay eggs (females). As dual-purpose breeds have only become interesting in recent years, they are not able to keep up with specialized meat-type and laying breeds. Dual-purpose hens lay fewer eggs and the males produce less meat even when fattened over a longer period of time. These inefficiencies also mean an increase in production costs associated with feed and housing, resulting in higher product prices [3]. Yet, dual-purpose breeds could produce an improved meat quality and taste, in addition to meeting consumer animal welfare expectations; therefore, consumers might be willing to pay a higher price for these products [1,4,5].

The movement for dual-purpose breeds does not only stem from the ethical aspects surrounding the culling of day-old chicks. The current specialized lines of production have led to a limited gene pool used in poultry breeding; therefore, the use of dual-purpose breeds, particularly traditional (or local) breeds, is important to the conservation of poultry genetic resources [6,7]. Traditional breeds, such as the French Bresse Gauloise (BG) breed, have also been used in Germany as dual-purpose chickens, while local breeds, such as the Vorwerkhuhn (VH) originating from Germany, are mainly kept by hobby breeders. However, their laying performance is rather low. Crossbreeding of such traditional breeds with high-performing commercial laying hens such as White Rock (WR) could be used to produce a dual-purpose genotype with a higher laying performance [8].

Another problem in the poultry industry is that animal farming requires a high amount of protein-rich feedstuff. The production of these feedstuffs causes a greater environmental impact on the entire poultry farming system than rearing the animals [9]. Although the requirement for large amounts of protein-rich feedstuffs has attracted criticism in recent years, it will likely remain necessary to meet future demands for human dietary protein [10]. Soybeans, specifically

soybean meal, are widely used as a protein source in poultry diet formulations; however, since the EU's soybean yield is not sufficient to cover the requirements of its own poultry industry, there is a need to import soybean products from other countries, such as United States of America, Brazil and Argentina [11,12]. The large amount of soybean imports (13 million tons by the EU in 2016 [11] and 3.5 million tons by Germany in 2017 [13]) contributes to instability in the EU agricultural sector, mainly due to price volatility of soybeans on the global market and production sustainability issues [12]. Additionally, EU citizens are concerned with genetically modified soy crops and deforestation in the Americas [12,14]. Alternatives to soybean products as poultry feed ingredients are regionally grown protein crops, such as beans and peas. These would contribute to a greater independency of local agricultural industries, as they would no longer have to rely on soy imports and their volatile prices, and provide environmental benefits like biological nitrogen fixation, in addition to having the potential to increase poultry production efficiencies [15].

Faba beans (Vicia faba L.; FBs) are one of the oldest and most widely cultivated legumes [16]. They contain approximately 30% protein [17], which is complemented further by an advantageous amino acid composition rich in lysine, yet variable in methionine and cysteine [16]. These characteristics make the FB a suitable candidate as poultry feed protein source [17]. In spite of their high nutritional value, FBs are considered to contain antinutritional factors (i.e., vicin and convicin; together abbreviated as VC) that have challenged their use in poultry diets [18,19]. The levels of VC vary depending on the FB cultivar [16]. It remains unclear whether a modern low-VC cultivar contains a low enough amount of antinutritional factors to allow for the substitution of soybean meal with FB in a poultry diet [20]. Literature is conflicted regarding the effect of FB as a dietary protein source in poultry diets. Not all findings are conclusive and appear to depend on the antinutritional characteristics of FB as well as bird physiological development [17]. For example, Laudadio et al. [21] and Dänner et al. [20] find that FB can be included in laying hens' diets without having a significant negative effect on laying performance or egg quality; however, it was found in [22] that the inclusion of FB in laying hens' diets can decrease egg weight. In addition, broiler nutrition (apparent metabolizable energy; AMEn) values are found to be adversely affected by antinutritional factors in FB; however, adult cockerels appear to be more resilient towards antinutritional factors [17].

The main objective of this study was to test the effect of FB as a locally produced soybean meal replacement on meat quality traits, including sensory analysis, of cockerels for two local dual-purpose chicken breeds and one high-performing laying line. The locally grown FBs contain

average and reduced VC contents in order to ascertain the limit of antinutritional factors in these genotypes. Furthermore, this system offers the chance to fatten the brothers of laying hens of local breeds in a regional production system and therefore to refrain from culling male chicks. More specifically, the aim of this study is to assess whether traditional breeds can be used as a basis to develop a local alternative poultry production system based on their meat quality and sensory characteristics under different diets. The effect of poultry diets containing different local FB cultivars in these particular genotypes remains the variable under investigation.

2. Materials and Methods

This experiment is in accordance with the European Union directive on the protection of animals used for scientific purposes (Directive 2010/63/EU) and was approved by the Lower Saxony State Office for Consumer Protection and Food Safety (LAVES; ref. 33.9-42502-04-17/2622).

2.1. Animal Management and Sampling

One-day-old male chicks of Bresse Gauloise (BG), Vorwerkhuhn (VH), and White Rock (WR) breeds were reared in indoor pens using a commercial starter at the Friedrich-Loeffler-Institute (FLI; Celle, Germany) for three weeks. The BG and VH chicks were directly hatched at FLI; WR chicks were provided by from Lohmann Tierzucht GmbH (Cuxhaven, Germany). At 21 days, 120 BG, 94 VH, and 120 WR male chicks were transported to the Department of Animal Sciences at the University of Goettingen (Goettingen, Germany), where 40 chicks of each genotype were randomly assigned to one of three feed groups. Decreased hatchability of VH chicks resulted in reduced feed group size (approx. 30 animals per feed group). In total, there were nine different experimental groups (3 breeds × 3 feed groups). The chickens were reared in an indoor-floor system with a solid floor and with fans for ventilation and cooling. The density of each pen was 10 birds/3 m2, with the exception of VH, where seven to eight birds were held per pen; for each feed/breed combination there were four replicates. The temperature was held constant at 20 ± 2 ◦C, and the photoperiod was 16 h.

Three different diets (Table 1) were fed across all breeds starting at day 21. The control (C) group was fed soybean-meal-based feed, while the rations of the other two groups were based on FB feed mixture. The difference between the two FB-based diets was the VC content: one diet had a high (0.14%) VC content (VC+); while the VC content of the other diet was low (0.02%) (VC-). Table 1 outlines the ingredient composition of each experimental diet in

percentage of ingredient per kg of feed. All animals were provided feed (pelleted) and water ad libitum.

The animals were reared from September 2017 to December 2017 or January 2018, therefore reaching slaughter ages of 10, 15, and 16 weeks for BG, VH, and WR, respectively. Age differences are due to different growth rates of the breeds reaching the same body weight (approximately 2100 g) at slaughter. At slaughter, the birds were electrically stunned, exsanguinated by neck cut, scalded, eviscerated, weighed, and chilled at 4 ◦C for 24 h. Twenty-four hours after slaughter (post mortem; p.m.) the carcasses were weighed and manually dissected. Results concerning the animals' growth performance and carcass parameters have been reported elsewhere [23].

For each of the nine groups (3 breeds × 3 feeds), approximately 20 animals (BG 20, VH 16, WR 20) were allocated for sensory analysis, and 10 samples per group were used for physicochemical analyses; the rest of the samples were used for analyses not pertaining this study.

Table 1. Ingredient composition of each experimental diet.

	Control	Vicin+	Vicin-
Ingredients (%)			
Wheat	30.0	8.0	8.0
Corn	36.0	25.2	25.2
Soybean meal	24.4	-	-
Blue sweet lupines, cv. Boruta	-	28.6	28.6
Peas, cv. Astronaute	-	10.5	10.5
Faba beans, cv. Fuego	-	20.2	-
Faba beans, cv. Tiffany	-	-	20.2
Grass meal	5.6	0.1	0.1
Soybean oil	0.2	2.7	2.7
Dicalcium phosphate	1.3	2.2	2.2
Calcium carbonate	1.0	0.7	0.7
Salt (NaCl)	0.3	0.4	0.4
DL-Methionine	0.2	0.4	0.4
Vilomix Broiler premix 77047[1]	1.0	1.0	1.0
Chemical analyses			
Dry matter (%)	90.0	90.3	90.1
Ash (g/kg DM)	67.6	64.5	64.9
Crude protein (g/kg DM)	211.6	220.5	228.3
Crude fat (g/kg DM)	29.7	56.2	58.7
Crude fiber (g/kg DM)	43.8	60.4	68.5
Methionine (%)	0.49	0.48	0.43
Cysteine (%)	0.30	0.27	0.29
Lysine (%)	0.97	1.01	1.07
Theonine (%)	0.71	0.66	0.69
Vicin (%)	0.005	0.095	0.016
Convicin (%)	0.003	0.043	0.006
VC (Vicin + Convicin; %)	0.008	0.138	0.022
Tannin (mg/g)	4.22	4.48	4.01

[1] Vitamin–mineral premix provided per kg of diet: Fe, 32 mg; Cu, 12 mg; Zn, 80 mg; Mn, 100 mg; Se, 0.4 mg; I, 1.6 mg; Co, 0.64 mg; retinol, 3.6 mg; cholecalciferol, 0.088 mg; tocopherol, 40 mg; menadione, 4.5 mg; thiamine, 2.5 mg; riboflavin, 8 mg; pyridoxine, 6 mg; cobalamin, 32 µg; nicotinic acid, 45 mg; pantothenic acid, 15 mg; folic acid, 1.2 mg; biotin, 50 µg; choline chloride, 550 mg. Source: Adapted from [23].

2.2. Physicochemical Analysis

The following physicochemical analyses were conducted on 10 samples per feed/breed combination: pH; color; water holding capacity (WHC), measured as storage loss and cooking loss; instrumental tenderness, measured as shear force; and content of flavor-related nucleotides, i.e., inosine-5′-monophosphate (IMP), adenosine-5′-monophosphate (AMP), and inosine. pH and nucleotides were analyzed in the left breast. Remaining parameters were recorded using the right breast samples, which were stored between 24 and 72 h p.m. in modified atmosphere (80% O2/20% CO2) packaging (MAP) using a PP tray with absorbent liners and heat-sealed with an oriented OPET/PP film (<3 cm3/m2/24 h bar oxygen transmission rate; <12 cm3/m2/24 h bar carbon dioxide transmission rate) using a vacuum packaging machine (TS 100, KOMET Maschinenfabrik GmbH, Plochingen, Germany) and

stored at 4 ◦C without illumination. The pH values were determined at three different times (20 min p.m., 24 h p.m., and 72 h p.m.) by inserting a pH-electrode and a thermometer (Portamess 911, Knick Elektronische Messgeräte GmbH & Co. KG, Berlin, Germany) into the cranial part of the left breast. The pH-meter was regularly calibrated between breeds, using standard buffers for pH 4 and pH 7 at room temperature. Color was quantified using CIELAB coordinates (L*a*b* values). Three measurements were taken on non-overlapping areas (free of obvious color defects) using a colorimeter (CR-600d, Konica Minolta, Tokyo, Japan). Color was recorded on the ventral part of the right breast with skin at 24 h p.m. and without skin at 24 and 72 h p.m. The average of the three-color measurements was used in further analysis. The spectrometer was calibrated before every session using a white tile provided by the manufacturer. Storage loss was monitored by weighing the right breast at 24 h p.m. prior to packaging and reweighing at 72 h p.m., where the percent difference in weight was attributed to storage loss. Afterwards, these samples were frozen at −20 ◦C until cooking loss and shear force analyses were conducted (approx. 8 weeks p.m.). Samples were thawed overnight at 4 ◦C and freshly vacuum-packaged; then they were immersed in a hot water bath (1092, GFL Gesellschaft für Labortechnik mbH, Burgwedel, Germany) at 80 ◦C for 50 min until reaching a core temperature of 76 ◦C, as measured by inserting a thermometer (926, Testo SE & Co. KGaA, Lenzkirch, Germany). After cooling to room temperature, the samples were weighed in order to calculate the cooking loss as a percentage of overall weight loss. The samples were later wrapped in aluminum foil and stored overnight at 4 ◦C. Prior to conducting shear force analysis, samples were left unwrapped at room temperature for 10 min. Shear force values were measured with a TA.XTplus Texture Analyzer (Stable Micro Systems, Surrey, UK) equipped with a 5 kg load cell and a Meullenet-Owens Razor Shear Blade (MORS-Blade). The conditions for the test were the following: pretest speed 2 mm/s, test speed 10 mm/s, trigger type 10 g. Each breast sample was sheared four times perpendicular to the muscle fiber orientation, with a 1.5 cm distance from each cut. Results of each sample are presented as an average of the four measurements. Shear force is reported as the peak shear force (N) which is necessary to completely shear through the sample.

To determine the content of IMP, AMP, and inosine, samples of raw meat from the left breasts (5 samples per group) and left legs (10 samples per group) were taken at 24 h p.m., frozen with liquid nitrogen, and stored at −72 ◦C. Six months after slaughter, IMP, AMP, and inosine content was determined using the method of Morzel and Van De Vis [24] with some modifications. Minced samples (0.200 g) were homogenized (Schuett-homgenplus

homogenizer, Schuett-biotec GmbH, Germany) with 1 mL of 5% (w/v) TCA (aq) for 1 min at 1600 rpm (Pico & Fresco 17/21 centrifuge, ThermoElectron LED GmbH, Osterode, NE, Germany) followed by chilling on ice for 15 min. The liquid extract was centrifuged at 4 ◦C for 5 min at 12,000 × g. The supernatant (200 µL) was diluted 1:4 (v/v) for the breast samples and 1:2 (v/v) for the thighs, with 5 % (w/v) TCA (aq) at pH 7.0. Extracts were kept at −20 ◦C before being injected into the HPLC system. The system (VWR Hitachi, Chromaster) was equipped with a 5260 pump, a 5260 autosampler (injection volume: 10 µL), and a 5410 UV detector operating at 260 nm. A LiChroCart Licrosphere 100 RP8 (250 × 4.6 mm, 5 µm) column was maintained at 30 ◦C in a 5310 column oven. The mobile phase consisted of 100 mM KH2PO4 (aq), 1.44 mM TBAHS (aq), and 0.5% methanol (aq, pH 7.0). Quantification was performed by an external calibration method. Identification of the analytes was performed by comparison of retention times. All analyses were performed in duplicate.

2.3. Sensory Analysis

The samples for sensory analysis were stored between 24 and 72 h p.m. in MAP packaging under the same conditions as samples for physicochemical analysis (see Section 2.2). At 72 h p.m., the samples were vacuum-packed in plastic bags and frozen at −20 ◦C until training or evaluation. All training and evaluation sessions took place in the sensory laboratory at the University of Goettingen, which complies with the international standard ISO 8589. All samples were thawed overnight at 4 ◦C prior to cooking for training or evaluation. Chicken breast samples were prepared according to the cooking loss procedure (see Section 2.2). The breasts were cut in 1 cm^2 pieces and served on warm plates (Figure 1a) marked with a 3-digit code. Leg samples with skin were roasted in a commercial oven for 35 min at 190 ◦C and 50% air humidity until they reached a minimal core temperature of 76 ◦C, measured by inserting a thermometer (926, Testo SE & Co. KGaA, Lenzkirch, Germany) into the thigh, and kept warm in a food warmer (Bain Marie, Bartscher, Salzkotten, Germany) until served. Each panelist received one complete leg on a warm plate marked with a 3-digit code (Figure 1b).

(**a**) Breast samples

(**b**) Leg sample

Figure 1. Pictures of (**a**) breast and (**b**) leg samples prepared for sensory evaluation.

Conventional descriptive analysis was carried out by a trained panel consisting of 10 assessors, who were experienced in descriptive sensory profiling of meat-related products and were trained and selected according to ISO 8586. All assessors provided written informed consent prior to participation.

The panel evaluated different chicken breasts and chicken legs from three breeds (BG, VH, WR) fed with three different diets (C, VC+, VC-), resulting in nine different products per cut (breast, leg). Assessors defined attributes in appearance, odor, taste, flavor, and texture that best described the samples and were trained further in these. To evaluate the breast samples, a total of 21 attributes were collected. Similarly, a total of 20 attributes were collected to describe the leg samples. A list of all attributes along with their definitions and scales for breasts and legs are presented in Tables A1 and A2 (Appendix A), respectively. Training per cut was directly followed by evaluation of the nine products per cut, i.e., chicken breast training and evaluation was completed prior to starting sensory analysis of leg products.

The trained panelists evaluated the nine chicken breast products in triplicate in four sessions, where each assessor evaluated six samples per session. Leg products were only assessed in duplicate. All samples were evaluated, in a sequential monadic manner, in three different set orders that were allocated to three or four assessors for each session. After the evaluation of each sample, panelists were asked to neutralize their senses by drinking water; additionally, untoasted white bread was available for neutralization. Using EyeQuestion survey software (Version 4.8.7, EyeQuestion, Elst, the Netherlands), each sensory attribute was evaluated on a 10 cm unstructured line with an unmarked scale ranging from 0 (no perception) to 100 (strong perception). The electronically collected data were later used for statistical analysis.

