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ORIGINAL ARTICLE

Characterization of the lipid profile of abdominal and gizzard fat of broiler chickens

Caracterización del perfil lipídico de la grasa abdominal y molleja de pollos parrilleros

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Abstract It evaluated the influence of the diet on the lipidic profile of abdominal and gizzard fat of broiler chickens from farms with different climatic conditions. For determining the fatty acids of gizzard and abdomen samples it was used 300 g of fat (60 % abdominal and 40 % of gizzard). The color of solid and fused chicken fats was determined through the chromatic coordinates of the system CIE-L*a*b*. No significant differences existed ($p \leq 0.05$) among the lipid profiles of the pieces of chickens, which is related to the stability of the feeding that the poultry received in each one of the farms. Palmitic and oleic acids were the majority of fatty acids in the chicken fat.

Keywords chicken fat; lipid profile; animal nutrition.

Resumen Se evaluó la influencia de la dieta en el perfil lipídico de la grasa abdominal y de la molleja de pollos parrilleros provenientes de granjas con diferentes condiciones climáticas. Para la determinación de los ácidos grasos de muestras de molleja y abdomen se utilizaron 300 g de grasa (60 % abdominal y 40 % de molleja). Se realizó la evaluación del color a las grasas de pollo sólida y fundida a través de las coordenadas cromáticas del sistema CIE-L*a*b*. No existieron diferencias significativas ($p \leq 0,05$) entre los perfiles lipídicos de las canales de pollos, lo cual está relacionado con la estabilidad de la alimentación que recibieron las aves en cada una de las instalaciones. Los ácidos palmítico y oleico fueron los ácidos grasos mayoritarios de la grasa de pollo.

Palabras clave grasa de pollo, perfil lipídico, nutrición animal.

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PUBLIS EDITORIAL

Introduction

In Chile, the poultry industry has experienced significant growth in recent decades, positioning itself as one of the main producers and consumers of chicken meat in Latin America. According to reports, per capita chicken meat consumption in Chile has increased significantly, with an average of 24.03 kg of poultry consumed per person in 2020, reflecting a growing trend towards chicken as a protein source in the Chilean diet. Additionally, poultry meat production has maintained an annual growth rate of 7.6% over the last decade, evidencing strong demand both nationally and internationally. Chile is among the six largest chicken meat producers in the region and is the third largest exporter, highlighting the importance of this industry for the country's economy (Gutiérrez, 2020).

The content and composition of lipids in chicken meat are influenced by various factors, including genetics, age, sex, environmental conditions, and nutritional aspects. Nutritional factors, in particular, play a fundamental role, emphasizing the energy and lipid and protein composition of the diet. According to Mir et al. (2017), the variation in the quality of chicken meat can be attributed to these factors, which affect not only the amount of fat but also the proportion of fatty acids present in muscle tissue. In recent decades, research in animal nutrition has focused its efforts on improving the nutritional value of animal products to meet consumer demands for healthier foods with longer shelf lives (Choi et al., 2023). Specifically, poultry meat, being a monogastric animal, contains a high percentage of polyunsaturated fatty acids, making it susceptible to modifications through different nutritional strategies (Cartoni et al., 2022).

Abdominal fat in slaughtered chickens represents between 2% and 2.5% of their total weight (Santos et al., 2020). This fat has great potential as an ingredient in the production of sausages, as it contains high concentrations of oleic, palmitic, and linoleic acids. However, small producers often discard it, along with offal, feathers, and blood, generating a negative environmental impact.

In recent years, consumers have become more aware of the influence of diet on their health, leading to a shift in eating habits, especially regarding the quantity and type of fats consumed. Current dietary recommendations promote reducing saturated fat intake and increasing polyunsaturated fats, as the latter has been shown to have beneficial effects in preventing cardiovascular diseases and cancer. It has been suggested that diets should obtain more than 30% of their total energy from polyunsaturated and monounsaturated fatty acids, limiting saturated fatty acid intake to a maximum of 10% (Ros et al., 2015). The objective of this study was to evaluate the influence of diet on the lipid profile of abdominal fat and the gizzard of broiler chickens.

Materials and methods

To evaluate the influence of diet on the lipid profile of abdominal fat and the gizzard, broiler chickens were selected from three farms (A, B, and C) in the Libertador Bernardo O'Higgins Region. For ethical reasons, the names of these farms are not disclosed. The animals had ad libitum access to food and water. Additionally, an analysis of the composition of the feed provided at each of the farms was conducted.

To determine the fatty acids in the samples of abdominal fat and gizzard, 300 g of fat (60% abdominal and 40% gizzard) were used. The extraction of fats and fatty acids was performed using the Soxhlet method, utilizing diethyl ether. Subsequently, the fats were methylated to form fatty acid methyl esters (FAME), which were quantified by gas chromatography, using C11:0 methyl ester as an internal standard. The total fat content was estimated by summing the individual fatty acids, expressed as triglycerides (Prosser et al., 2010).

