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Study of the Technological and Sensory Characteristics of Fat Extracted from Poultry Skins

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Abstract | This research aims to critically analyze chemical makeup of chicken skin fat in comparison to the tail fat. Color and odor characteristics of the extracted fat were also assessed. Morevoer, the fat was added to preparations of chicken breast sausages and the sensory qualities of the sausages changed were observed. Chemical analysis identified that chicken skin fat contains good amounts of fat and cholesterol, equal to what is found in tail fat. It had more moisture, protein and ash than tail fat. The refractive index, specific gravity and density of the extracted fat were 1.4456, 0.841 and 0.87010, respectively which were similar to those of tail fat. On the other hand, viscosity was lower, at 14.321 centipoise and the melting temperature increased to 46.0°C. Analysis of chemical constants proved that fat from the tissues was very similar to tail fat with respect to iodine value, peroxide value, acid value, unsaponifiable matter and ester value. A minor variation was found in the saponification value which was 198.23 mg KOH/g in chicken skin fat and 199.10 mg KOH/g in tail fat. In sausage preparation, higher quality, more acceptably flavoured sensory properties were seen in the extracted fat than in tail fat and the standard sample. There was a light-yellow color and had no smell at all. From this, it is noted that it is possible to extract fat from the surplus and cheap chicken skin to replace the expensive machine fat, due to its good properties and excellent qualities.

Keywords | Chicken fat, Physical properties of fat, Chemical constants of fat, Healthy low-fat sausage, Chemical content of chicken skin, Sensory properties of poultry fat

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INTRODUCTION

Today, agricultural waste and animal processing plant waste constitute valuable raw materials for the recovery of valuable compounds. Chicken skin is one of the most important by-products of chicken slaughtering plants, and it is often underutilized (Delavar and Farmani, 2018).

Chicken skin contains approximately 30-40% fat and 2-8% protein on a wet weight basis (Farmani and Rostammiri, 2015). The fat in chicken skin also has interesting properties that make it suitable for use in food technology. It contains lower amounts of saturated fatty acids and higher levels of n_3 and n_6 fatty acids compared to animal fat, lard, and palm oil (Farmani and Rostammiri, 2015). Chicken skin is also a good source of collagen and lipids, as also demonstrated by Sarbon *et al*. (2013). Idris *et al*. (2015) have pointed out, the abundance of chicken fat and skin as waste from the poultry industry is a vital environmental problem. The feasibility of converting waste chicken fat and skin into bio-oil was studied by extraction with analytical solvents, then the effects of temperature were verified. The temperature of 60 °C was chosen, and the hexane solvent with ultrasound achieved the highest production of bio-oil. While, Giusti (2009) showed that the increasing presence of chicken skins as waste from poultry factories negatively affects the economics of the poultry industry due to the cost of disposal as well as human health. He showed that extracting chicken skin fat with solvents ensures the extraction of oils in a better way. This is also what was explained by (Fernandez, *et al*., 2009) and also the sample of (Maher and Bressler, 2007) when extracting oils from animal waste and also (Wisniewski el at., 2010) who extracted oils from fish waste.

While, Soliman and El-Shattory (2020) demonstrated that surplus chicken skin from poultry processing plants can be used as a source of pure free fatty acids using the dry extraction method, studying the physical and chemical properties of these fats, and identifying fatty acids using gas chromatography. Feddern *et al*. (2013) have demonstrated the high potential for recycling waste, including chicken skin, a low-value waste that is rarely or insufficiently used in fat production and extraction from skins. They also demonstrated that chicken skin is rich in fatty acids such as oleic and palmitic acids, and that the former can be preserved or increased by reacting with modified fats and reducing the latter, making the resulting fat more applicable from a nutritional and technological perspective. The current study aimed to use surplus chicken skin in meat and poultry product manufacturing plants and extract fat from it using simple methods to replace expensive machine fat and introduce it into the sausage industry and conduct the necessary tests on it.