2.4. Statistical Analysis

Due to the different slaughter ages, the statistical analyses of the evaluated physicochemical and sensory data were done separately for each breed; therefore, the feed effect was compared within breed.

Data analysis of physicochemical parameters was performed with SPSS (Version 24, IBM Corporation, New York, NY, USA) statistical software. Mean values were calculated and feed effect was compared within each breed with a one-way ANOVA using Tukey's multiple comparison statistical test at a 95% confidence level ($\alpha = 0.05$).

For the statistical analysis of sensory data, the linear mixed model (LMM) procedure from SPSS (Version 26, IBM Corporation, New York, NY, USA) was used for mixed model calculations. All calculations were compared within each breed. In the statistical model for breast samples, "feed" was defined as a fixed effect, while "panelist", "animal", "feed*panelist", and "feed*animal" were defined as random effects. In the statistical model for leg samples, "feed" was defined as a fixed effect, while "panelist" and "feed*panelist" were defined as random effects. Within the model, a least significant difference (LSD) statistical test at a 95% confidence level ($\alpha = 0.05$) was used.

For the sole purpose of visualization, a principle component analysis (PCA) was carried out with treatment group means across all parameters. The PCA was computed using RStudio (version 1.2.5033, R Foundation for Statistical Computing, Vienna, Austria) coupled with the FactoMineR package [25]. Variables were standardized and number of components was assessed based on a scree-plot.

3. Results

3.1. Physicochemical Results

When evaluating physicochemical parameters, the feed had an apparent effect on chicken breast quality depending on breed (Tables 2 and 3). Across feed groups, no significant effects were observed in VH samples. pH values in both BG and WR with VC+ diets showed significant differences vs. control. While a VC+ diet significantly decreased the pH for BG at 24 h p.m. vs. control, the effect was the opposite in WR. In WR, the inclusion of VC increased the pH value of the samples at 24 and 72 h p.m. when compared to C; this increased pH value was significantly higher than that of C when WR was fed with a VC+ diet.

Table 2. Means (standard deviations) for physicochemical parameters (n = 10): pH_{20}, pH_{24}, pH_{72}, color (L* = lightness, a* = redness, b* = yelowness), storage loss, cooking loss, and shear force of breast muscle per breed (BG = Bresse Gauloise, VH = Vorwerkhuhn, WR = White Rock) and feed (C = control, VC+ = high in vicin, VC- = low in vicin).

Breed		**BG**			**VH**			**WR**	
Diet	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**
pH									
pH_{20}	6.27 (0.20)	6.29 (0.19)	6.29 (0.29)	6.18 (0.22)	6.41 (0.21)	6.26[1] (0.16)	6.32 (0.25)	6.26 (0.17)	6.23 (0.23)
pH_{24}	5.92 (1.03)	5.67 (0.44)	5.73 (0.45)	5.78 (0.31)	5.75 (0.22)	5.74 (0.30)	5.84 (0.13)	6.09 (0.13)	5.96 (0.35)
pH_{72}	5.49 [a] (0.33)	5.10 [b] (0.16)	5.27 [a,b] (0.22)	5.96 (0.18)	5.96[2] (0.23)	5.86 (0.40)	5.43 [a] (0.33)	5.70 [b] (0.08)	5.57 [a,b] (0.14)
Color with skin									
L^*_{24}	64.09 (3.04)	61.58 (3.60)	62.89 (3.47)	68.09 (1.90)	67.79 (3.70)	67.38 (4.75)	63.19 (5.24)	65.58 (3.84)	65.71 (2.58)
a^*_{24}	3.61 (2.02)	3.57 (1.79)	3.13 (0.86)	3.12 (1.49)	3.57 (0.90)	3.46 (1.83)	2.30 (1.09)	1.21 (0.75)	2.05 (1.63)
b^*_{24}	15.15 (3.53)	15.93 (2.18)	17.53 (1.87)	14.19 (2.30)	15.70 (2.20)	15.88 (2.25)	18.19 [a] (4.09)	13.64 [b] (2.77)	15.12 [a,b] (3.06)
Color without skin									
L^*_{24}	61.78 (4.44)	60.19 (2.58)	63.24 (2.87)	62.83 (2.18)	61.70 (1.69)	62.32 (2.48)	62.17 [a,b] (1.69)	61.43 [a] (2.43)	64.03 [b] (2.55)
a^*_{24}	0.10 [a] (0.53)	0.83 [b] (0.58)	0.58 [a,b] (0.45)	0.73 (0.73)	1.33 (0.72)	1.11 (0.67)	0.14 (0.52)	-0.42 (0.47)	0.10 (0.53)
b^*_{24}	10.64 (2.06)	12.36 (2.65)	12.53 (1.77)	10.05 (2.33)	10.59 (2.01)	9.82 (1.29)	9.76 [a] (1.76)	5.98 [b] (1.46)	7.61 [c] (1.20)
L^*_{72}	61.20 (4.03)	60.46 (2.38)	62.25 (3.20)	61.05 (2.26)	60.48 (1.92)	61.02 (1.67)	61.05 (1.63)	59.73 (2.52)	61.36 (2.42)
a^*_{72}	0.88 [a] (0.40)	1.54 [b] (0.75)	1.23 [a,b] (0.51)	1.46 (0.75)	1.94 (0.75)	1.55 (0.61)	1.00 (0.37)	0.90 (0.59)	0.97 (0.56)
b^*_{72}	10.59 (1.17)	12.46 (2.04)	12.39 (1.80)	9.24 (2.36)	10.25 (1.89)	9.22 (1.31)	8.58 [a] (0.93)	7.18 [b] (1.03)	8.10 [a,b] (1.32)
Water holding capacity									
Storage loss (%)	2.60 (0.34)	2.34 (0.54)	2.21 (0.44)	2.33 (0.22)	2.16 (0.34)	2.01 (0.41)	2.23 [a] (0.29)	1.31 [b] (0.43)	1.53 [c] (0.54)
Cooking loss (%)	21.87 (1.53)	20.79 (1.40)	21.31 (0.97)	20.54 (1.19)	20.21 (1.14)	20.49 (0.89)	21.99 [a] (0.98)	22.57 [a,b] (1.36)	23.58 [b] (1.34)
Instrumental tenderness									
Shear force (N)	3.91 (0.76)	3.82 (0.64)	3.93 (0.91)	4.83 (0.68)	5.21 (0.83)	5.04 (0.99)	5.29 [a] (0.76)	4.60 [b] (0.36)	4.51 [c] (0.63)

[a,b,c] Values within a breed with differing superscript letters are statistically significantly different ($\alpha = 0.05$). [1] n = 8 due to missing measurements at time of observation. [2] n = 9 due to missing measurements at time of observation.

The main differences in BG were found in the color of the samples, mainly in the redness (a*) of the meat. For samples measured at 24 and 72 h p.m., a diet with FB significantly increased redness of the chicken breasts without skin (meat color) in only BG birds compared to a diet with soybean meal; although only VC+ and C are statistically significant, VC- values remained increased as compared to C for both BG and VH breeds. However, vicin content (VC- vs. VC+)

did not statistically affect meat color. In WR samples, VC+ led to a significant decrease in yellowness (b*) of meat color at 24 and 72 h p.m. when compared to C. This change was also present in the skin tone of the samples at 24 h p.m. Overall, the color trend in WR samples was that an increasing vicin content resulted in less yellow tones of skin and meat. Furthermore, at 24 h p.m., a VC- diet significantly increased the lightness (L*) of samples when compared to a VC+ diet; this effect was seen in both BG and WR breeds.

Table 3. Means (standard deviations) for IMP, AMP, and inosine content of breast (n = 5) and leg (n = 10) muscles per breed (BG = Bresse Gauloise, VH = Vorwerkhuhn, WR = White Rock) and feed (C = control, VC+ = high in vicin, VC- = low in vicin).

Breed		**BG**			**VH**			**WR**	
Diet	**C**	**VC+**	**V-**	**C**	**VC+**	**V-**	**C**	**VC+**	**V-**
Breast (n = 5)									
IMP	248 (17)	251 (44)	273 (10)	318 (26)	320 (46)	305 (42)	307 (35)	332 (21)	288 (39)
AMP	4 (1)	3(2)	4 (2)	7 (4)	10 (3)	7 (3)	9 (4)	5 (2)	10 (4)
Inosine	51 (9)	58(9)	60 (8)	17 (3)	17(4)	17(3)	20 (4)	16 (6)	21 (13)
Leg (n = 10)									
IMP	147 (13)	141 (11)	146 (14)	147 (12)	150 (11)	143 (12)	151 [a] (9)	146 [a] (10)	138 [b] (11)
AMP	4(2)	2 (1)	2.3 (0.8)	4 (2)	4 (2)	3 (2)	3 (2)	4 (2)	4 (1)
Inosine	11 (3)	12 (3)	10 (3)	8 (3)	8 (2)	8 (2)	6 (2)	6 (2)	6.5 (0.8)

All values are presented in mg/100g. [a,b,] Values within a breed with differing superscript letters are statistically significantly different ($\alpha = 0.05$).

Aside from differences in color, WR also showed significant differences between the different diets in storage and cooking loss. In contrast to storage loss, where C samples lost more moisture than VC+ and VC- samples, the faba bean diets resulted in a higher loss of water in cooking loss. Feed also had a statistically significant effect on shear force in WR birds; control samples of WR showed a significantly higher shear force when compared to WR chicken breast produced using faba bean (VC+ and VC-) diets.

IMP resulted as the most abundant nucleotide for both tissues and for all the genotype/feed combinations, followed by inosine and AMP. Breast samples showed no significant difference between feed groups within the same breed. In the case of thigh samples, instead, a significant difference ($p < 0.05$) between the control and the VC- group was found for the IMP content of the WR chickens.

3.2. Sensory Results

Across the three breeds, feed appeared to play a limited role in influencing organoleptic quality. Table 4 outlines the sensory attributes that were affected in at least one breed by feed in the breast samples; results for all sensory attributes can be found in the supplementary material (Tables S1–S3).

Table 4. Estimated marginal means of statistically significant (α = 0.05) sensory attributes (*n* = 10, r = 3), as quantified using unstructured line scales (0 = not perceptible, 100 = strongly perceptible), of chicken breast samples per breed (BG = Bresse Gauloise, VH = Vorwerkhuhn, WR = White Rock) and feed (C = control, VC+ = high in vicin, VC- = low in vicin).

Breed	**BG**			**VH**			**WR**		
Diet	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**
Aroma									
Barn	17.6	18.8	20.7	19.9 ^{a,b}	21.5 ^{a}	17.4 ^{b}	19.7	22.7	19.4
Appearance									
Fibrousness	42.3 ^{a,b}	37.8 ^{a}	43.2 ^{b}	44.9	40.9	43.7	44.6	39.1	41.8
Texture									
Tenderness	71.0	70.1	66.6	61.7 ^{a,b}	60.1 ^{a}	68.4 ^{b}	70.7 ^{a}	67.2 ^{a,b}	63.6 ^{b}

^{a,b} Values within a breed with differing superscript letters are statistically significantly different (α = 0.05).

Results of BG breast filets showed only a difference in the fibrousness, measured as the degree of visible fibers on the cut side of the sample. BG chicken breast samples produced with a VC- diet had a more fibrous appearance than samples with a VC+ diet. For VH chicken breast, barn aroma and tenderness had statistically different values dependent on feed. The VH samples produced with VC- had a more reduced barn aroma than VC+ samples, yet with no significant difference to C samples. Likewise, tenderness differed between VH chicken breasts produced with VC- and VC+, where the lower vicin faba bean feed (VC-) contributed to a more tender product. Finally, tenderness was also influenced by feed in the production of WR chicken breast. Tenderness was significantly higher for feed group C compared to the VC- group, but with no difference to a VC+ diet.

Similar to chicken breast samples, only a few sensory attributes were affected by feed in a roasted thigh and drumstick (leg) product. Table 5 presents the sensory attributes that showed statistically significant difference in at least one breed by feed in the leg samples; results for all sensory attributes can be found in the supplementary material (Tables S4–S6). Feed played a larger role in the organoleptic quality of VH legs, whereas BG and WR samples remained

mostly unaltered. Faba bean feed tended to increase the crispiness in BG leg samples; samples produced with VC- had significantly higher crispiness compared to the control group. Feed affected aroma, flavor, and texture attributes in VH legs. A high vicin content (VC+) significantly increased the barn aroma when compared to control; however, a low vicin content had no significant difference to samples fed with control. The control feed resulted in a product that tasted more metallic and had a more intensive aftertaste, overall. The high-vicin faba bean feed had significantly lower values for metallic flavor compared to the control group; the low-vicin feed resulted in a reduced aftertaste. Furthermore, samples of animals fed with VC- were significantly juicier than those of the VC+ diet; however, they were no different than the C group. Finally, flavor and texture attributes in WR were affected by the different diet groups. Animals fed with a VC- diet had a significantly less greasy/oily flavor when compared to control. Similarly, a faba bean diet decreased the crispiness of the samples, particularly for the VC- diet, when compared to control feed.

Table 5. Estimated marginal means of statistically significant ($\alpha = 0.05$) sensory attributes ($n = 10$, r = 2), as quantified using unstructured line scales (0 = not perceptible, 100 = strongly perceptible), of leg samples per breed (BG = Bresse Gauloise, VH = Vorwerkhuhn, WR = White Rock) and feed (C = control, VC+ = high in vicin, VC- = low in vicin).

Breed	**BG**			**VH**			**WR**		
Diet	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**	**C**	**VC+**	**VC-**
Aroma									
Barn	19.3	14.3	13.6	10.7 ^{a}	14.6 ^{b}	12.3 ^{a,b}	20.9	16.2	16.4
Flavor									
Greasy/oily	36.3	40.3	41.9	34.8	36.4	36.0	38.9 ^{a}	38.0 ^{a,b}	33.3 ^{b}
Metallic	15.4	13.9	13.8	18.8 ^{a}	14.3 ^{b}	16.5 ^{a,b}	18.3	17.2	15.1
Aftertaste	25.5	24.9	25.3	28.9 ^{a}	26.5 ^{a,b}	25.3 ^{b}	26.4	26.7	24.6
Texture									
Crispiness	21.6 ^{a}	32.7 ^{b}	35.4 ^{b,c}	29.8	28.1	38.6	36.8 ^{a}	30.8 ^{a,b}	23.9 ^{b}
Juiciness	49.1	48.5	50.1	49.3 ^{a,b}	43.0 ^{a}	51.4 ^{b}	46.3	48.3	48.8

^{a,b,c} Values within a breed with differing superscript letters are statistically significantly different ($\alpha = 0.05$).

3.3. Overview of Interaction between Physicochemical and Sensory Characteristics

An overview in the form of a principle component analysis of group means is presented in Figure 2. Here, it becomes obvious that breed (associated with age of slaughter, etc.) plays an important role in characterizing quality, but it is also apparent that FB affects meat quality, whether physicochemical or organoleptic. Vicin and convicin content of the faba bean plays a

limited role in WR and BG breeds, where VC+ and VC- groups congregate together. However, the same cannot be said for VH, where VC+ and C group together.

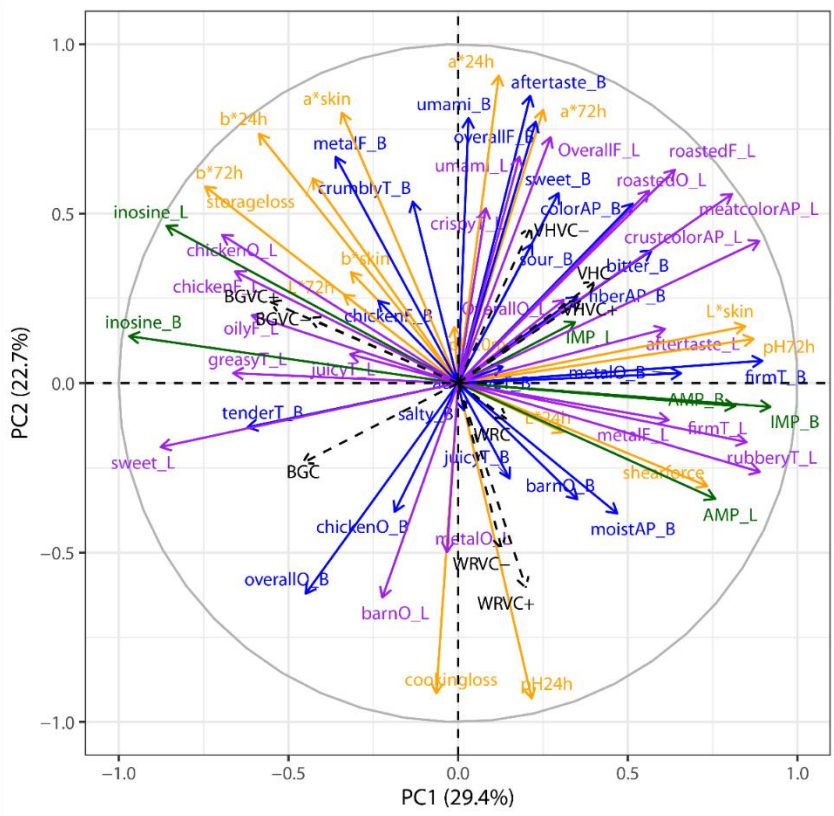

Figure 2. PCA loading plot showing the correlation of all physicochemical meat quality parameters, sensory variables, and nucleotide levels. Per group (breed type × feed type, n = 9) arithmetic means were used and standardized across groups such that correlations instead of co-variance are used for the PCA.