The color analysis of the fat samples was performed using an X-RITE spectrophotometer, measuring the CIE-Lab* coordinates in 30 fat samples at different points on their surface.

Results and discussion

The lipid deposition in animal tissues had two origins: exogenous, coming from the diet (Table 1), and endogenous, synthesized de novo by the animal. The type of lipid deposition depended on the balance between the exogenous and endogenous lipid portions. It has been observed that the inclusion of fat in the diet reduced hepatic lipogenic activity, establishing a balance between exogenous contribution and endogenous lipid synthesis, which kept the total lipid content of the animal relatively constant (Duarte et al., 2014).

This reduction in endogenous lipogenesis resulted, on one hand, from a lower starch content in the diet due to the inclusion of fat, which reduced the substrate for fatty acid synthesis; and on the other hand, from direct inhibition of lipogenic enzymes by dietary lipids (Saponaro et al., 2015). Thus, hepatic lipogenesis increased when dietary energy came from carbohydrates and decreased with the addition of lipid sources (Carvajal, 2015; Hernández-Rodas et al., 2016).

Several studies supported the possibility of modifying the proportion of fatty acids in chicken meat through feeding to obtain healthier profiles. In this regard, the incorporation of sunflower and corn oils, rich in oleic acid, into the diets increased the monounsaturated fatty acids in the final product. When low-fat diets were administered to the birds, most of the fatty acids in their tissues came from de novo synthesis from carbohydrates (Gallardo et al., 2012). The main fatty acids resulting from endogenous synthesis were saturated fatty acids, such as palmitic (C16:0) and stearic (C18:0) acids, and monounsaturated fatty acids, such as oleic (C18:1, ω-9) and palmitoleic (C16:1, ω-7) acids (Ferreri et al., 2020).

Additionally, the use of soy in the diet decreased the proportion of saturated fatty acids and improved the ω-6/ω-3 ratio in the lipids of the meat. Some studies have evaluated the use of different sources rich in specific fatty acids in the diets of animals to produce chicken meat with a higher content of these fatty acids (Attia et al., 2020). The content of saturated fatty acids increased with the inclusion of coconut oil (Piracicaba et al., 2009) or palm oil, while the content of oleic acid increased with olive, sunflower, corn, and soy oils (Andreotti et al., 2001).

Table 1. Formulation of the fattening feed for chickens in the selected farms.

Ingredient	**Formulation (%)**				
	1	**2**	**3**	**4**	**5**
Sorghum	10.0	10.0	10.0	10.0	10.0
Soybean oil	3.20	3.50	3.75	4.00	4.1
Yellow corn	10.0	10.00	10.0	10.00	10.0
White corn	44.5	44.25	45.0	44.90	45.05
Corn gluten	4.4	4.75	4.6	4.20	4.15
Bone meal	3.0	3.1	2.95	3.20	3.25
Soybean meal	11.25	11.00	15.0	14.8	14.6
Roasted soybeans	10.0	10.0	4.0	5.1	5.05

Table 2 presents the lipid profile of the feed used in the farms. No differences were observed in the total fat content between the evaluated diets, although there was variation in the percentages of the ingredients. The predominant fatty acids in the feed were linoleic, oleic, and palmitic, with average values of 52.1%, 25.08%, and 11.27%, respectively.

Table 2. Lipid profile of the fattening feed for chickens in the selected farms.

Fatty acids (%)	**Fattening feed**				
	1	2	3	4	**5**
C≤14 (Others)	0.0	0.0	0.0	0.0	0.0
C14:0 (Myristic acid)	0.19	0.18	0.16	0.15	0.15
C16:0 (Palmitic acid)	11.5	11.3	11.2	11.1	11.25
C16:1 (Palmitoleic acid)	1.05	0.95	1.0	1.0	1.02
C18:0 (Stearic acid)	4.1	3.9	3.85	3.95	4.0
C18:1 (Oleic acid)	25.05	25.1	25.0	25.15	25.1
C18:2 (Linoleic acid)	52.1	52.2	52.15	52.0	52.05
C18:3 (Linolenic acid)	5.6	5.5	5.45	5.55	5.5
C≥19 (Others)	0.68	0.7	0.69	0.71	0.7
Total fat in the diet (%)	7.52	7.49	7.46	7.46	7.52

The formulation of the fattening feed for chickens on the farms directly influenced the lipid profile. It is observed that soybean oil, an important source of lipids, progressively increases in the formulation, from 3.2% in the first feed to 4.1% in the fifth formulation. This variation is consistent with the levels of polyunsaturated fatty acids, such as linoleic acid (C18:2), which maintains a stable and high value between 52.0% and 52.2%, aligned with the greater proportion of soybean oil, which is rich in this fatty acid. Likewise, linolenic acid (C18:3), although with small variations, is also related to this source of vegetable lipids.

On the other hand, soybean meal, another key source of lipids, experienced an increase in formulations 3, 4, and 5 (up to 15%), which could influence the levels of unsaturated fatty acids, such as oleic acid (C18:1), which remained constant (25.0 - 25.15%). Finally, the stability of the total fat in the diet (7.46 - 7.52%) reinforces the consistency in the formulation of the feed, with minor adjustments that do not alter the lipid profile of the feed.