MATERIALS AND METHODS

Chicken skin was purchased at a poultry store in Baghdad. The vendor was willing to use a new method (applying low temperatures) to remove the feathers. The skin was taken off by hand, the meat was frozen a bit and then chopped into tiny pieces. About 100 g of the skin was measured out, then 50 mL of distilled water was added (this represents half the weight of the skin). Homogenization of the mixture at 2000 rpm was done for 30 seconds. After that, 200 mL of chloroform and 400 mL of methanol were blended together at 2000 rpm for one minute. Another 200 mL of chloroform was used, and the solution was stirred at 2000 rpm for 30 seconds before adding 200 mL of distilled water and stirring for another 30 seconds. Afterwards, the mixture was centrifuged at 2000–2500 rpm for 10 minutes, separating the extracted materials into three layers: the aqueous (lower layer), the semi-solid and the fat layer dissolved in chloroform. Once the fat was separated from the other parts, filtration with filter paper was done and then the solvent was evaporated at 50°C to collect the chicken skin oil (Ahmed and Al-Zaidi, 2023). Sensory evaluation was carried out on the oil and its chemical formula; physical properties and some chemicals were examined as well. The oil was used as a fat alternative in making sausages.

Chemical analysis

Following AOAC (2010), moisture, protein, fat and ash content were tested by standard methods. Those figures for cholesterol have been obtained by applying the method developed by Al-Salim (2014).

Physical properties

The physical properties such as refractive index, density and specific gravity were estimated according to the method of Pearson (1981). Viscosity was estimated according to the method of Sathe and Salunkhe (1981). The tables in Weast and Melvin (1982-1983) were used to extract the specific density and viscosity of water. The melting point was estimated according to what was mentioned by (Al-Salem, 2014) and what is mentioned in AOAC (2010).

Chemical constants

To obtain iodine value, peroxide value and ester value, Pearson's (1976) method described in Al-Ani (2001) was applied. The Pearson method from Pearson (1981) cited by Al-Salim (2014) was applied to find both the acid value and the saponification value. Unsaponifiable matter was examined following the IUPAC (1979) methods mentioned in Al-Salim (2014).

Sensory evaluation

To obtain iodine value, peroxide value and ester value, Pearson's (1976) method described in Al-Ani (2001) was applied. The pearson method from Pearson (1981) cited by Al-Salim (2014) was applied to find both the acid value and the saponification value. Unsaponifiable matter was examined following the IUPAC (1979) methods mentioned in Al-Salim (2014).

Statistical analysis

To test the effects of different samples on the parameters, the SAS Statistical Analysis System (2018) was used for statistical analysis by applying a Completely Randomized Design (CRD). Least Significant Difference (LSD) analysis was used to determine the differences between the means, with a significance level of 0.05.

RESULTS AND DISCUSSION

The results in Table 1 showed the chemical content of chicken skin, the fat extracted from it, and the fat from the machine. It is noted from the Table 1 that chicken skin was characterized by its high moisture, fat, and protein content, and low ash content, recording 39.88% moisture and 35.02% fat. These results are consistent with the findings of (Abdul-Rahim and Al-Abbadi, 2015) when they studied the chemical content of chicken skin before preparing gelatin. Meanwhile, the protein and ash contents, reaching (1.02, 23.14%, respectively, were consistent with the findings of (Abdul-Rahim, 2006) when they studied the chemical content of chicken skin before extracting the gum from it. The Table 1 also shows the chemical content of chicken skin fat and tail fat. It is noted from the Table 1 that chicken fat had a higher moisture, protein and ash content than tail fat, without significant differences at the (0.05) level, as it reached (1.73, 7.88, 10.45% for each of moisture, protein and ash, respectively. These results were consistent with Mohammadizhad and Farmani (2022) and were close to the results of Fermani and Rostammiry (2015) when they studied the chemical content of chicken skin before extracting gelatin and fat from it.

The percentage of fat and cholesterol was higher in the gluteal fat with slight, insignificant differences compared to chicken skin fat, reaching 78.15 and 85.43% in each of the chicken skin fat and gluteal fat, respectively. As for cholesterol, it was recorded at 164.00 and 179.00mg/100 g in both chicken skin fat and gluteal fat. These results were consistent with what was shown by (Farmani *et al*., 2016) when they estimated the physicochemical properties of chicken skin fat and (Feddern *et al*., 2010) when they studied the physicochemical properties of chicken skin fat. These values were higher than what was reached by (Al-Rubaie *et al*., 2017) when they estimated cholesterol in beef meat and fat.

It is also worth noting that the fat yield extracted from chicken skin reached 27.33%, which is close to and slightly higher than the 26.99% obtained by (Mahmoudnzhad and Farmani, 2022).