4. Discussion

Our study illustrates that, as within other more specialized poultry production systems (i.e., meat-type and laying), faba beans present themselves as a feasible dietary protein source. Although total product yield is an important factor to consider with different feedstuff groups, it is not the only defining factor in evaluating the acceptability of FB in poultry meat production. Therefore, our study focused on evaluating the effect different FB diets have on physicochemical as well as organoleptic meat quality of three different breeds; few previous studies focus on such aspects.

pH is one of the most important physicochemical characteristics in meat since it is related to water holding capacity and color. Similar values to BG and VH for pH at 24 h p.m. were obtained by Siekmann et al. [26] for a dual-purpose hybrid (Lohmann Dual) and by Muth et al. [27] for BG. Although there are slight differences in pH values between the different breeds (which might be attributed to other factors such as age or genetics), within each breed there has been no effect between feed groups in pH at 20 min and 24 h p.m. This is also reported in [19,28], where researchers do not report any significant differences between soy-based and faba-bean-based diets in chicken breast. Nonetheless, we observe that a high content of VC caused a low pH value at 72 h p.m. in BG.

Faba beans were found to influence meat color in broiler chickens by Laudadio et al. [19] and in guinea fowl broilers by Tufarelli and Laudadio [28]. This is important given that meat color is assumed to be one of the most important characteristics evaluated at the point of purchase [29]. An unfamiliar product color can negatively impact consumer expectations [30]. In our study, FB diets did not affect color uniformly across breeds. In WR, b* values were significantly reduced with FB diets with or without skin and in both 24 and 72 h p.m. chicken breast. No color differences were recorded in other color parameters or in other breeds; therefore, it is likely that the color difference in WR chicken breast skin is due to the refraction of the altered lean meat color (below the partially translucent skin). The lower b* values are contradictory to the findings of Laudadio et al. [19], who fed a wheat-based diet where the control group dietary protein source was soybean meal and the test group dietary protein source was faba beans. WR chicken breast samples are also lighter (L*) in color when birds are fed a VC- diet; however, FB in general did not increase lightness. Laudadio et al. [19] observed darker samples with the feeding of faba beans in broiler chicks, whereas Tufarelli and Laudadio [28] found faba beans to increase lightness in guinea fowl broiler meat. In BG chicken breasts, increased redness values (a*) are observed for both time periods (24 and 72 h p.m.); this corresponds with the findings of [19] in broiler chicken meat. We do not observe an effect of diet on product color in VH samples, illustrating the need to not overgeneralize the effect of feed on meat color across breeds.

We also observe an effect of FB feed on instrumental tenderness and water holding capacity, where WR chicken breast samples raised on FB diets have increased water holding capacity (reduced storage losses) and are more tender (decreased shear force) as measured by a texture analyzer. Laudadio et al. [19] also observed a statistically significant increase in water holding

capacity (as measured by a filter paper–oven drying method) in their faba-bean-fed broiler chicken breast samples; drip loss also tended to be decreased (as measured with the filter paper method). Tufarelli and Laudadio [28] also verified faba beans' effect on water holding capacity in guinea fowl broilers. Unfortunately, to the best of our knowledge, no studies exist investigating instrumental tenderness of poultry meat from chickens fed faba bean diets. However, it would be expected that instrumental tenderness values are reduced (i.e., samples are more tender) with an increased water holding capacity.

AMP, IMP, and inosine all derive from the breakdown of adenosine triphosphate (ATP),n which occurs in muscle during the slaughter and the postmortem aging phases [31]. Among these, IMP plays a predominant role in the formation of meat flavor by contributing to the umami taste [32]. The data obtained in this study confirm that IMP is the most abundant nucleotide, while AMP shows the lowest concentration values [33–35]. Furthermore, across all the three breeds in this study, IMP and inosine contents tend to be higher in chicken breast compared to the legs, as already observed in other studies [33,34,36].

With regard to the effect of the feed for each of the genotypes, from a general point of view it seems that the replacement of soybean meal with FB has no significant effect on the content of the selected nucleotides. In the past, levels of IMP in chicken meat were proved to be related to dietary purine nucleotide, betaine, and soybean isoflavone contents [37]. Although there is a lack of information about the concentration of these compounds in the three experimental diets, we can assume that the replacement of soybean meal with FB did not lead to significant changes in their levels.

To the best of our knowledge, we are the first to investigate the effect of faba bean diets on organoleptic properties of poultry meat. Furthermore, in profiling three different breeds, our results offer three distinct sensory profiles for Bresse Gauloise (BG), Vorwerkhuhn (VH), and White Rock (WR) poultry meat; to the best of our knowledge, these have also not yet been documented. Instead, research has focused on creating sensory profiles of meat from chickens reared in different production systems (e.g., [4,38–40]) or compared to other indigenous breeds (e.g., [41,42]) or to other specific diets (e.g., [38,43]).

As research has shown, depending on several factors like breed [44], feedstuff [38], and age [4,39], chicken breast samples have different attributes in different intensities that best describe their organoleptic properties. However, there are a few general attributes that are present in

chicken meat despite the abovementioned factors, such as chicken and metallic aroma, umami taste, and chicken and metallic flavor. Texture is one of the most important sensory qualities associated with consumers' satisfaction [45], and attributes such as firmness, tenderness, and crumbliness are usually of interest for meat samples. Horsted et al. [39] showed that chicken aroma, chicken flavor, and umami taste in breast samples are positively correlated to the product's overall liking, while a metallic aroma and taste have a negative correlation to the overall liking. A study by Lawlor et al. [38] showed that for one of five groups of consumers, firmness of the initial bite was correlated to product preference, while for a different group an astringent taste and a crumbly texture were positively correlated to overall liking. On the other hand, for roasted chicken samples, Sow and Grognet [46] showed that juiciness, oiliness, sweetness, and hardness are attributes correlated to product preference, while chewiness, astringency, and smoothness were negatively correlated to preference.

In general, the effect of the different feed groups led to slight organoleptic changes in BG breast and leg samples. Breast samples of animals fed with FB showed a slight, not statistically significant, improvement in their sensory profile, i.e., higher score in those attributes (often) positively associated with consumer preference, e.g., more intense chicken aroma and more intense umami taste. Similarly, FB diets improved some attributes in BG leg samples, though not significantly, when compared to control, e.g., decrease in barn and metallic aroma. In general, the sensory profiles for Bresse Gauloise, especially reared with FB diets, showed a slight improvement in organoleptic properties.

The effect of FB diets in Vorwerkhuhn (VH) led to several organoleptic changes in breast and leg samples, particularly in aroma, flavor, and texture. In the overall profile of breast samples, the effect of FB was reflected by the improvement of some attributes, particularly barn aroma and tenderness. The VC- content led to the least intense barn aroma of all samples. A similar effect was observed in tenderness, as the VC- diet showed the highest tenderness in breast samples. Interestingly, for both attributes, the opposite effect was noticed with a VC+ content diet, suggesting that a faba-bean-based diet only improves the aroma and tenderness when the VC content is low. Our results also show that FB diets favored the flavor of leg samples by reducing the metallic taste and the overall aftertaste when compared to a soy-based diet. The effect of a low-VC-content diet improved the texture of leg samples, particularly their juiciness. Therefore, there appears to be no consistent faba bean effect for VH, but VC content remains important in determining organoleptic quality.

The White Rock (WR) sensory profile deviated from BG and VH, which was not surprising given that WR is a laying breed, whereas the other two are traditional dual-purpose breeds. In breast samples, the FB diets mostly had a negative effect on texture attributes, particularly for tenderness, which is an important attribute associated with overall liking of chicken. In leg samples, the FB diets also affected aroma and flavor attributes although not statistically significantly. These changes were also observed in the other two breeds, where barn aroma and metallic aroma and taste decreased with the inclusion of faba beans in the diet. Similar to breast samples, FB diets had a negative effect on texture attributes, namely firmness and particularly crispiness in WR. While Lawlor et al. [38] showed that firmness is a desired attribute in chicken breast meat, the preference for crispiness is unknown. Nonetheless, it could be accepted that (older) WR animals fed with faba beans will not likely produce the most acceptable poultry meat on the market.

Due to the differing slaughter ages, it is difficult to compare the three different breeds since genotype, age, feed, slaughter conditions, and production systems can influence the sensory profile of chicken breast meat. According to [44], genetic variation only accounts for small differences in taste attributes, whereas age has been shown to increase the intensity of aroma and flavor in meat [4,39]. Our results also show a slight increase in overall flavor for breeds reared longer, especially when comparing the overall flavor of the three breeds fed with control (soy-based) feed. Therefore, the numerical difference amongst the breeds of this study should be interpreted with caution.

Finally, it is important to mention that consumers see the concept of dual-purpose breeds as a more animal-friendly practice [1,5,47,48] for which they would be willing to pay a higher price if meat quality is improved while their expectations on animal welfare are met [1,4,5]. Additionally, studies have shown that consumers are willing to pay more for regional products [49,50]. Consequently, consumers should be willing to pay more for this production system of dual-purpose local breeds fed with regional feedstuff, especially when doing so would improve meat quality parameters.

These results are of relevance to the poultry industry, particularly to breeders of particular local breeds used for dual purposes. This production system offers small-scale breeders an opportunity to target niche markets that demand more ethical or sustainable production methods. The improvement of meat quality parameters and the increase in overall flavor of meat from chickens fed with faba beans show a promising future for this production system.

5. Conclusions

Occasionally, differences in meat quality when compared to a status quo soybean meal control group can be attributed to the presence of faba beans or differing vicin and convicin contents in cultivars. However, the effects of diet remain relatively small across all three breeds under investigation, and the presence of faba beans usually improves meat quality parameters. Most interesting is the limited effect that vicin and convicin cultivars have on meat quality, where faba bean diets often present themselves as similar within a breed compared to the soybean meal control. The exception is the VH, where meat quality is slightly negatively impacted by the higher vicin and convicin content but remains on par with the control. Overall, faba beans appear to be an acceptable dietary protein source for rearing local breeds for meat production.

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Appendix

Attribute definitions and scales for breast and leg samples

Table A1. Sensory attributes, definitions, and scales used to evaluate breast samples.

Attribute	Definition [1]	Scale
	Odor	
Overall intensity	The sum of all perceptible odors.	Not perceptible–Very perceptible
Animal/barn	The intensity of smell of animal/stable.	
Metallic	The intensity of smell of metal/blood.	
Cooked chicken	The intensity of smell of cooked, unseasoned chicken or chicken soup.	
	Appearance	
Color intensity	Intensity of the beige color on the cut side.	Light–Dark
Fibrousness	Degree of visible fibers on the cut side of the sample.	Not recognizable–Very recognizable
Moisture release	Amount of moisture that is released after pressing the sample with a fork.	Dry–Moist
	Taste	
Overall intensity	The sum of all perceptible flavors.	Not perceptible–Very perceptible
Sweet	The intensity of sweetness.	
Sour	The intensity of sourness.	
Salty	The intensity of saltiness.	
Bitter	The intensity of bitterness.	
Umami	The intensity of umami taste.	
Cooked chicken	The intensity of the taste of cooked, unseasoned chicken or chicken soup.	
Metallic	The intensity of the taste of metal or blood.	
Aftertaste intensity	The intensity of the aftertaste.	
	Texture	
Firmness	Force required to bite through the piece with the incisors.	Soft–Firm
Juiciness	Amount of fluid released during the first three chews.	Not juicy–Very juicy
Adhesiveness	Cohesion of the sample during chewing.	Not cohesive–Very cohesive
Tenderness	Force required to chew the piece until it can be swallowed.	Not tender–Very tender
Crumbliness	Number of pieces formed before swallowing; how strongly the mass holds togther or decays during chewing.	Not crumbly–Very crumbly

[1] Definitions were suggested and accepted by the panelists.

Table A2. Sensory attributes, definitions, and scales used to evaluate leg samples.

Attribute	Definition [1]	Scale
	Odor	
Overall intensity	The sum of all perceptible odors.	Not perceptible–Very perceptible
Roasted	The intensity of smell of roasted meat.	
Cooked chicken	The intensity of smell of cooked, unseasoned chicken or chicken soup.	
Animal/barn	The intensity of smell of animal/stable.	
Metallic	The intensity of smell of metal/blood.	
	Appearance	
Crust color	The intensity of the brown color of the crust.	Light–Dark
Meat color	The intensity of the brown color of the meat on the cut side of the sample.	Light–Dark
	Taste	
Overall intensity	The sum of all perceptible flavors.	Not perceptible–Very perceptible
Sweet	The intensity of sweetness.	
Umami	The intensity of umami taste.	
Cooked chicken	The intensity of the taste of cooked, unseasoned chicken or chicken soup.	
Roasted	The intensity of the taste of roasted (seasoned) meat.	
Fat/oily	The intensity of the taste of fat/oil.	
Metallic	The intensity of the taste of metal or blood.	
Aftertaste intensity	The intensity of the aftertaste.	
	Texture	
Crispiness	Force (and intensity of noise) required to break the piece with the incisors.	Not crispy–Very crispy
Firmness	Force required to bite through the piece with the incisors.	Soft–Firm
Juiciness	Amount of fluid released during the first three chews.	Not juicy–Very juicy
Rubbery	Force applied while chewing until the piece can be swallowed.	Not rubbery–Very rubbery
Greasy mouthfeel	Intensity of physical greasy sensation in the mouth caused by fat particles in the sample.	Not greasy–Very greasy

[1] Definitions were suggested and accepted by the panelists.

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II.2 Meat quality parameters, sensory properties and consumer acceptance of chicken meat from dual-purpose crossbreeds fed with regional faba beans.

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Abstract

Consumers' concerns regarding the ethical and environmental practices of the current poultry production system have led to the search for an alternative production method. This study evaluated samples of three dual-purpose chicken crossbreeds: Vorwerkhuhn × Bresse Gauloise (VBG), Vorwerkhuhn × White Rock (VWR), and Bresse Gauloise × White Rock (BWR), fed with two variants of faba beans (vicin/convicin-rich and -poor: VC+ and VC−, respectively) and soybeans to examine whether the FB-based diets affected the meat quality of the crossbreeds. pH, color, water holding capacity, tenderness, nucleotide content and proximal composition were analyzed instrumentally, whereas sensory properties were identified by a trained panel and product acceptance was evaluated by frequent chicken consumers. Results showed that from instrumental measurements, the yellowness of the samples was affected by the type of feedstuff, whereas most other parameters were affected by the crossbreed, particularly color and nucleotide content. Sensory attributes, specifically, overall chicken aroma as well as firmness and crumbliness, were affected by an interaction of the feedstuff and crossbreed. Consumer preference did not show significant differences between samples. Overall, a faba-bean-based diet appeared to be a suitable alternative to a soybean-based diet on the crossbreeds VBG, VWR, and BWR when assessing the overall quality and taste of chicken breasts.

Keywords

alternative protein source; Kollbecksmoor; preference; slow-growing; *Vicia faba*

1. Introduction

Poultry meat production and consumption has grown worldwide for several years [1]. Germany has been a part of this trend, i.e., poultry consumption has increased by 4.12 kg per capita in the last ten years [2]. This growth has mainly been attributed to the general perception that this type of meat is healthier than red meat [3,4]. In the past few decades, specialized chicken breeds have been selected to achieve a higher performance at a comparably low cost [5]; therefore, separating production into fattening (meat-type) and laying (egg-type) lines. In the fattening line, both sexes are used for meat production, whereas in the laying line, only hens are used for egg production. Male layers do not produce enough meat (when compared with broilers); thus, they are deemed as "not profitable" and are therefore culled shortly after hatching [6]. In Germany, around 45 million ale chicks from laying breeds are killed due to non-profitability each year [7]. This practice has raised ethical concerns among consumers in European countries, including Germany [8–10]. Stakeholders' attention to this issue has led to the development of alternatives to this practice, including the use of dual-purpose breeds (DPBs). DPBs are breeds where females produce eggs and males produce meat [11,12]. However, DPBs lay fewer eggs and produce less meat than specialized breeds, even if they are kept for a longer period of time. This difference in performance makes it challenging to compete with the specialized breeds because DPBs lead to increased costs related to feed and housing [13] which implies higher product prices. Nonetheless, the general impression that such "non-conventional" production methods produce tastier, healthier, more animal friendly and ethically justifiable alternatives could lead to consumers being willing to pay higher prices for such products [6,9,14]. Additionally, this topic is of particular relevance to the poultry industry, because in Germany, a law to prohibit the killing of day-old chicks took effect from the beginning of 2022 [7].