Animal fat deposits largely come from the diet, and the fatty acid profile in the tissues reflects that of the diet. Table 3 shows the lipid profile of the carcasses of the studied birds. There were no significant differences (p>0.05) between the lipid profiles of chickens from the different farms, which was related to the stability of the feeding they received (Tables 1 and 2).

Table 3. Lipid profile of chicken carcasses from the selected farms (n = 30)

Lipid profile	Farms			Variation coefficient (%)
	A	B	C	
Palmitic acid (%)	18.0	17.5	17.94	1.25
Oleic acid (%)	27.0	26.0	27.2	1.96
Linoleic acid (%)	17.5	17.0	16.83	1.66
Saturated fat (%)	23.5	22.0	23.06	2.75
Unsaturated fat (%)	51.0	50.0	52.62	2.11
Monounsaturated fat (%)	32.5	31.0	33.2	2.85
Polyunsaturated fat (%)	18.0	18.2	18.65	1.49
Omega 3 (mg/100 g)	1100	1150	1162	2.36
Omega 6 (mg/100 g)	17100	17200	17335	0.56
Omega 9 (mg/100 g)	28700	26700	29984	4.75

It was observed that the bird fat contained a higher percentage of unsaturated fats (51.2%) compared to saturated fats (23.3%), which coincided with the diet received. Additionally, the fat presented an adequate amount and proportion of fatty acids from the ω-6 and ω-3 families (Ros et al., 2015).

Abdominal fat could be used as an ingredient in sausage production due to its high concentration of oleic, palmitic, and linoleic acids. Reports have indicated proportions of saturated, monounsaturated, and polyunsaturated fatty acids that varied between 29-35%, 47-57%, and 10-24%, respectively, depending on the analyzed fat sample. The low amount of saturated triglycerides (<3%) was a consequence of the low concentration of solid fat at room temperature (3-10% at 20 °C). The predominant fatty acids in chicken fat were palmitic and oleic, which aligned with the results of this research.

According to the study by Ming et al. (2002), chicken fat contained about 60% unsaturated fatty acids, making it more unsaturated than beef tallow. Monounsaturated fatty acids, such as oleic acid, were considered beneficial for the prevention of coronary diseases. Chicken fat was recognized as an important source of monounsaturated fatty acids, with concentrations ranging from 45% to 50%, in contrast to beef tallow, which contained between 30% and 40%. Monounsaturated fatty acids helped reduce cholesterol levels in certain individuals with normal triglyceride levels, and it was recommended that these fatty acids represent half of the calories coming from the lipid fraction of the diet.

The high activity of oleins in the abdominal fat of chickens suggested that it could be used as frying oil or mixed with solid fats to increase its plasticity. Furthermore, its high oleic acid content allowed its use as a dietary supplement of monounsaturated fatty acids or in the production of lipid structures (Ming et al., 2002). The results of the instrumental color analysis of solid and melted chicken fat are shown in Table 4.

Table 4. Chromatic coordinates of melted and solid chicken fats (n = 30)

Sample	L*	a*	b*	C*	h°
Melted fat	40.5	1.0	66.0	66.0	89.5
Solid fat	71.0	3.5	25.0	25.0	82.0

The analysis of the chromatic coordinates of chicken fat reveals significant differences between its melted and solid states, which influence sensory attributes such as color and should be considered in the formulation of products like sausages.

The solid fat presents a high luminosity value (L*) of 71.0, indicating a lighter color compared to the melted fat, which has an L* value of 40.5, reflecting a darker color. This difference in luminosity may be related to the structure of the lipids in the solid state, which retain less color, while in the melted state, compounds are released that tend to darken the product.

Regarding the b* component, which measures the intensity of yellow-blue tones, the melted fat has a significantly higher value (66.0) than the solid fat (25.0). This indicates that the melted fat takes on a more pronounced yellow hue due to the greater oxidation of unsaturated fatty acids during heating. This color difference should be taken into account in sausage production, where the percentage of fat used will directly affect the sensory perception of the color of the final product, particularly if melted or solid fat is chosen.

Therefore, using chicken fat as an ingredient in the formulation of processed meat products, whether melted or solid, will influence its color, a key attribute for consumer acceptance, depending on the percentages and types of fat employed in the product formulation.

Conclusions

There were no significant differences ($p \leq 0.05$) between the lipid profiles of the carcasses of chickens from the different processing farms, which is related to the stability of the feeding received by the birds in each of the facilities. Palmitic and oleic acids were the predominant fatty acids in chicken fat.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Author contributions

Yanelis Ruiz and Nahir Y. Dugarte: Conceptualization, data curation, formal analysis, investigation, methodology, supervision, validation, visualization, drafting the original manuscript and writing, review, and editing.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Statement on the use of AI

The authors acknowledge the use of generative AI and AI-assisted technologies to improve the readability and clarity of the article.

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