Data presented in Table 2 showed that the physical properties of chicken skin and buttock fat. The results of the statistical analysis showed that the average values of the refractive index, specific gravity, and density for both chicken skin and buttock fat were very good and did not differ significantly between them. The refractive index of chicken skin was (1.4556) and (1.4685). These values were close to what was reached by Kakhia (2006) when he showed that the refractive index of animal fats was (1.4641), while Atay *et al*. (1998) found that the refractive index of buttock fat was (1.4632). These results were also comparable to what was shown by Al-Salem (2014) when he estimated the refractive index of buttock fat at (1.4568). As for the specific gravity, it reached (0.841 and 0.993) in both chicken and buttock fat, respectively, without a significant difference between them. These values were close to what Al-Hussaini (2007) which showed that the specific gravity of animal fats is around (0.855), and is consistent with (Kakhia, 2006) who indicated that the specific gravity of animal fats is around (0.950-0.975) and the reason for the high specific gravity of fats is due to their high content of unsaturated fatty acids with multiple double bonds (Swern, 1979).

The density of chicken skin fat reached (0.87010), which is slightly less than the density of the machine fat, which is (0.89221). The reason for the variation in density is also due to the variation in its composition of unsaturated fatty acids with double bonds and the variation in their molecular weights. These results agreed with what was reached by

Table 1: Chemical content of chicken skin, fat extracted from it, and buttock fat.

Sample	Chemical content				
	Moisture %	**Protein %**	**Fat %**	**ash%**	**Cholesterol mg/100 g**
Chicken skin	39.88 ±2.47 a	23.14 ±1.26 a	35.02 ±1.94 b	1.02 ±0.06 b	-
Chicken fat	10.45 ±0.62 b	7.88 ±0.48 b	78.15 ±4.05 a	1.73 ±0.11 a	164.00 ±1.57 a
Buttock fat	6.65 ±0.37 c	5.93 ±0.32 b	85.43 ±4.79 a	1.10 ±0.04 b	179.00 ±18.93 a
Value L.S.D.	3.429 *	2.785 *	9.022 *	0.548 *	25.084 NS

Means with different letters within a column are significantly different from each other * (P≤0.05).

Table 2: Physical properties of chicken skin and buttock fat

Sample	Physical properties				
	refractive index	**specific gravity**	**Viscosity senti boys**	**Density**	**Melting point degrees celsius**
chicken fat	1.4556 ±0.24	0.841 ±0.07	14.321 ±0.68	0.87010 ±0.12	46.00 ±1.73
buttock fat	1.4685 ±0.19	0.993 ±0.11	15.644 ±0.73	0.89221 ±0.08	42.00 ±1.26
T-test	0.207 NS	0.186 NS	1.169 *	0.152 NS	3.72 *
* (P≤0.05).					

Kakhia (2006), as he mentioned that the density of animal fats is usually less than 0.9260. The results also agreed with Feddern *et al.* (2013) who have studied the fats extracted from chicken skin and fatty acids. The viscosity and melting point of chicken skin fat varied slightly compared to those of the veal fat in the statistical analysis tables.

It was noted that the viscosity of chicken skin fat reached 14.321 centipoise, which is lower than that of veal fat, which reached 15.644 centipoise. However, this difference was slight and insignificant. This was consistent with (Al-Salem, 2014), who showed that the viscosity of fats depends largely on their unsaturated fatty acid content. The higher the percentage of this type of acid in the oils, the lower their viscosity, and vice versa. These results were higher than the viscosity of the two-spoon golden oil studied by (Hanna, 2003), which was 0.8200 centipoise. The melting point of chicken skin fat was slightly higher, with insignificant differences, than that of the veal fat, reaching (46.00°C and 42.00°C) in each of them, respectively. This difference in the melting point values may be due to the difference in their content of saturated and unsaturated fatty acids, as the more unsaturated fatty acids they contain, the lower their melting point. The melting point of oils and fats also increases with the increase in the length of the fatty chain and decreases with the increase in the degree of unsaturation, and the melting point of fatty acids with an even carbon chain is higher than the melting point of fatty acids with an odd carbon chain (Swern, 1979). These results were consistent with what Al-Moussawi (2000) reached when comparing the physical properties of the melting point of many types of animal fats such as cows, camels and sheep. The results were also consistent with what Ziggers (2005) showed when he studied the melting point of sheep fat and found it to be 42°C. This was also confirmed by Atay el al. (1998), who determined the melting points of sheep fat and confirmed that they are higher than the melting point of animal butter. This was also confirmed by (IFHVP, 2005).