The selection of specialized chicken breeds has also led to a loss of genetic diversity in poultry breeding. The conservation of traditional breeds contributes to the preservation of genetic resources [15,16]. Nowadays, there are commercial (e.g., Lohmann Dual (Lohmann Breeders GmbH, Cuxhaven, Germany)) and traditional DPBs (e.g., Vorwerkhuhn, Bresse Gauloise) being used in Germany. However, in order to increase traditional DPBs' laying and/or fattening performances, crossbreeding these traditional breeds with high-performing commercial breeds has been practiced to produce a DPB with a higher laying performance [17]. For instance,

crossing the traditional breed Vorwerkhuhn (VH) with White Rock (WR) produces a DPB which has a higher laying performance than VH [18].

With the increased demand for chicken meat, the demand for protein-rich feedstuff is higher than what the European Union can produce; therefore, it needs to be imported from other countries [19,20]. Soybeans are largely used as a protein source in poultry diet formulations [21]. Nonetheless, soybean production is associated with deforestation, particularly in South America where, by 2016, 9% of forest loss was converted to soybean cultivation area [22]. Additionally, the dependency on its import is causing instability to local agriculture due to the price volatility of soybeans on the global market [23]. An alternative to soybeans as a protein source for feedstuff formulation is the use of other protein crops such as peas and beans. These crops are grown locally and therefore provide the agricultural sector with an opportunity to stop depending on soybean imports [23]. Faba beans (Vicia faba L.) are one of the most widely cultivated legumes [24]; their global production grew from 4.59 million tons in 2015 to 5.43 million tons in 2019 [25]. They provide the environmental benefits of improving soil fertility by fixating biological nitrogen which results in increased soil biological activity [23,26]. Faba beans are also highly nutritious due to their rich contents of K, Ca, Mg, and Fe [27,28], lysine [24,27], and protein (~30%) [29]. However, research has shown [21,30] that faba beans (FBs) also contain antinutritional factors, named vicin and convicin (together, VC), which limit their use in poultry diets. Additionally, results in the literature are inconsistent regarding the effect of FBs as a protein source in poultry diets, as it appears to depend on the genotype of the animal and on antinutritional characteristics of FBs [29], whose VC content depends on the specific cultivar [24]. Regarding laying hens, Laudadio et al. [31] and Dänner et al. [32] found that FB did not affect laying performance or egg quality when included in the diet of the hens; however, Koivunen et al. [33] found that FB decreased the egg weight when added to the diets of laying hens. In a more recent study [18], a VC-poor (0.022%) diet decreased the laying performance at the end of the laying period of the breed VH when compared with a soybean-based diet, while a VC-rich (0.138%) diet was intermediate; however, there was no difference in the other two breeds (Bresse Gauloise (BG) and WR) examined. Regarding fattening of the cockerels, Nolte et al. [34] found no significant effect on the animal growth and carcass performance of three different breeds (BG, VH, WR) fed with soybeans, VC-rich (0.14%), and VC-poor (0.02%) diets. An additional experiment by Escobedo del Bosque et al. [35] tested meat quality parameters (physicochemical and sensory) of breast samples from BG, VH, and WR fed with soybean- and FB-based feedstuff. It was found that, on occasion, small differences in meat

quality could be attributed to the inclusion of FBs in the animals' diet depending on the breed being examined. Generally, the presence of FBs improved meat quality.

The goal of this experiment was to examine whether the FB-based diets affect the meat quality of the crossbreeds of BG, VH, and WR. No adverse effects have been found in animal growth, carcass performance, and product quality (physicochemical and sensory analyses) of the pure breeds fed with two variants (VC-poor and VC-rich) of FB; therefore, we expect no adverse effect in the product quality of crossbreeds fed with FB.

2. Materials and Methods

This experiment was conducted in accordance with the European Union directive on the protection of animals used for scientific purposes (Directive 2010/63/EU) and was approved by the Lower Saxony State Office for Consumer Protection and Food Safety (LAVES; ref. 33.9-42502-04-17/2622). Additionally, all human participants (sensory assessors and consumers) gave written informed consent to take part in the study before it started. These studies were conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of Goettingen, Germany.

2.1. Animal Management and Sampling

In this study, the following crossbreeds were researched: VBG (Vorwerkhuhn males × Bresse Gauloise females), VWR (Vorwerkhuhn males × White Rock females), and BWR (Bresse Gauloise males × White Rock females). The chicks were hatched and reared for the first three weeks of life at the Institute of Animal Welfare and Animal Husbandry of the Friedrich-Loeffler-Institut in Celle, Germany, in indoor pens using a commercial starter diet. At 21 days, 120 chicks of each crossbreed were transported to the Department of Animal Sciences at the University of Goettingen (Goettingen, Germany), where 40 chicks of each crossbreed (10 per pen) were randomly assigned to one of three feed groups, generating a total of 9 different experimental groups (3 crossbreeds × 3 feed groups) with four replicates each. The animals were reared in an indoor-floor system, where each pen measure 2 × 1.5 m. and was covered with wood shavings. The temperature was lowered from 22 °C to 20 °C and the photoperiod was 16 h.

All crossbreeds were subject to three different diets (Table 1) starting at day 21. The control diet (C) was based on soybean meal, whereas the other two diets were based on faba beans with different VC contents: one diet provided a high (0.136%) VC content (VC+), whereas the other

consisted of a low (0.016%) VC content (VC−). Table 1 shows the ingredient composition of each diet. Feed and water were given ad libitum.

The animals were reared for 13, 14, and 15 weeks for VBG, BWR, and VWR, respectively, in order to reach a target live weight of approximately 2100 g. Details regarding the slaughter of the birds, as well as results related to growth and carcass performance, are reported in [34].

Half of the animals in each group (3 crossbreds × 3 feeds) were used for sensory analysis, and the other half were used to analyze physicochemical meat quality traits.

Table 1. Ingredient composition of each experimental diet.

	Control	**Vicin+**	**Vicin-**
Ingredients (%)			
Wheat	30.0	8.0	8.0
Corn	36.0	25.2	25.2
Soybean meal	24.4	-	-
Blue sweet lupines, cv. Boruta	-	28.6	28.6
Peas, cv. Astronaute	-	10.5	10.5
Faba beans, cv. Fuego	-	20.2	-
Faba beans, cv. Tiffany	-	-	20.2
Grass meal	5.6	0.1	0.1
Soybean oil	0.2	2.7	2.7
Dicalcium phosphate	1.3	2.2	2.2
Calcium carbonate	1.0	0.7	0.7
Salt (NaCl)	0.3	0.4	0.4
DL-Methionine	0.2	0.4	0.4
Vilomix Broiler premix 77047[1]	1.0	1.0	1.0
Chemical analyses			
Dry matter (%)	89.7	90.1	90.2
Ash (g/kg DM)	67.3	64.3	67.0
Crude protein (g/kg DM)	213.0	213.1	214.3
Crude fat (g/kg DM)	33.5	67.0	67.3
Crude fiber (g/kg DM)	45.2	72.0	74.0
Methionine (%)	0.46	0.50	0.49
Cysteine (%)	0.29	0.29	0.30
Lysine (%)	0.90	1.08	1.09

[1] Vitamin–mineral premix provided per kg of diet: Fe, 32 mg; Cu, 12 mg; Zn, 80 mg; Mn, 100 mg; Se, 0.4 mg; I, 1.6 mg; Co, 0.64 mg; retinol, 3.6 mg; cholecalciferol, 0.088 mg; tocopherol, 40 mg; menadione, 4.5 mg; thiamine, 2.5 mg; riboflavin, 8 mg; pyridoxine, 6 mg; cobalamin, 32 µg; nicotinic acid, 45 mg; pantothenic acid, 15 mg; folic acid, 1.2 mg; biotin, 50 µg; choline chloride, 550 mg. Source: Adapted from [34].

Ten samples of each group were used to conduct the following analyses: pH, color, storage loss, cooking loss, instrumental tenderness (shear force), content of flavor-related nucleotides (i.e., inosine-5′-monophosphate (IMP), adenosine-5’-monophosphate (AMP) and inosine), and meat composition parameters (i.e., protein, intramuscular fat and water content). Figure 1 presents a scheme of the sample analyses. All experiments, except for proximate composition and consumer evaluation, were realized at the University of Goettingen.

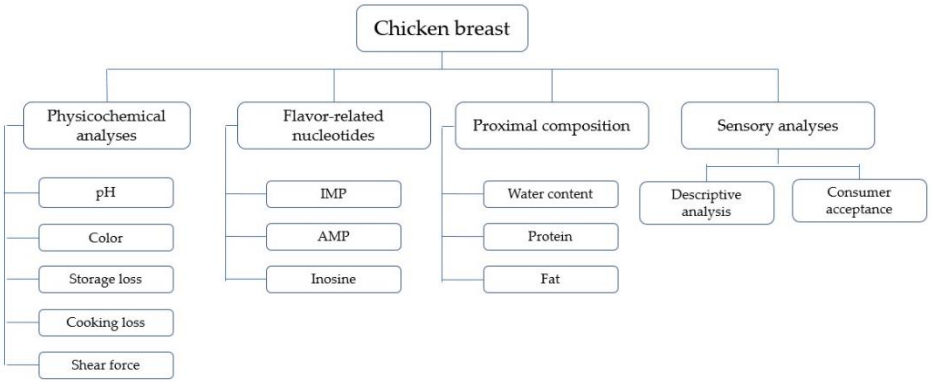

Figure 1. Scheme of the sample analyses.

2.2. Physicochemical Analysis

All breast samples were stored between 24 and 72 h postmortem (p.m.) in modified atmosphere (80% O2/20% CO2) packaging using a polypropylene (PP) tray with absorbent liners and heat-sealed with an oriented OPET/PP film (< 3 cm3/m2/24 h bar O2 transmission rate; < 12 cm3/m2/24 h bar CO2 transmission rate) using a vacuum packaging machine (TS 100, KOMET Maschinenfabrik GmbH, Plochingen, Germany) and stored at 4 °C without illumination.

The pH values were measured by inserting a pH electrode and a thermometer (Portamess 911, Knick Elektronische Messgeräte GmbH & Co. KG, Berlin, Germany) into the breast at 20 min p.m., 24 h p.m., and 72 h p.m. [36–38]. The instrument was calibrated with standard buffers for pH 4 and pH 7 (Carl Roth GmbH + Co. KG, Karlsruhe, Germany) at room temperature every time a new crossbreed was analyzed. The color of the samples was measured using CIELAB (L*a*b*; lightness, redness, and yellowness, respectively) coordinates by using a colorimeter (CR-600d, Konica Minolta, Tokyo, Japan), which was calibrated before each session with a white tile from the manufacturer, over non-overlapping areas [36–38]. The aperture size was 8 mm, and the illuminant D65 and standard observer angle was 10°. Color was recorded at 24 (breast with and without skin) and 72 h p.m. (breast without skin). Next, water holding capacity was measured as storage and cooking loss. Storage loss was measured by weighing the breast at 24 h p.m. and then at 72 h p.m., the percentage difference in weight was considered storage loss. Next, these samples were stored at −20 °C for 8 weeks p.m. until further analyses were conducted. Similar storage conditions have been previously tested in turkey and chicken breast meat [39,40] and no significant differences were found between fresh and frozen/thawed

samples when testing cooking loss and shear force. Before further testing, for cooking loss and shear force analyses, samples were thawed overnight at 4 °C and re-packaged for immersion in a hot water (80 °C) bath (1092, GFL Gesellschaft für Labortechnik mbH, Burgwedel, Germany) for 50 min until reaching a core temperature of 76 °C. This temperature was measured by inserting a thermometer (926, Testo SE & Co. KGaA, Lenzkirch, Germany) into the sample. Once the samples reached room temperature, they were weighed; cooking loss was measured by weighting the samples prior to cooking and after cooking, and the percentage difference in weight was the cooking loss. After weighting, aluminum foil was used to wrap and store the samples overnight at 4 °C. The following day, once samples reached room temperature, shear force was measured according to Xiong et al. [41] with the following modifications: a TA.XTplus Texture Analyzer (Stable Micro Systems, Surrey, UK) equipped with a 5 kg load cell and a Meullenet-Owens Razor Shear Blade (MORS-Blade) [36,37]. The conditions for the test were: pretest speed 2 mm/s, test speed 10 mm/s, trigger type 10 g. Each sample was sheared four times perpendicular to the muscle fiber orientation, with a 1.5 cm distance from each cut. Shear force is reported as the peak shear force (N) needed to completely shear through the sample.

2.3. Flavor-Related Nucleotides

Samples of raw meat were collected at 24 h p.m., frozen with liquid nitrogen, and stored at −72 °C to later measure flavor-related nucleotide content. IMP, AMP, and inosine contents were determined six months p.m. by adapting Morzel and Van De Vis' method [42]. Two hundred milligrams of minced samples were homogenized (Schuetthomgenplus homogenizer, Schuett-biotec GmbH, Goettingen, Germany) with 1 mL of 5% (w/v) trichloroacetic acid (TCA) (aq) (Carl Roth GmbH + Co. KG, Karlsruhe, Germany) for 1 min at 1600 rpm (Pico & Fresco 17/21 centrifuge, ThermoElectron LED GmbH, Osterode, Germany) and then chilled on ice for 15 min. The liquid extract was centrifuged at 4 °C for 5 min at 12,000× g. The supernatant (200 µL) was diluted 1:4 (v/v) with 5 % (w/v) TCA (aq) at pH 7.0. Extracts were kept at −20 °C before being injected into the high-performance liquid chromatography (HPLC) system (VWR Hitachi Chromaster, VWR International GmbH, Hannover, Germany), which was equipped with a 5260 pump, a 5260 autosampler (injection volume: 10 µL), and a 5410 UV detector operating at 260 nm. A LiChroCART Lichrosphere 100 RP-8 (250 × 4.6 mm, 5 µm) (Merck KGaA, Darmstadt, Germany) column was maintained at 30 °C in a 5310 column oven. The mobile phase consisted of 100 mM KH2PO4 (aq) (Carl Roth GmbH + Co. KG, Karlsruhe, Germany), 1.44 mM TBAHS (aq) (Sigma-Aldrich, Merck KGaA, Darmstadt, Germany), and

0.5% methanol (aq, pH 7.0) (VWR International GmbH, Hannover, Germany). The quantification was performed by an external calibration method and the identification of the analytes was performed by a comparison of retention times from the reference standards (Sigma-Aldrich, Merck KGaA, Darmstadt, Germany). All analyses were performed in duplicate.

2.4. Proximate Composition

To measure the contents of protein, intramuscular fat and water, 10 samples of breast meat from each group were removed at 72 h p.m., then homogenized 6 times at 1000 rpm for 30 sec in a grinder (Grindomix GM 200, Retsch GmbH, Haan, Germany), then vacuum packed in high-density polyethylene (HDPE) and stored at −20 °C. Nine months after slaughter, samples were thawed for 24 h and placed in a Petri dish where the concentrations of these parameters were obtained by near-infrared transmission spectroscopy using a Foss FoodScan™ (FOSS A/S, Hillerød, Denmark), following Anderson's method [43].

2.5. Sensory Evaluation

All samples used for sensory analyses were stored at 24 h p.m. in MAP packaging, in the storage conditions stated in Section 2.2. Next, at 72 h p.m., they were vacuum-packed in polyamide/polyethylene bags and frozen at −20 °C until needed. Samples were then thawed overnight at 4 °C before use. Samples were cooked following the method to measure cooking loss (Section 2.2), then cut in 1 cm2 pieces and served on warm plates marked with a three-digit code.

The sensory laboratory at the University of Goettingen (compliant with ISO 8589) was used to carry out all panel sessions. A trained panel of 9 assessors (7 female and 2 male) who had experience in creating a sensory profile of meat were trained and selected following international standard ISO8586. Before starting training and evaluation, all panelists signed a written consent form to participate.

Nine different products (three crossbreeds in three of each feed groups) were evaluated. All attributes that described the samples best were defined by the assessors, creating a list with 16 attributes on which they were further trained. Table A1 (Appendix A) presents a list with the attributes, definitions, and scales used to assess these samples. Product evaluation took place in five sessions, as each sample was evaluated three different times. In each session, panelists evaluated six samples in a sequential monadic manner. Four groups with a random order of

samples were created, and each group was then assigned to two or three assessors. Between each sample, panelists used drinking water, unsalted crackers and cucumber for palate neutralization. A scale of 0 (no perception) to 100 (strong perception) was used to evaluate the samples. The data were collected using EyeQuestion (Version 4.8.7, EyeQuestion, Elst, The Netherlands).

2.6. Consumer Study

Consumers' overall liking of samples was estimated using a nine-point hedonic scale [44] from "I do not like it at all" (1) to "I like it very much" (9). Then, consumers were presented a list of attributes (Table S1, Supplementary Material) from which they had to check all that apply (CATA) to describe the sample. The same procedure was repeated for consecutive samples. Between each sample, consumers neutralized their senses by drinking water; additionally, unsalted crackers were available for neutralization.

All consumer testing took place in a commercial sensory laboratory at ISI GmbH (Rosdorf, Germany). All samples used for the hedonic testing were cooked and served the same way as for the descriptive analysis (see Section 2.5). At the beginning of the test, consumers were informed that they would taste six chicken breast samples without any condiments. The reason for using no condiments was to avoid masking the mere flavor of meat, which was one of the points of interest in this study.

Due to a limited amount of material (meat) available, and in order to achieve a higher number of consumer responses, a balanced incomplete block design (BIBD) was generated where each consumer tasted six out of nine samples. The order of samples within each session was randomized to avoid first-order effect. The design divided samples into 3 groups (A, B, and C), where each group consisted of 6 samples (2 crossbreeds × 3 feed groups). Each crossbreed was evaluated with its 3 feed groups in order to avoid losing the interaction of crossbreed and feed. Table 2 outlines the design used for hedonic testing in more detail. Each session consisted of nine to twelve participants, who provided written informed consent prior to participation. Upon registration for the study, consumers were screened for their meat consumption, and only those that consumed chicken meat at least every two weeks were invited to participate in the test.

A total of 95 consumers (43 female and 52 male, aged 18 to 64 years) participated in the evaluation. Samples in group A were evaluated by 30 participants, samples in group B by 31 participants, and samples in group C by 34 participants. Therefore, each group was evaluated

by at least 60 participants, which was the minimum number of participants required for consumer testing according to norm DIN 10974.

Table 2. Balanced incomplete block design for breast samples tested with consumers (Product 1: VBG × C, Product 2: VBG × VC+, Product 3: VBG × VC−, Product 4: VWR × C, Product 5: VWR × VC+, Product 6: VWR × VC−, Product 7: BWR × C, Product 8: BWR × VC+, Product 9: BWR × VC−).

Group *	Session	Products		
A	1	1	2	3
		4	5	6
B	2	4	5	6
		7	8	9
C	3	1	2	3
		7	8	9
C	4	1	2	3
		7	8	9
A	5	1	2	3
		4	5	6
B	6	4	5	6
		7	8	9
B	7	4	5	6
		7	8	9
C	8	1	2	3
		7	8	9
A	9	1	2	3
		4	5	6

* Group A: Products 1–6, Group B: Products 4–9, Group C: Products 1–3 and 7–9. The order of samples within each session was randomized.

2.7. Statistical Analysis

Physicochemical parameters were analyzed using SPSS (IBM Corporation, New York, NY, USA) statistical software. Mean values were calculated, and significance effects were compared among all crossbreeds with a one-way ANOVA using Tukey's multiple comparison statistical test at a 95% confidence level ($\alpha = 0.05$). Sensory data was analyzed with the linear mixed model (LMM) procedure from SPSS. In the model, "product" was defined as a fixed effect, and "assessor", "replicate", and "replicate×assessor" were set as random effects. Within the model a Bonferroni statistical test at a 95% confidence level ($\alpha = 0.05$) was used. Consumer overall liking (OL) was also analyzed using the LMM procedure; however, in the model, "crossbreed", "feedstuff", and "crossbreed×feedstuff" were defined as fixed effects, whereas "assessor" was set as a random effect. Within the model, a Bonferroni statistical test at a 95% confidence level ($\alpha = 0.05$) was used. Due to the nature of the design (i.e., BIBD), CATA data had missing values for each sample (2.56% of total data), and were therefore imputed by calculating the median value using the multiple imputation procedure in SPSS. The data were then analyzed in

XLSTAT-Sensory (Addinsoft, Paris, France), where Cochran's Q-test with Sheskin means comparison tests was used to identify differences between the samples. Additionally, a partial least squares regression (PLSR) analysis was performed with standardized (1/SD) sensory data (x variables) and consumer data (y variables) using The Unscrambler X (Camo Analytics, Oslo, Norway) to identify relevant sensory attributes that drive the overall liking of consumers.

3. Results

The following section presents the results of physicochemical analyses, flavor-related nucleotides, proximate composition as well as sensory results of descriptive and affective testing.

3.1. Physicochemical Results

Table 3 shows the results for each physicochemical parameter for each group in detail. Few differences were found between the pH of the samples. pH at 24 h p.m. was mostly affected by the interaction between the feedstuff and the crossbreed, whereas the differences in pH of samples at 20 min p.m. and 72 h p.m. were attributed to a crossbreed effect. pH 20 min p.m. was lower in VBG than in VWR and BWR, whereas pH 72 h p.m. was lower in VBG than VWR. Color showed the most notable distinction between all samples, where the intensity of the yellowness (b*) of samples without skin measured at 72 h p.m. varied mainly due to an interaction effect of the crossbreed and feedstuff. Additionally, both measurements at 24 h p.m. (with and without skin) showed a difference in yellowness based on the feedstuff, where C is yellower than VC−. In contrast, most variations of all other color measurements between samples were due to a crossbreed effect; for instance, the a* and b* of BWR samples with skin differed from those of VBG and VWR with skin. As for the water holding capacity, there were no differences found between samples when measuring storage or cooking loss. Similarly, when measuring shear force, there were no significant differences found between samples.

3.2. Flavor-Related Nucleotides and Proximate Composition

Table 4 shows the results for nucleotide content and proximate composition for each sample in detail. The analysis and quantification of flavor-associated nucleotides showed a higher content of IMP, followed by inosine and AMP. Results showed a significant crossbreed effect in the content of these nucleotides, particularly in inosine content where VBG significantly differed from VWR and BWR, and in AMP content, where it was significantly lower in BWR than VBG and VWR. Table A2 (Appendix B) shows the methodological results of the nucleotide

quantification. Regarding meat composition parameters, the water content did not differ between the samples. Protein content was affected by a crossbreed effect and a higher protein content was observed in BWR when compared with VBG. A difference in fat content was found between VC+ and VC− samples of VBG crossbreeds, and also between VC+ samples of VBG and VWR crossbreeds.

3.3. Sensory Results

Table 5 presents the results of the sensory evaluation (descriptive analysis) in detail. In breast samples, the fibrous appearance was affected by a crossbreed effect, whereas aroma was mostly affected by the crossbreed and feedstuff interaction. The attributes of overall aroma and chicken aroma presented significant differences between VBG and VWR. However, these differences were found between different feed groups: in VBG, C had a lower overall aroma than VC− and VC+. Similarly, chicken aroma in VBG × VC+ were different than other VBG and VWR samples. Regarding the flavor of the samples, differences were found in sourness due to a feedstuff effect, whereas the overall flavor intensity was affected by the interaction between crossbreed and feedstuff. Significant differences were found in the firmness of samples, where for the BWR crossbreed, C was firmer than the VC+ and VC− variants, as well as VBG×C, VBG×VC+ and VWR×VC− samples. These differences show an effect of the interaction between crossbreed and feedstuff. Similarly, crumbliness showed significant differences between crossbreeds and feedstuff, specifically VWR×C was significantly less crumbly than VWR×VC+ and BWR×C.

Participants appeared to prefer samples with C or VC+ feedstuff, because these obtained the highest percentages of mentions in “I like it very much” (highest score). In contrast, the most disliked samples were those with a VC+ diet and BWR breed. As observed in Table 6, the highest number of participants for each sample rated the meat between points 6 and 7, on the 9-point scale. Although there seemed to be a preference for VWR and BWR × C, when assessing the means for overall consumer liking, there were no significant differences between samples. However, a slight feedstuff effect ($\alpha < 0.1$) was present.

Table 3. Means, standard deviations and crossbreed, feedstuff and interaction effect for physicochemical parameters of each sample.

Parameter	Means and Standard Deviations									Effect					
	VBG			VWR			BWR			Crossbreed		Feedstuff		Crossbreed × Feedstuff	
	C	VC+	VC−	C	VC+	VC−	C	VC+	VC−	F	*p*	F	*p*	F	*p*
pH															
pH $_{20}$	6.1 ± 0.20	6 ± 0.18	6 ± 0.19	6.2 ± 0.18	6.2 ± 0.19	6.1 ± 0.18	6.1 [1] ± 0.27	6.1 ± 0.14	6.3 ± 0.19	5.51	**	0.22	n.s.	1.91	n.s.
pH $_{24}$	5.5 ± 0.08	5.6 ± 0.07	5.7 ± 0.10	5.6 ± 0.09	5.7 ± 0.25	5.6 ± 0.07	5.6 ± 0.13	5.6 ± 0.14	5.6 ± 0.11	0.03	n.s.	1.72	n.s.	2.74	*
pH $_{72}$	5.5 ± 0.09	5.6 ± 0.07	5.6 ± 0.10	5.6 ± 0.09	5.8 ± 0.25	5.6 ± 0.05	5.6 ± 0.08	5.6 ± 0.09	5.6 ± 0.12	3.99	*	3.08	#	1.85	n.s.
Color with skin															
L* $_{24}$	65.8 ± 3.71	63 ± 4.35	60.5 ± 5.49	64.9 ± 3.79	62.6 ± 4.49	64.4 ± 4.14	62.7 ± 5.85	61.4 ± 4.25	60.9 ± 2.55	2.16	n.s.	2.77	#	0.96	n.s.
a* $_{24}$	2.5 ± 0.52	1.9 ± 1.11	2 ± 1.09	1.3 ± 0.90	2 ± 1.14	1.9 ± 0.99	0.7 ± 0.61	1.1 ± 0.90	0.6 ± 0.73	16.46	***	0.28	n.s.	1.54	n.s.
b* $_{24}$	16.7 ± 2.73	15.1 ± 3.13	13.8 ± 2.07	13.9 ± 1.97	14.4 ± 3.31	14 ± 1.99	13.7 ± 3.18	12.4 ± 2.61	10.9 ± 3.05	8.48	***	3.53	*	0.966	n.s.
Color without skin															
L* $_{24}$	64.2 ± 4.72	61.3 ± 3.96	61.0 ± 4.81	59.4 ± 3.19	59.8 ± 4.93	61.3 ± 3.71	59.7 ± 4.43	58.7 ± 3.08	58.9 ± 3.47	4.40	*	0.61	n.s.	1.00	n.s.
a* $_{24}$	−0.1 ± 0.40	−0.1 ± 0.65	−0.1 ± 0.66	0.8 ± 0.82	0.5 ± 0.73	0.3 ± 0.51	−0.2 ± 0.49	−0.3 ± 0.35	0.1 ± 0.53	14.92	***	0.42	n.s.	1.47	n.s.
b* $_{24}$	9.5 ± 1.43	10 ± 1.54	7.8 ± 2.65	11.4 ± 1.92	10 ± 1.18	9.5 ± 1.35	10.3 ± 1.62	9.8 ± 1.48	10.2 ± 1.93	4.09	*	3.69	*	2.00	n.s.
L* $_{72}$	64.7 ± 3.64	62.4 ± 2.94	61.8 ± 4.03	59.6 ± 2.19	59 ± 3.99	60 ± 2.76	59.2 ± 3.72	57.5 ± 2.53	58.7 ± 2.75	15.59	***	1.93	n.s.	0.70	n.s.
a* $_{72}$	0.6 ± 0.54	0.7 ± 0.55	0.9 ± 0.79	1.2 ± 0.64	1.2 ± 0.63	0.9 ± 0.36	1.0 ± 0.65	1.1 ± 0.50	1.3 ± 0.44	3.80	n.s.	0.08	n.s.	0.85	n.s.
b* $_{72}$	9.4 ± 1.88	10 ± 1.31	8.2 ± 1.85	9.6 ± 1.34	8.6 ± 1.60	8.7 ± 1.00	8.1 ± 1.82	8.4 ± 1.27	9.6 ± 1.69	0.79	n.s.	0.12	n.s.	3.78	**
Water holding capacity															
Storage loss (%)	2.2 [1] ± 0.55	2 [1] ± 0.24	1.8 [1] ± 0.13	2.1 ± 0.25	4.8 [1] ± 5.86	1.9 ± 0.32	1.8 [1] ± 0.13	1.7 ± 0.28	1.8 ± 0.38	2.92	#	2.14	n.s.	2.30	#
Cooking loss (%)	22.3 ± 1.54	21.5 ± 1.01	22 ± 1.76	19.6 ± 7.41	20.3 ± 1.55	21.3 ± 1.18	20.8 ± 1.79	20.9 ± 1.14	21.4 ± 0.94	2.28	n.s.	0.54	n.s.	0.37	n.s.
Instrumental tenderness															
Shear force (N)	4.8 ± 1.12	4.8 ± 0.74	4.7 ± 1.05	5.3 ± 0.83	5.1 ± 0.84	4.7 ± 0.81	4.3 ± 1.30	4.6 ± 1.22	4.5 ± 0.71	2.32	n.s.	0.44	n.s.	0.46	n.s.

VBG = Vorwerkhuhn × Bresse Gauloise, VWR = Vorwerkhuhn × White Rock, BWR = Bresse Gauloise × White Rock, C = control, VC+ = high in vicin, VC−= low in vicin. [1] n = 9 due to missing measurements at time of observation. *, **, ***: $p < 0.05$, 0.01, 0.001, respectively; #: $p < 0.10$; n.s.: not significant

Table 4. Means, standard deviations and crossbreed, feedstuff and interaction effect for flavor-related nucleotides and proximal composition of samples.

Parameters	**Means and Standard Deviations**									**Effect**					
	VBG			**VWR**			**BWR**			**Crossbreed**		**Feedstuff**		**Crossbreed × Feedstuff**	
	C	**VC+**	**VC−**	**C**	**VC+**	**VC−**	**C**	**VC+**	**VC−**	**F**	***p***	**F**	***p***	**F**	***p***
Nucleotides (mg/100g)															
IMP	303 ± 31	264 ± 40	279 ± 42	320 ± 18	272 ± 42	295 ± 26	249 ± 34	273 ± 51	259 ± 36	3.60	*	1.20	n.s.	1.40	n.s.
AMP	9 ± 3	10 ± 4	12 ± 5	10 ± 2	9 ± 3	9 ± 2	7 ± 2	6 ± 1	6 ± 1	6.79	**	0.22	n.s.	1.00	n.s.
Inosine	29 ± 8	20 ± 2	24 ± 8	16 ± 4	15 ± 4	19 ± 5	17 ± 3	17 ± 2	20 ± 5	9.61	***	2.10	n.s.	1.81	n.s.
Chemical composition (%)															
Protein	23.8 [1] ± 1.2	23.6 ± 1.31	23.4 ± 1.41	24.9 ± 0.36	24.7 ± 0.77	24.7 ± 0.65	25.2 ± 0.43	25.2 ± 0.38	25.2 ± 0.33	27.40	***	0.47	n.s.	0.17	n.s.
Fat	0.9 [1, abc] ±1.33	1.1 [a] ± 1.49	0.7 [bc] ± 1.6	1.1 [ac] ± 0.33	0.7[b] ± 0.81	0.8[abc] ± 0.66	1 [abc] ± 0.39	1 [abc] ± 0.34	1 [abc] ± 0.28	2.05	n.s.	2.60	#	4.79	**
Water	72.8 [1] ± 1.48	72.8 ± 1.67	72.7 ± 1.78	72.8 ± 0.38	72.5 ± 0.92	72.6 ± 0.76	73.1 ± 0.46	73 ± 0.39	72.7 ± 0.32	2.21	n.s.	1.02	n.s.	0.30	n.s.

VBG = Vorwerkhuhn × Bresse Gauloise, VWR = Vorwerkhuhn × White Rock, BWR= Bresse Gauloise × White Rock, C = control, VC+ = vicin-rich, VC− = vicin-poor. [1] $n = 9$ due to missing measurements at time of observation. [a, b, c] Values with differing superscript letters are statistically significantly different ($p < 0.05$). *, **, ***: $p < 0.05$, 0.01, 0.001, respectively; #: $p < 0.10$; n.s.: not significant

Table 5. Means, standard deviations and crossbreed, feedstuff and interaction effect for sensory attributes.