Table 3 showed the chemical constants of chicken skin fat and tail fat. It was noted from the Table 3 that the prepared chicken skin fat had very good properties compared to tail fat. When studying the iodine value, it was noted that chicken skin fat had a lower value than the iodine value of tail fat, with a very small difference, as the iodine value of both skin fat and tail fat reached (45.50 and 54.34), respectively. The high iodine value in fats means the presence of fatty acids with a higher degree of unsaturation. The more unsaturated fatty acids the fat contains, the higher its iodine value, and vice versa (USDA, 2005). These results were consistent with Hamilton (2004), who studied the iodine value of sheep tail fat and beef fat, and also close to what Maries (2010) found when studying the iodine value of various fats extracted from cows, sheep, pigs, and poultry.

The peroxide value (p.v) was higher in chicken fat (4.28 mEq/kg fat) compared to the tail fat (2.55 mEq/kg fat). Although the difference was significant at the level of (0.05), it was within the permissible limits and maintained its good qualities. The reason for the difference in peroxide values is due to the presence of more natural antioxidants in the unsoaped part of fats and oils, which are tocopherols that provide protection to the oil (Swern, 1979). These results were consistent with what Mohammadnezhad and Farmani (2022) reached, who found that the peroxide value of chicken skin fat extracted by several methods was recorded as (4.92 mEq/kg fat). It also agreed with what was stated by (Feddern *et al*., 2010) when studying the chemical constants of visible poultry skin fats, including the peroxide value and free fatty acids. It also agreed with Iskander and Mohamed (2010) when studying the peroxide values of chicken fat during a 6-month freezing period. It was also noted that the acidity and unsaponifiables values were slightly higher in chicken skin fat compared to machine fat, with the acidity values reaching (3.11, 2.52) mg KOH/g fat in each, respectively. This difference is attributed to the different sources of fat, which differ in their moisture and iron content. It is known that water and iron are factors that facilitate the hydrolysis process, which results in the decomposition of free fatty acids and, consequently, an increase in the acidity value measured in oils (Hsieh *et al*., 1989; Talburt and Smith, 1975). These results were consistent with (Knothe, 2007), who indicated that the source of fat and methods of preservation have the greatest impact on this value. The unsaponifiable substances increased significantly compared to chicken

Table 3: Chemical constants of chicken skin and buttock fat.

Sample	Physical properties					
	Iodine number	**Peroxide value milliequivalents/ kg fat**	**Acidity value mg KOH/g fat**	**Saponification value mg KOH/g fat**	**Unsaponifiable materials %**	**The value of the cover**
Chicken fat	45.50 ±2.17	4.28 ±0.17	3.11 ±0.13	198.23 ±13.47	0.695 ±0.16	196.53 ±17.37
Buttock fat	54.34 ±2.58	2.55 ±0.09	2.52 ±0.20	199.10 ±15.04	0.923 ±0.22	199.08 ±16.84
T-test	6.02 *	1.73 *	0.489 *	16.53 NS	0.207 *	15.32 NS

* (P≤0.05).

skin fat, reaching (0.923 and 0.695%) in each of them, respectively. The value of chicken skin fat was comparable to what Mahammadnezhad and Farmani (2022) reached when they studied this characteristic in chicken skin fat extracted by different methods. The difference in the content of unsaponifiable substances is due to the difference in their content of citrullinated substances and tocopherols. The high percentage of unsaponifiable substances reduces the exposure of oils to oxidation because they provide protection as natural antioxidants (Swern, 1979). These results were consistent with Alfredo (1993) when he estimated the value of unsaponifiable substances for beef fat and higher than the percentage of unsaponifiable substances indicated by AFOA (1996), which was renewed 1-2% as a maximum. The results also agreed with Al-Husseini (2007) when she studied these constants for machine fat.

As for both the saponification value and the esterification value, their values were close, and each of them increased slightly, insignificantly at the level of (0.05) in the buttock fat compared to the fat extracted from chicken skin. The saponification value was recorded as (199.10, 198.23) mg KH/g of fat, and the esterification value was (199.08, 196.53) in both the buttock fat and the chicken skin fat, respectively. The variation in these values is due, firstly, to the difference in the type of animal from which the fat was extracted, and secondly, to the difference in the fat content of fatty acids, which differ in the length of their chains and are linked to glycerides (Swern, 1979). These results were consistent with Atay *et al*. (1998) when they studied the saponification and esterification value of buttock fat, which amounted to (199.53 mg KOH/g fat) and chicken fat (198.73 mg KOH/g fat). These results also agreed with Al-Hussaini (2007) when she studied the esterification values of buttock fat, which amounted to 194.65, as she showed that the difference in esterification values between types of fats is due to the difference in the percentage of esterified carboxyl groups present in fatty acids.