Attributes	Means and Standard Deviations									Effect					
	VBG			VWR			BWR			Crossbreed		Feedstuff		Crossbreed × Feedstuff	
	C	VC+	VC−	C	VC+	VC−	C	VC+	VC−	F	*p*	F	*p*	F	*p*
Appearance															
Fibrousness	34.6	34.8	38.0	28.0	28.2	29.8	37.7	35.7	33.7	45.39	*	3.72	n.s.	0.05	n.s.
Aroma															
Barn	52.0	60.5	54.3	51.7	54.7	52.5	56.1	54.4	54.5	1.19	n.s.	1.90	n.s.	1.37	n.s.
Metallic	30.7	30.3	29.2	28.3	28.1	28.2	25.0	29.3	24.6	2.40	#	0.61	n.s.	0.51	n.s.
Chicken	21.5^{ab}	14.9^{b}	27.1^{a}	26.9^{a}	21.7^{ab}	19.0^{ab}	20.8^{ab}	22.2^{ab}	22.8^{ab}	0.19	n.s.	1.65	n.s.	3.01	*
Overall	52.2^{a}	55.0^{ab}	56.7^{b}	56.3^{ab}	56.8^{b}	53.0^{ab}	55.1^{ab}	55.5^{ab}	55.4^{ab}	0.30	n.s.	0.67	n.s.	2.46	*
Taste															
Sour	51.5	57.7	50.2	50.7	54.8	52.2	50.8	50.7	48.0	2.00	n.s.	3.21	*	0.82	n.s.
Chicken	34.4	33.3	35.0	40.1	30.3	31.4	36.6	34.2	31.6	0.011	n.s.	2.51	#	1.09	n.s.
Metallic	47.1	53.8	46.4	41.4	48.8	50.2	47.4	47.4	44.8	0.90	n.s.	2.55	#	1.85	n.s.
Umami	23.0	19.5	23.6	27.0	22.1	21.4	23.6	22.9	22.0	0.34	n.s.	1.53	n.s.	0.78	n.s.
Overall	42.9	38.4	45.6	46.0	44.3	40.0	39.0	42.9	42.3	0.55	n.s.	0.10	n.s.	2.69	*
Aftertaste	33.0	31.6	34.1	34.7	33.7	32.6	31.3	32.8	32.7	1.12	n.s.	0.12	n.s.	1.24	n.s.
Texture															
Firmness	43.7^{a}	49.7^{bc}	49.0^{abc}	47.1^{abc}	50.0^{bc}	45.5^{ab}	51.1^{c}	45.5^{ab}	45.5^{ab}	0.00	n.s.	0.58	n.s.	3.61	**
Juiciness	34.8	35.5	33.6	36.6	31.5	33.9	36.6	33.8	36.1	0.51	n.s.	1.23	n.s.	0.74	n.s.
Cohesiveness	49.1	50.3	47.5	45.2	48.8	50.5	49.6	52.0	47.7	0.64	n.s.	1.63	n.s.	1.67	n.s.
Tenderness	54.2	51.3	49.6	51.4	51.0	54.1	51.5	53.1	55.1	0.47	n.s.	0.253	n.s.	1.39	n.s.
Crumbliness	48.9^{ab}	49.3^{ab}	50.6^{ab}	45.9^{a}	52.6^{b}	51.3^{ab}	52.5^{b}	49.4^{ab}	48.5^{ab}	0.07	n.s.	0.47	n.s.	2.80	*

VBG = Vorwerkhuhn × Bresse Gauloise, VWR= Vorwerkhuhn × White Rock, BWR = Bresse Gauloise x White Rock, C = control, VC+ = vicin-rich, VC− = vicin-poor. Mixed model: fixed effect: crossbreed, feedstuff, crossbreed*feedstuff, random effects: assessor, replicate, replicate*assessor. $^{a, b, c}$ Values with differing superscript letters are statistically significantly different ($\rho < 0.05$). *, ** : $\rho < 0.05$, 0.01, respectively; #: $\rho < 0.10$; n.s.: not significant.

Table 6. Consumers' acceptance of chicken meat.

Breed	**VBG (*n* = 64)**			**VWR (*n* = 61)**			**BWR (*n* = 65)**			**Effect**		
Diet	**C**	**VC+**	**VC−**	**C**	**VC+**	**VC−**	**C**	**VC+**	**VC−**	**C**	**F**	**C × F**
Hedonic scale (% of participants)												
I like it very much (9)	6.3	9.4	9.4	11.5	8.2	4.9	7.7	6.2	6.2			
(8)	12.5	14.1	18.8	18	18	16.4	21.5	13.8	10.8			
(7)	25	26.6	12.5	24.6	16.4	18	20	27.7	26.2			
(6)	26.6	14.1	25	18	21.3	21.3	20	15.4	16.9			
Neither like nor dislike (5)	4.7	10.9	6.3	8.2	6.6	6.6	12.3	7.7	6.2			
(4)	12.5	10.9	15.6	13.1	19.7	19.7	10.8	9.2	15.4			
(3)	3.1	10.9	6.3	6.6	4.9	8.2	4.6	6.2	10.8			
(2)	4.7	0	4.7	0	3.3	4.9	1.5	7.7	6.2			
I dislike it very much (1)	4.7	3.1	1.6	0	1.6	0	1.5	6.2	1.5			
Top 3 boxes (T3B)	43.8	50.0	40.6	54.1	42.6	39.3	49.2	47.7	43.1			
Bottom 3 boxes (B3B)	12.5	14.1	12.5	6.6	9.8	13.1	7.7	20.0	18.5			
Overall liking	5.9 ± 2.02	6.0 ± 2.01	6.0 ± 2.04	6.4 ± 1.75	6.0 ± 1.97	5.8 ± 1.91	6.2 ± 1.82	5.7 ± 2.26	5.6 ± 2.05	n.s.	#	n.s.

VBG = Vorwerkhuhn x Bresse Gauloise, VWR = Vorwerkhuhn × White Rock, BWR = Bresse Gauloise × White Rock, C = control, VC+ = vicin-rich, VC− = vicin-poor. Top 3 boxes: sum of the highest 3 responses in the scale; Bottom 3 boxes: sum of the lowest responses in the scale. #: $p < 0.10$; n.s.: not significant.

The results of Cochran's Q test for each CATA attribute are presented in Table S1 in the supplementary material. Cochran's Q test showed that the calculated ρ-value was lower than the significance level ($\alpha = 0.05$) in the firmness of samples VBG × C and VWR × VC+, where the latter had a firmer texture. This difference was also noticed by the sensory panel. However, it did not seem to have an effect in the overall liking (OL) of the samples, as these do not statistically differ.

The relationship between consumer preference and sensory characteristics was evaluated using a partial least squares (PLS) regression. The aim of the PLSR was to identify the most relevant chicken sensory attributes that influence the overall liking of the product. The results of the regression model are presented in Figure 2.

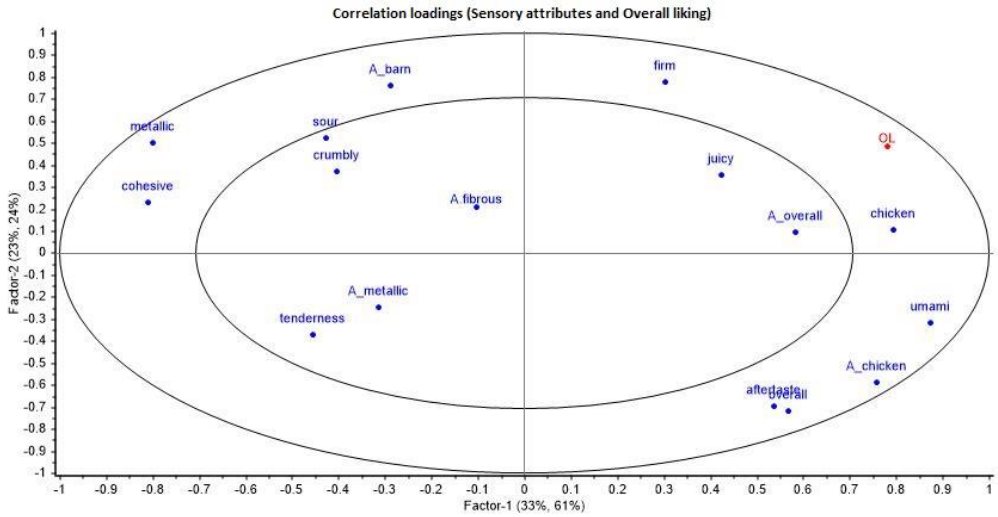

Figure 2. Correlation loadings for panel and consumer data.

The correlation coefficient (r = 0.609) was investigated to see how well the model fitted the data. The model explained 56% of the sensory data (x) and 85% of the consumer overall liking (y). These results showed that chicken flavor, umami flavor, firmness, juiciness, chicken aroma, and overall aroma were positively associated with the OL of the samples. On the other hand, cohesiveness, tenderness, metallic flavor and aroma were negatively associated with the OL of the evaluated samples.

4. Discussion

As shown in [34], the breast yields of these crossbreeds are very similar, and no significant difference was found when comparing the different diets. Although yield performance is an important factor to consider when assessing the acceptability of a breed or feedstuff, there are also other defining parameters to consider. Hence, this study showed that using faba beans as a protein source is an acceptable alternative to soybeans, based on evaluating the physicochemical and organoleptic parameters of these samples.

Regarding the values of pH at 24 h p.m., no significant differences between the samples were observed. The values obtained in this study were slightly lower than in other studies with dual-purpose cockerels [36,45], which can be attributed to slaughter age, genetic factors, and slaughtering conditions. Moreover, in [35], similar pH values were found 20 min p.m. and slightly higher values in pH 24 h p.m. in the parent breeds (BG, VH, and WR) fed with the same diets, whereas [46] found similar values in BG and broilers at 12 weeks. Similarly, other studies that have tested soybean-based versus faba-bean based diets in poultry have also

reported no differences in the pH values of breast muscles [30,47]. Additionally, pH values of all samples at 20 min and 24 h p.m. do not indicate signs of pale, soft, and exudative (PSE) or dark, firm, and dry (DFD) incidence [48,49], which are unfavorable for the further processing of meat. Aside from pH, color is an important meat quality trait since it is usually considered by consumers to infer the quality of the product at the point of sale [3,50,51]. Similar values in the lightness of breasts from parent breeds [35] were observed; however, differences in redness and yellowness at 24 h p.m. were found. This difference in color could be attributed to genetics, because it is a factor that influences poultry skin and meat color [50,52]. Other studies also found large variations in breast color between different breeds, including dual-purpose breeds [36,53,54] and, consistent with the results of the present study, De Marchi et al. [55] and Almasi et al. [56] observed yellower skin and meat in indigenous breeds and slow-growing genotypes.

Characteristics such as WHC and instrumental tenderness are also of importance for meat quality. The values of WHC and instrumental tenderness of these crossbreeds were similar to those of the parent breeds [35]. However, in this study, we did not find any significant differences regarding these characteristics based on crossbreed or feedstuff.

The contents of AMP, IMP, and inosine are also of importance because these nucleotides, particularly IMP, are strongly associated with the increase in umami taste which is related to meat flavor intensity [57]. No differences were found between samples in the concentration of the abovementioned nucleotides. Similar to previous research [35,58–60], IMP was found in the highest concentration compared with the other nucleotides. A relevant IMP content was only found in fresh samples because AMP breaks down rapidly after slaughter [61]. Finally, the chemical composition of the samples was affected by the crossbreed and the interaction between crossbreed and feedstuff. The average moisture content of the samples was between 72% and 73%, similar to previous research with other genotypes [45,62]; however, it slightly differed (1–2%) from that of BG, a parent breed, in Muth et al.'s study [46]. The fat content in the samples was significantly influenced by the interaction effect of the crossbreed and the feedstuff. Additionally, similar results were obtained by Baéza et al. [63], where 12-week-old chickens (male and female from different genotypes) obtained values of intramuscular fat from 0.8% to 1.2%. Finally, when comparing the protein content in the breast muscles it became evident that there was a strong crossbreed effect, where BWR had the highest protein content, followed by VWR and VBG.

Similar to physicochemical characteristics, organoleptic properties are also strongly affected by genotype, feedstuff, and age [14,64–66]. Therefore, studies have usually focused on evaluating the organoleptic properties of meat from chickens of different breeds [35,36,67–69], fed with different diets [35,38, 65], or reared in different production systems [14,65,66,70].

In this study, aroma differences were only present in crossbreeds of a Vorwerkhuhn parent, which is the only breed that showed differences in aroma attributes in a previous study [35]. The differences in the attributes of overall aroma intensity and chicken aroma are associated with an interaction effect of crossbreed and feedstuff. In overall flavor, the difference in VWR between soybean-based and faba-bean-based diets was also reflected in the fat content of the samples; a higher amount of intramuscular fat heavily influences meat flavor [71]. The texture attributes of firmness and crumbliness showed a significant interaction effect (crossbreed and feedstuff), particularly in firmness. Nonetheless, these results were not confirmed by the instrumental shear force test, where samples did not exhibit any significant differences. However, this might be due to the different testing temperatures of samples (instrumental shear force was at room temperature whereas sensory tests were in warm conditions), as consumers also indicated similar significant differences in the firmness of some samples via their CATA ratings.

Many odor, flavor, and texture attributes are present in different products; however, some attributes are particularly relevant for the overall liking of products. In the case of chicken meat, taste has been shown to have the greatest influence on the OL, followed by tenderness and juiciness, whereas the effects of aroma and color are less significant [72]. Similarly, Sow et al. [73] found that the attributes of juicy, oily, sweet, hard, mouth persistent, and yellow color were highly correlated with consumer preference, whereas tenderness, although positively correlated with OL, was not considered a relevant sensory driver of preference. Similar to these previous studies, our results also show the influence of flavor, texture and aroma attributes, in that order, in the correlation to OL. In this study, the flavor and aroma attributes which showed a positive correlation to OL were chicken aroma and flavor, as well as umami flavor, whereas metallic taste and aroma showed a negative correlation to OL; similar results were obtained by Horsted et al. [66]. This was also reflected in the frequencies of the top three boxes (T3B) of consumer acceptance, where VBG×VC−, VWR×C, VWR×VC+ and BWR×C also showed a higher intensity (in the sensory evaluation) of positively correlated attributes to OL, such as overall aroma and firmness. In this study, tenderness was negatively correlated to the OL of the samples, although it is usually positively correlated to the OL of meat products [74,75],

including poultry [66,73,73]. This might be due to the type of production system, i.e., not a commercial breed and reared for a longer period of time, as Horsted et al. [66] also observed that niche production systems scored lower in tenderness when compared with standard products. Nevertheless, the negative association of tenderness to OL in these samples could be compensated by the positive association of firmness and juiciness to OL. The results of this study also indicated heterogeneous consumer liking, as a high variability between samples was observed (average standard deviation = 2) with respect to overall liking.

Based on the distribution of the hedonic assessment, a preference for C and VC+ feedstuff was observed. Although the frequency of T3B in BWR×VC+ was one of the highest, its value in the bottom three boxes (B3B) was the lowest. In most cases, the frequencies in the T3B were less than 50%, whereas those of the B3B were over 10%, even reaching up to 20% for BWR×VC+. This suggested that the samples were not particularly liked; however, this may have been due to the lack of seasoning in the samples. The use of spices and herbs has been shown to positively influence the OL of meat products, particularly of those with a low fat content [76,77], such as chicken breast.

Results of animal performance are of great importance for the breeding of dual-purpose chickens, because this helps determine their suitability as an alternative to current practices. To date, research shows that the use of faba beans does not affect growth and fattening performance; moreover, the BG breed and its crossbreeds were more suitable for meat production [34]. In our previous research with the parent breeds (BG, VH, and WR), the use of faba beans did not affect the quality parameters (instrumental and sensory) of the meat. Although differences between the breeds were found (e.g., BG was more tender, VH had a higher content of flavor-related nucleotides), it was still unclear whether these were due to the breed itself or to the 6-week age difference of the breeds [35]. However, in this study, most differences in physicochemical parameters were due to a crossbreed effect; because these differences were positively associated with quality for different breeds in different parameters (e.g., higher IMP content—associated with a more intense chicken flavor which is correlated to OL—in VWR when compared with BWR), based on these quality parameters, it is difficult to select a specific crossbreed that can be recommended for rearing dual-purpose breeds.

The results obtained are of relevance to the poultry industry because dual-purpose breeds are a viable alternative to the culling of day-old male chicks. However, they only apply to these specific crossbreeds fed with these particular feedstuffs. The production of these breeds (DPBs)

also provides small-scale farmers an opportunity to target consumers that demand a more ethical production method, and who often indicate to be willing to pay higher prices for animal-friendly practices [6,9,14] and regional products [78–80] when these production systems do not compromise product quality.

5. Conclusions

The results of this study enabled us to quantify different meat quality parameters as well as identify sensory characteristics and consumer preferences for VBG, VWR, and BWR fed with vicin/convicin (VC)-rich and VC-poor faba-bean-based diets and a soybean-based diet. The analyses of meat quality parameters showed that the different crossbreeds, rather than feedstuff, were responsible for the slight differences in specific parameters. The sensory analysis showed that differences in attributes were mostly attributed to the interaction between the crossbreed and feedstuff, particularly in texture and aroma. Based on their sensory attributes, the samples were not clearly distinguished between each other by the panelists. Consumer evaluation showed that all samples were equally accepted by consumers; however, a VC-rich diet seemed to be better accepted than a VC-poor diet. Based on this study and on previous research, we conclude that a diet based on faba beans did not differ from a soybean-based diet when assessing the overall quality of chicken breasts; therefore, it can be used to substitute this protein source. The many differences between crossbreeds in different physicochemical parameters make it hard to recommend the rearing of a specific DPB; however, the lack of significant differences in sensory evaluation, including consumer acceptance showed that each of these crossbreeds can be used as DPBs without compromising hedonic quality.

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Appendix A

Table A1. Sensory attributes, definitions and scales used to evaluate samples.

Attribute	Definition [1]	Scale
	Odor	
Overall intensity	The sum of all perceptible odors.	Not perceptible—Very perceptible
Animal/barn	The intensity of smell of animal/stable.	Not perceptible—Very perceptible
Metallic	The intensity of smell of metal/blood.	Not perceptible—Very perceptible
Cooked chicken	The intensity of smell of cooked, unseasoned chicken, chicken soup.	Not perceptible—Very perceptible
	Appearance	
Fibrousness	Degree of visible fibers on the cut side of the sample.	Not recognizable—Very recognizable
	Taste	
Overall intensity	The sum of all perceptible flavors.	Not perceptible—Very perceptible
Sour	The intensity of sourness.	Not perceptible—Very perceptible
Umami	The intensity of umami taste.	Not perceptible—Very perceptible
Cooked chicken	The intensity of the taste of cooked, unseasoned chicken or chicken soup.	Not perceptible—Very perceptible
Metallic	The intensity of the taste of metal or blood.	Not perceptible—Very perceptible
Aftertaste	The intensity of the aftertaste.	Not perceptible—Very perceptible
	Texture	
Firmness	Force required to bite through the piece with the incisors.	Soft—Firm
Juiciness	Amount of fluid released during the first three chews.	Not juicy—Very juicy
Cohesiveness	Cohesion of the sample during chewing.	Not cohesive—Very cohesive
Tenderness	Force required to chew the piece until it can be swallowed.	Not tender—Very tender
Crumbliness	Number of pieces formed before swallowing; how strongly the mass holds together or decays during chewing.	Not crumbly—Very crumbly

[1] Definitions were suggested and accepted by the panelists.

Appendix B

Table B1. Analytical performances of nucleotide quantification.

	RT (min)	LoD (ug/mL)	LoQ (ug/mL)	Intraday (CV%)	Inter-day (CV%)	Dynamic Linear Range (ug/mL)	Calibration Equation	R^2
IMP	3.89 ± 0.07	0.17	0.51	2.28	9.32	0.5–1000	Y = 22325x − 37939	0.9997
Inosine	4.8 ± 0.1	0.31	0.95	5.00	9.47	0.5–500	Y = 60623x − 183766	0.9994
AMP	9.7 ± 0.1	1.17	3.56	5.00	9.47	5–1000	Y = 33235x + 346258	0.9941

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General discussion

The topic of dual-purpose breeds has been of interest in the past years due to public attention and consumers' concerns regarding the culling of day-old male chicks of layer breeds. While other alternatives (i.e., *in-ovo* gender determination and fattening of the layer brother) offer a solution to this problem, the rearing of dual-purpose breeds, particularly traditional breeds, also helps preserve genetic resources. Similarly, the topic of local protein feedstuff, specifically legumes (such as faba beans), has been of interest in the last decade as part of the Protein Crop Strategy which aims to conserve and develop legumes in order to increase their consumption (BMEL, 2021). Moreover, the price volatility of soybeans on the global market contribute to instability in the EU (de Visser et al., 2014); especially in the last couple of years as the supply chain of animal feedstuff was negatively impacted by import/export restrictions due to COVID-19 (e.g., Argentina, Brazil, and USA reduced their soybean exports) (Hashem et al., 2020; Seleiman et al., 2020). This has caused a price increase of soybean meal in the past couple of years (Insider Inc., 2022; Rahimi et al., 2022). Hence, the importance of local alternative protein feedstuff continues to grow.

In order to evaluate consumer acceptance of a product, different aspects have to be considered since consumers assess several intrinsic and extrinsic product attributes when deciding whether to purchase a product or not. In this dissertation, different approaches were used to determine consumer acceptance and product quality through extrinsic and intrinsic product attributes. To achieve the main research objective, two different topics (local dual-purpose breeds and local faba beans as protein feedstuff) were researched in parallel in an interdisciplinary way (consumer research and meat quality). Section I focused on exploring and gathering knowledge on which extrinsic product attributes are valuable to consumers regarding DPBs and poultry feedstuff, while Section II focused on analyzing intrinsic product attributes that determine meat quality from a physicochemical and sensory perspective. This final part of the dissertation will discuss the main findings, the limitations of this research, and a general conclusion will be drawn.

Extrinsic product attributes

The first study conducted in the scope of this dissertation focuses on the use of pictures to evaluate consumers' perceptions of chicken breeds and acceptance of pictures in product packaging. The importance of this study lies in the under researched field of using images of animals in meat packaging, particularly to promote specific animal breeds. The obtained results

show that consumers' knowledge of chicken breeds is limited, and association of animal produce (meat or eggs) is based on the color of the feathers (white breeds are associated to meat and egg production). The idea of introducing specific DPBs to consumers via pictures was also put to test since pictures or images have long been implemented as a marketing tool due to the picture-superiority effect which suggests that images are more memorable than text (Whitehouse et al., 2010). However, the use of images in meat products is rare as these might cause a state of discomfort in consumers due to the meat-paradox, i.e., liking meat but disliking killing animals (Loughnan et al., 2010). This effect was observed in this study, as only a small percentage of consumers accept pictures of animals in the packaging of meat. Hence, making it challenging to communicate specific chicken breeds in a visual way. However, this approach could be used for product differentiation in a niche market where consumers are more engaged with animal welfare.

Consumers' interest in food quality, specifically in the information they obtain (e.g., via marketing or labeling) when purchasing a product, has been increasing. As results from this thesis show, there are several extrinsic attributes that are valued by consumers; however, not all of them are taken into account at the time of purchase. Therefore, it is necessary to identify what information about a product consumers value the most. The second and third studies in this section focus on exploring and evaluating different extrinsic product attributes in chicken meat. The results of these studies show that price, place of origin, and animal husbandry are among the most valued extrinsic attributes for chicken meat.

Many product quality attributes are not visible to consumers; therefore, these are communicated on the product packaging via labels. These labels provide consumers an opportunity to make informed decisions when purchasing a product. However, the decision is not completely informed if consumers are not aware of the meaning behind specific phrases or labels. This lack of information regarding the different terminology and labels might contribute to consumers' unrealistic expectations of certain attributes (e.g., animal husbandry practices). Additionally, if too much information is presented, this can create confusion or disinterest in reading all presented information (Verbeke, 2005), as shown in the third study (I.3).

Price is one of the most important determinants in food choices (Brečić et al., 2017) as shown in studies I.2 and I.3. While a lower price is usually preferred by consumers, some consumers are willing to pay a higher price as long as their product quality expectations are met (e.g., taste, animal welfare).

In the case of place of origin, the results of this work show that regional or national products are preferred over imported ones, including animal feed. The topic of preference of national or regional products has long been studied in several product categories (e.g., Chambers et al., 2007; Chamorro et al., 2015; Feldmann and Hamm, 2015; Schnettler et al., 2008), including meat products (e.g., Byrd et al., 2017; Chung et al., 2009; Schnettler et al., 2008). However, information regarding animal feedstuff is not usually presented to consumers, therefore many do not think about this attribute. When presented with information regarding its origin, the results of this work show that this attribute is as important as the origin of the product itself. Consumers that give more importance to feed and product origin show a stronger sense of responsibility towards consumption of regional products. The preference for local product origin can also be explained by consumers' desire to support the local region/economy, or to reduce transportation distances. Similar results were found in other studies (Profeta and Hamm, 2018; Profeta and Hamm, 2019; Wägeli et al., 2015) where consumers were willing to pay a higher price for animal products from animals fed with local feed for similar reasons.

While feed origin has been shown to be an important attribute for consumers, preference for the type of feedstuff has rarely been studied. In a study by Altmann et al. (2022), when consumers were given the choice of traditional (soybean based), insect or algae feedstuff, a segment of consumers preferred alternative animal feed and were willing to pay more for such products. The results of this dissertation indicate that consumers prefer local or German faba beans rather than Brazilian soy; however, it is unclear whether this preference is related to the place of origin or the feedstuff itself. Seen that the place of origin has a strong influence in consumers' purchasing decision in both studies concerning this topic, it can be assumed that the preference relies on the origin of the feedstuff. Nonetheless, as Altmann et al. (2022) showed, environmentally conscious consumers might prefer and be willing to pay a higher price for an alternative to soybean meal as feedstuff, such as faba beans, especially if these are locally sourced.

Consumers claim animal husbandry is an important factor considered when purchasing animal products, although most have little knowledge regarding current farm practices (Alonso et al., 2020; Gangnat et al., 2018). However, in the last decades, interest towards information regarding animal conditions has increased (EC, 2016). This work shows that most consumers want products from animals that were reared under acceptable (to their standard) conditions, including having outdoor access, having green fields and enough space to roam around, and living a longer and healthier life. A term that usually comes along when discussing animal

husbandry is animal welfare. Since there is no official definition for animal welfare (BZL, 2022), this term is usually interpreted in different ways by different stakeholders (e.g., farmers think of it differently than consumers). For producers, animal welfare is associated with avoiding or limiting negative experiences (e.g., having access to food, water and shelter) while making sure that the animals grow to meet production goals while for consumers the term is associated with species-specific behavior (e.g., having outdoor access, having enough space to move and forage) and their ability to live in a natural environment (Borkfelt et al., 2015; Sato et al., 2017; Vigors, 2019). Consumers are willing to pay a higher price for animal products from animals living under such conditions (Mulder and Zomer, 2017). As a response to consumers' rising interest in farm animal welfare, several stakeholders including retailers have shown interest in options to increase farm animal welfare. For instance, the Tierwohl Initiative was created in order to improve the conditions in which animals are reared. In this scheme, retailers financially support farmers to implement measures to improve animal welfare standards beyond what is legally required. Currently, around 90% of the chicken meat in Germany is produced according to the specifications of this initiative (Initiative Tierwohl, 2022). Additionally, different labels have been created to inform consumers of the distinct types of husbandry systems. For example, the "Haltungsform" label allows consumers to easily identify the type of husbandry system under which the animal was reared (Haltungsform, 2022). However, the results from this work show that some consumers are confused by these labels as they are not sure what the information behind means. Communicating quality attributes via labeling is relevant in the market, as there is a higher WTP for products that meet (specific to each consumer) animal welfare criteria since these are considered to have a better quality (Alonso et al., 2020). Nonetheless, it is important to make information more easily understandable or educate consumers on how to read such labels.

As opposed to the attributes place of origin and animal welfare associated to animal husbandry, the consumers' preference for the attribute of animal breed has not been extensively studied. There are, however, studies regarding consumers' acceptance of dual-purpose chicken breed products (Brümmer et al., 2018a; Brümmer et al., 2018b; Busse et al., 2019; Gangnat et al., 2018), in which consumers show, in general, a positive outtake on dual-purpose breeds. The results of this dissertation show that while consumers might support the idea of DPBs, this attribute alone will not persuade consumers to purchase meat, as other attributes continue to be more important to consumers. This is, however, reasonable as not many consumers are familiar with the concept of DPBs (Busse et al., 2019; Gangnat et al., 2018) and can therefore not picture

the benefits these products may provide. Literature addressing consumer preference for specific chicken breeds is also limited and mostly focuses on local or indigenous breeds (Bett et al., 2013; Lee et al., 2017). The studies in this dissertation explore whether a specific local chicken breed (i.e., Bresse Gauloise, Vorwerkhuhn, White Rock, and Kollbecksmoor) is preferred over another one and to evaluate the importance of this attribute when measured against others. Results show that while the use of local products is favored, as previously discussed, the specific breed is irrelevant to consumers. A slight preference for breeds with white feathers was observed; however, this is expected as results show that most consumers associate birds with white feathers with meat and egg production. There is, however, an exception to the relevance of a specific local dual-purpose chicken breed: Bresse Gauloise. This breed is considered a delicacy in France and it is marketed as such emphasizing its traditional breeding and the Protected Designation of Origin seal. In Germany, there is still no DPB which is as extensively known as Bresse in France and can be marketed as such. Therefore, there is still an opportunity for a local DPB to become the leader in this niche market. There is little research concerning the willingness to pay for regional/local or traditional animal breeds over modern breeds; however, it is expected that consumers' WTP for local breeds is higher as local origin has been proven to increase WTP. Hence, the inclusion of the conservation of traditional breeds and origin in marketing strategies should be explored (Kohlschütter et al., 2007)

Not only are extrinsic attributes valuable for consumers, but these also influence consumers' hedonic perceptions. A review on literature about product origin (Fernqvist and Ekelund, 2014) shows that by labeling the country or region of origin, consumers' product evaluations were better, even affecting (positively) hedonic liking. Similarly, Gross et al. (2021) found that products with animal welfare labels are better evaluated (hedonically) than those with no information, while Cerjak et al. (2011) found that information regarding local breeds increases hedonic expectations.

It has been established that the use of local dual-purpose breeds provides a more animal-friendly alternative to the status quo, and also helps conserve genetic material of traditional breeds. In many cases, improving farm animal welfare does not provide a clear return of investment to the business as productivity does not always increase (Fernandes et al., 2022). This is the case for DPBs since this alternative does not increase productivity when compared to the status quo, and the costs associated with keeping these breeds are much higher than conventional production, as they require more land and resources (e.g., water, energy, food), thus creating a higher strain on the environment (Damme et al., 2015). However, these issues should not

minimize the positive impact of using alternative breeds to avoid the culling of day-old chicks and the use of traditional breeds to preserve genetic resources, but be used for future research in order to find ways in which the environmental impact of DPBs can be reduced. A step towards this is the reduction of GHG emissions related to growing, processing, and transporting animal feedstuff which account for the highest environmental impact of the poultry industry, even higher than rearing the animals (Boggia et al., 2010; Leinonen and Kyriazakis, 2016). The use of local protein crops (such as faba beans), rather than soybean meal imports from the Americas, can improve the environmental impact associated with feedstuff production and transportation (Köpke and Nemecek, 2010; Leinonen and Kyriazakis, 2016). However, this is only relevant if no negative effect on animal performance and the quality of its products is present.

Intrinsic product attributes

As the main concern regarding dual-purpose breeds is their lower profitability due to their lower production performance, most literature regarding DPBs focuses on measuring fattening or carcass (Baldinger and Bussemas, 2021a; Lambertz et al., 2018; Mueller et al., 2018; Siekmann et al., 2018; Tiemann et al., 2020) and laying (Baldinger and Bussemas, 2021b; Hammershøj et al., 2021; Nolte et al., 2020) performance. However, animal performance is not the only important aspect of DPBs as it is imperative that the meat quality of the alternative breeds can meet that of modern broilers. To analyze meat quality parameters of poultry meat a series of attributes have to be evaluated; however, it is important to keep in mind that there are several factors that influence these parameters, such as genetics, age, animal nutrition and management, biochemical changes post mortem (which are influenced by pre slaughter conditions), processing (e.g., storage, chilling, cooking) (Mir et al., 2017). This dissertation includes two studies that evaluate different physicochemical properties (e.g., pH, color, water holding capacity, instrumental tenderness) of chicken breast from two local DPBs (Bresse Gauloise, Vorwerkhuhn), a high performing laying breed (White Rock), and their crossbreeds (VBG: Vorwerkhuhn x Bresse Gauloise, VWR: Vorwerkhuhn x White Rock, and BWR: Bresse Gauloise x White Rock). The results of these experiments are of great value as these are the first to analyze alternative protein feedstuff in these local DPBs.