Table 4 shows the sensory properties of chicken skin fat and lard. It is noted from the Table 4 that chicken skin fat was characterized by a light yellow color, while lard was beige (closer to white). Both types of fat were odourless. The slight difference in color may be due to the difference in the source used to prepare the animal fat. The prepared fat was used in preparing chicken sausage. Therefore, Table 5 shows the sensory evaluation scores for sausage made from chicken skin fat and its comparison with sausage made from lard. It is noted from the Table 5 that the sausage made from chicken skin fat was characterized by very good sensory properties compared to the standard comparison sample and the lard sample. It recorded the highest scores in color, tenderness, juiciness, and general acceptability compared to the lard and the standard sample. As for flavor, it recorded a value slightly lower than that of sausage made from lard, with a non-significant difference Toldra (2010).

Table 4: Sensory properties of chicken skin fat and buttock fat.

Sample	Sensory properties	
	Color	**Smell**
Chicken skin fat	light yellow	odorless
Buttock fat	Beige color	odorless

This was also demonstrated by Toldra and Reig (2011), who stated that the use of different ingredients in sausage production, as well as different cooking and preservation methods, clearly impacts the sensory properties of the prepared product. These results also agree with those of Kenijz *et al*. (2020) when they assessed the sensory properties of sausage prepared using vegetable fats and proteins. The results also agree with those of Abdulrahem *et al*. (2022) when they assessed the sensory properties of sausage prepared from chicken breast and chicken fat. The results also agree with those of Han and Bertram (2017) and Choe (2018) when they studied the sensory properties of sausage prepared from chicken.

CONCLUSIONS

We conclude from this study that the use of surplus and inexpensive chicken skin, which can be highly polluting when leftover, in the production and preparation of chicken skin fat with very good chemical, physical, and sensory specifications, as a replacement for expensive machine fat, is economically and technologically feasible. We extracted the

Table 5: Sensory evaluation scores for sausage made from chicken skin fat.

Sample	Sensory properties				
	Color	**Flavor**	**Juice**	**Softness**	**General acceptance**
T1	5.3 ±0.28	5.2 ±0.17 b	4.3 ±0.18 b	5.3 ±0.21	5.1 ±018 b
T2	5.6 ±0.31	6.0 ±0.24 ab	5.3 ±0.21 a	5.6 ±0.19	6.3 ±0.27 a
T3	5.5 ±0.24	6.3 ±0.29 a	4.6 ±0.25 ab	5.5 ±0.23	5.8 ±0.19 ab
value L.S.D.	0.439 NS	0.871 *	0.794 *	0.433 NS	1.07 *

Means with different letters within a column are significantly different from each other * (P≤0.05).

fat from chicken skin using organic solvents such as chloroform and methanol, and obtained animal fat with very good specifications, which we identified through studying the chemical fat indicators and the physical and sensory properties of the prepared fat. When introduced into food systems, it was highly accepted by evaluators.

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NOVELTY STATEMENT

This study is the first to comprehensively compare the chemical, physical, and sensory properties of fat extracted from chicken skin with conventional tail fat, highlighting its viability as a low-cost and high-quality alternative for use in sausage production. The research demonstrates that chicken skin fat, derived from underutilized poultry processing waste, possesses comparable or superior functional and sensory characteristics to traditional animal fats. This not only offers a sustainable solution for waste valorization but also introduces an economically beneficial ingredient into the meat processing industry.

AUTHOR'S CONTRIBUTION

MMA: Conceptualization, methodology, data collection, chemical and physical analysis, and manuscript drafting.
BAAA: Conducted sensory evaluation, contributed to statistical analysis, and assisted in result interpretation.
RMKA-Z: Supervision, project administration, review and editing of the manuscript, and correspondence with the journal.
All authors have read and approved the final version of the manuscript.

Generative AI and AI-assisted technology statement

In this study do not used Generative AI and AI-assisted technology statement.

Conflict of interest

The authors have declared no conflict of interest.

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