Study I.3 contributing to this dissertation, shows that meat color is of great relevance to consumers as it is associated to other attributes such as quality and freshness. In both experiments, differences in meat color between breeds were found, regardless of the diet. This is expected as genetics (along with strain and age) greatly influence skin and meat color

(Fletcher, 2002; McKee et al., 2012; Mir et al., 2017; Wilkins et al., 2000) and similar results have been found in other studies (Mueller et al., 2018; Siekmann et al., 2018). However, the inclusion of faba beans in poultry diet also influenced the color of the meat, particularly the yellowness; such changes of color due to the inclusion of faba beans have also been found in other studies (Laudadio et al., 2011; Tufarelli and Laudadio, 2015). Although, in these studies, the inclusion of faba beans in the diet affected the lightness of the sample rather than redness or yellowness. This suggests that the effect of faba beans in the color of chicken meat is subject to a specific breed. However, it remains unknown whether the differences between the samples are noticeable and accepted by consumers.

Water holding capacity is an important functional property of meat since it is correlated to tenderness and the way meat is further processed (Mir et al., 2017). In the first experiment, storage loss was affected by the type of feedstuff, especially in WR where a VC diet decreased this parameter, therefore increasing water holding capacity and increasing tenderness; similar results were obtained by Laudadio et al. (2011). However, results from the second experiment (crossbreeds) did not show feedstuff effect between samples. As differences between feedstuff are only seen in the first experiment where breeds were analyzed independently, results suggests that the breed has a greater effect on WHC than feedstuff.

Flavor related nucleotides, particularly inosine 5′-monophosphate (IMP), play an important role in the flavor formation and enhancement of meat products (Kawai et al., 2002; Tikk et al., 2006). The results of this dissertation show that in general, the breeds in the first experiment had higher IMP content than their crossbreeds, except for BG; however, no differences between diets were found. The second experiment showed similar results as differences between samples regarding nucleotide content were due to a crossbreed effect and the content of faba beans in the animals' diet had no significant effect on this attribute.

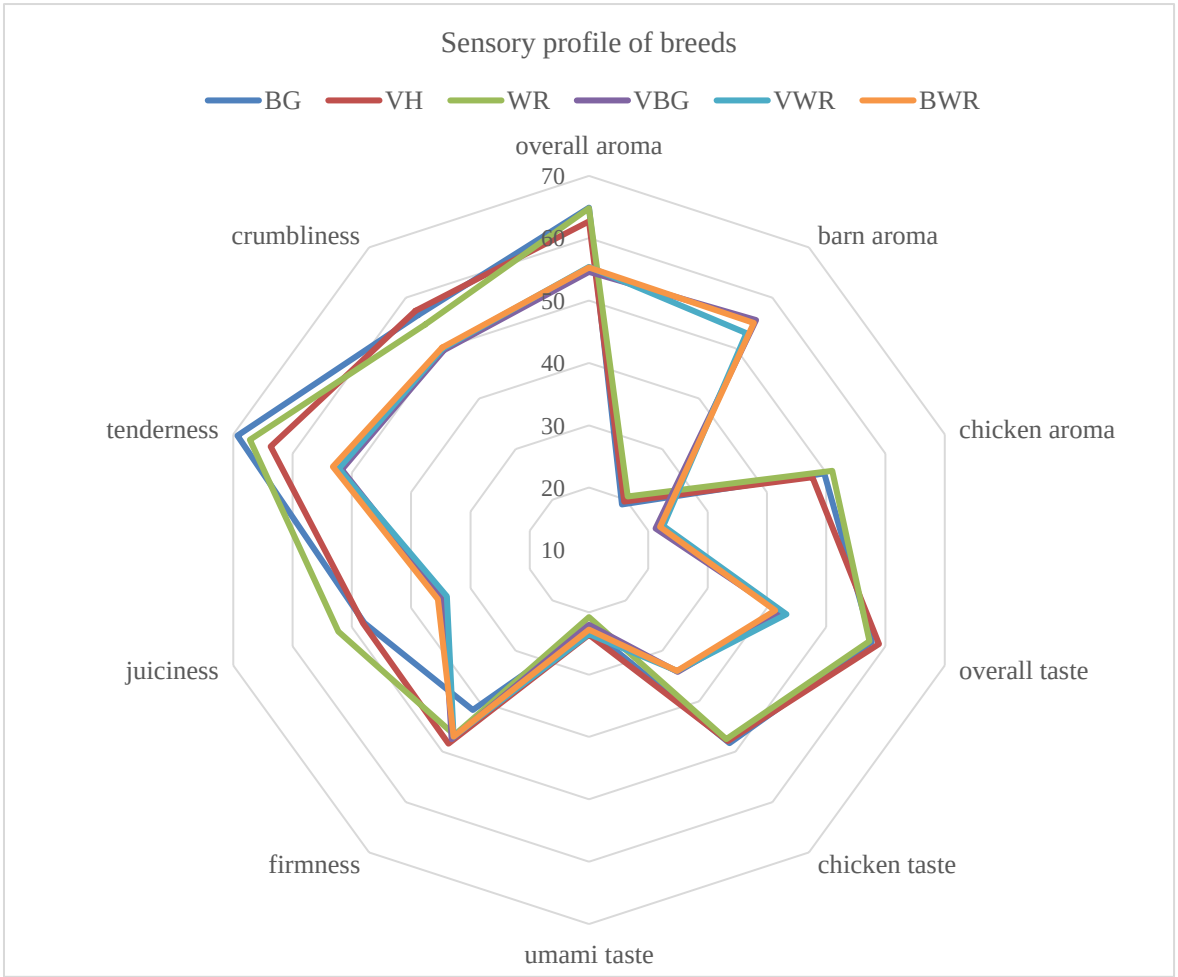
The chemical composition (protein, fat and minerals) of poultry meat is of great relevance as it is one of the reasons why it is preferred over other types of meats (Kennedy et al., 2004; Marangoni et al., 2015; Skunca et al., 2017). In the second experiment, a significant crossbreed effect was observed regarding the protein content in breast muscles; VBG had the lowest protein content. Similar values of protein content were observed in other DPBs (Mueller et al., 2018). Hence showing that the inclusion of faba beans in poultry diet does not influence the protein content of the meat.

The results obtained from the physicochemical analyses, nucleotide content, and proximal composition indicate that, in general, a faba bean-based diet did not have an adverse effect in

the meat quality of the specific breeds analyzed in this dissertation. This is of relevance to breeders who are interested in using alternative protein sources.

Both studies regarding intrinsic product attributes also analyze sensory parameters of the samples. A summary of the results for each breed can be found in Figure 1, where the mean values of all observations were used and only those attributes considered to be drivers of liking or showed differences were included. Both experiments and their results cannot be directly compared to one another as they were conducted by two panel leaders, in two consecutive years, and with birds of different ages.

Figure 1. Sensory profile of BG, VH, WR, VBG, VWR, and BWR.



Certain attributes, such as chicken aroma, chicken taste, umami taste, tenderness, and juiciness have been shown to be drivers of liking in chicken meat (Horsted et al., 2012), hence the importance of these attributes. In the first experiment, the barn aroma of samples in VH were

negatively affected by the higher content of VC; however, this was only observed in this breed. On the contrary, the inclusion of faba beans in the diet affected the tenderness of VH and WR; where a VC- content increased tenderness in VH and decreased tenderness in WR; similar results were obtained in the instrumental measurement of tenderness. For these breeds, both faba bean variants tested (VC+ and VC-) can be used as a substitute for soybeans. However, for VH the VC- variant is recommended as it improves the samples (as opposed to a VC+ variant). Finally, for WR breed a VC+ variant is recommended as it does not negatively affect sensory attributes. In the second experiment, differences found in sensory attributes were mostly attributed to an interaction effect between the crossbreeds and the feedstuff. On the contrary, consumer hedonic acceptance did not present any differences between samples. Consumer evaluation of VBG show a higher percentage of consumers that prefer a VC+ variant, in VWR the inclusion of faba beans in poultry diet was not well evaluated, finally, in BWR a VC+ variant is preferred by a higher percentage of consumers. For the evaluated breeds in the second experiment, a VC+ variant of faba beans is recommended based on consumer hedonic evaluation. However, it is important to mention that the lower values obtained in the hedonic testing can be improved with the use of seasoning, as it has been shown that by using herbs and spices in meat products, the overall liking of such products can increase, particularly if they have a low-fat content (Peters et al., 2014; Polsky et al., 2014).

These experiments are the first to investigate the effect of faba bean diets on organoleptic properties of poultry meat as most studies investigating the effect of faba beans focus on the quality assessment of physicochemical properties. Sensory characteristics of these particular breeds had not been previously studied, however other dual-purpose and slow-growing breeds have been researched (e.g., Pellattiero et al., 2020; Siekmann et al., 2018). Results in these studies show differences in texture and taste attributes between the alternative breeds and a commercial broiler. Although the experiments in this dissertation did not include a commercial broiler sample for comparison, it is important, as also suggested by Pellattiero et al. (2020) and Siekmann et al. (2018), to determine the market potential of products with the characteristics of our evaluated samples and to find how to best market such products. Often, sensory expectations are made by consumers' associations with extrinsic (credence) attributes (Cerjak et al., 2011; Fernqvist and Ekelund, 2014). For instance, Cerjak et al. (2011) found that consumers' preference for a sausage increased when information regarding a local pig breed was provided to participants. However, whether the combination of the abovementioned

extrinsic and intrinsic characteristics of DPBs fed with local faba beans are a product consumers will purchase in real life remains unknown.

Meat from dual-purpose chicken breeds and local faba beans as protein feedstuff in the German market

Although this alternative production system offers ethical (refraining from culling day-old chicks) and some environmental benefits (by producing local feedstuff and therefore avoiding soybean imports), the reality of its low production performance (vs. conventional systems) and the growing demand of poultry meat make it difficult to meet consumption demand. As confirmed by this dissertation, only a small number of consumers are willing to pay the increased price associated to higher production costs. Therefore, meat products of this system remain a niche market.

Moreover, animals from DPBs are usually smaller than conventional broilers, and therefore only selling breast filets makes the product more expensive. This can be tackled by selling whole animals; however, this is also a niche market. As shown in study I.3 in this dissertation, most consumers purchase cuts, specifically breast and legs, due to their convenience. Nevertheless, consumers in this study suggest the promotion of extrinsic product attributes (e.g., animal welfare, regional production) in order to increase the interest in whole animals.

Although consumers' interest in animal feed is growing (Stranieri and Banterle, 2015), their current knowledge on the specifics of animal feed is low; therefore, the focus of communicating the use of faba beans as feedstuff should be on the regionality of the product rather than on the product itself. However, the cost of producing local feedstuff is higher than importing, unless public subsidies are available to farmers or consumers pay higher prices for animal products produced with local feedstuff (Kaltenecker et al., 2017). This topic has been studied with German consumers and the willingness to pay higher prices for local feedstuff exists (Profeta and Hamm, 2018; Profeta and Hamm, 2019), however, only with specific consumer segments.

Another aspect that determines the success of a product, regardless of consumers' attitudes towards it, is its availability and comprehensible product information (Vecchio and Annunziata, 2012). Dual-purpose breeds are alternatives to the current production methods; hence, the amount of existing product is low and not easily accessible for all consumers as most are reared in small farms by hobby breeders. There are several initiatives (e.g., Initiative Zweinutzungshuhn, ei Care, Initiative "Huhn und Hahn", "Ökologische Tierzucht gGmbH")

that focus on rearing DPBs under organic standards. However, there is still no significant market share of these products (Deutscher Bundestag, 2020). Hence, there is a need for a strategy to create or improve existing value chains that allow meat from DPBs to be promoted and accessible in different channels (e.g., gastronomy, supermarkets, butcher). Perhaps a cooperation between breeders and retailers, similar to that of Tierwohl Initiative, might increase consumers' awareness as well as create demand for such products.

Consumers' willingness to pay for dual-purpose breeds and local feedstuff has been previously discussed. While literature indicates that consumers support DPBs and local feedstuff and are willing to pay a higher price for meat produced under these systems (Brümmer et al., 2018a; Brümmer et al., 2018b; Busse et al., 2019; Gangnat et al., 2018; Profeta and Hamm, 2018; Profeta and Hamm, 2019) it remains unclear how much more. Additionally, it is necessary to consider the inconsistency between attitudes towards consumption of products versus the actual purchase of such products (attitude-behavior-gap). In order to reduce this gap, Terlau and Hirsch (2015) recommend to improve communication of relevant quality attributes as well as creating unified and simple labels that provide transparency to the processes behind the labels.

In a nutshell, meat from dual-purpose breeds fed with local faba beans can be sold in the market as long as consumers are willing to pay a higher price for such products and the products' quality characteristics are met. In order for this niche market to continue existing and growing, it is necessary that consumers are educated on the information they are receiving through the labels. By educating consumers on the current practices in the poultry industry and the available alternatives, a shift in consumer preference and demands can be achieved. It seems as the most effective way to promote chicken meat from DPBs fed with local faba beans is through labeling since the use of sustainability-related labeling has shown to have a positive effect in consumers' quality perception and acceptability of products (Samant and Seo, 2016).

Limitations and future research

The main limitation of the present work is the interpretation of results as the studies regarding extrinsic product attributes are presented in hypothetical scenarios, which is problematic as stated preferences can be subject to socially desirable actions. Additionally, the research focused on consumers' acceptance of such products and not on determining their willingness to pay. Moreover, results of Section II (intrinsic product attributes) should be interpreted with caution as these only apply to the studied breeds fed with those specific diets.

When purchasing chicken meat there are several credence attributes as well as other extrinsic and intrinsic attributes that are taken into account. The combination of the different attributes as well as other external factors make it challenging to evaluate the complexity of consumers' choices. Therefore, the observations made in this work only serve as a guide.

An economic analysis of the real cost of chicken meat from DPBs fed with local faba beans might be valuable for future research as this would allow to create a more accurate assessment of consumers' WTP for such products.

General conclusion

This dissertation focused on investigating consumers' acceptance of dual-purpose chicken breeds and local faba beans as protein feedstuff. As specific examples in this research, the local breeds Bresse Gauloise and Vorwerkhuhn, the commercial laying breed White Rock and their crossbreeds were evaluated. Similarly, this work tested two faba bean-based diets containing different amounts of vicin-convicin against a conventional diet (soybean based) in several meat quality parameters.

There are many extrinsic product attributes that are relevant to consumers when purchasing chicken meat, for instance, place of origin or husbandry system. And while many consumers are supportive of the concept of dual-purpose breeds, not all consider this an important product attribute whenever purchasing chicken meat. Consumers' demand for transparency in production methods is growing, but the interest in transparency only applies to specific attributes, as most consumers do not find the specific breed of importance or do not want to see pictures of the animals on the meat packaging; making it difficult to communicate and market specific breeds. Therefore, products of dual-purpose breeds, particularly traditional, and local protein feedstuff remain in a niche market. In order for consumers in this particular niche to choose meat from a dual-purpose breed, it is necessary that the product provides them other relevant quality attributes (i.e., place of origin, animal welfare, price). Only then can information about a local dual-purpose or traditional breed be used as a marketing tool in order to differentiate the product.

The inclusion of VC-poor faba beans in the diets of Bresse Gauloise, Vorwerkhuhn, and White Rock appear to be an acceptable alternative to soybean-based diets from a meat quality perspective, as the VC-poor content in faba beans does not have a negative effect in the physicochemical parameters, nucleotide content, and sensory properties of breast filets from

these breeds. In the case of the crossbreeds, both variants of faba beans did not show any adverse effect in the physicochemical characteristics, nucleotide content and proximal composition of the samples. The breast samples of crossbreeds were not differentiated by panelists as most differences in attributes were attributed to an interaction between the crossbreed and feedstuff. Nonetheless, consumer acceptance of a faba bean-based diet is comparable to that of a soybean-based diet; particularly a faba bean-based diet with a higher VC content.

There is a gap between consumers' ideas of animal farming and animal welfare versus the industry standards. Hence, it is relevant, especially in a niche market, to understand consumers' expectations of products from dual-purpose breeds fed with local protein feedstuff in order to gain market. As not all attributes are of equal importance to all consumers, product differentiation is needed.

At the end of the day, food choices are a multidimensional process in which not only a consumer's environment, past experiences, attitudes and beliefs, but also many product characteristics heavily influence the decision. At the point of sale, it is impossible to control most of the dimensions that influence choices; however, information regarding the different product characteristics can be communicated to consumers in order to facilitate this decision.

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My meat does not have feathers: Consumers' associations with pictures of different chicken breeds

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Meat quality parameters and sensory properties of one high-performing and two local chicken breeds fed with *Vicia faba*

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Affidavit

I hereby declare on oath that:

1. This dissertation has been written and prepared independently and without unauthorized assistance.
2. This work has not been submitted in the same or a similar form to any other examination authorities.
3. I have not applied for a doctoral degree at any other university.

I am also aware that any untruthfulness regarding the above declaration will prevent admission to the doctoral program or will later entitle me to discontinue the procedure or to withdraw the obtained degree.

Göttingen, July 30th, 2022 _____

(Signature)