Using Chicken Secondary Products (Heads and Feet) to Enhance the Nutritional Quality of Cookies

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ABSTRACT

The chicken industry generates considerable amounts of secondary products, such as chicken heads and feet, which are usually discarded. The main objectives of this research were to assess the nutritional quality of chicken head powder (CHP) and chicken feet powder (CFP) and to explore their potential utilization in cookie production. The data showed that CFP recorded the highest content of ash (6.39%), protein (44.20%), and fat (16.35%) compared to other samples. Furthermore, cookies containing 10 percent of CHP or CFP were preferred by the majority of panelists. The addition of CHP or CFP significantly increased the cookies' spread ratio ($p \leq 0.05$). The amino acid profile illustrated that cookies samples with CHP or CFP (samples H10 and F10) recorded higher values of essential amino acids like histidine, phenylalanine, lysine, threonine, valine, leucine, and isoleucine when compared to the control. Additionally, oleic acid (18:1n-9) represented the major monounsaturated fatty acid. In contrast, linoleic acid (18:2n-6) was the most abundant polyunsaturated fatty acid, followed by linolenic acid (18:3n-3), with both recording their highest values in sample H10. This sample also contained the lowest content of linolelaidic acid (trans fatty acid). Indeed, the development of cookies using CHP or CFP with wheat flour will provide a nutritious food option (rich in protein and calcium) that is ready-to-eat for children. This study not only enhances the nutritional profile of the final product but also contributes to sustainability by reducing food waste.

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INTRODUCTION

The consumption of poultry meat (especially chicken) increased sharply around the world, and it is expected to increase globally by 2033 to represent 43% of the protein consumed from all meat sources **(OECD/FAO, 2024)**. Chicken processing generates significant by-products and wastes (two-thirds of the chicken processing yield, such as feet and neck bones), which could increase the environmental pollution **(Purwasih et al., 2019).** Moreover, **Akimova et al. (2023)** mentioned that chicken heads and feet were considered as secondary products of poultry, which are sold for pets as feed. These secondary products represent 5–7% of the bird's total weight. Chicken heads consist of the cheek, brains, eyes, tongue, and skull bones. Chicken heads contain protein, fat, minerals (especially calcium and phosphorus), and vitamins (like B12) (**Zhumanova et al., 2022; Suychinov et al., 2022; Gál et al., 2020**). On the other hand, feet consist of 3.5-4.0% of the body weight of the chicken's live weight and are regularly used as animal feed or in making soup mixtures **(Casey et al., 2001).** Chicken feet proteins contain collagen, which consists of amino acids like glycine, glutamic acid, proline, and hydroxyproline **(Hashim et al., 2014**); besides, **Purwasih et al., (2019)** illustrated that the feet flour contains calcium (4.31%) and phosphorus (2.47%). Different studies used poultry secondary products like heads, feet, neck, and bone flour in the manufacturing of different food products such as forcemeat formulations and cookies (**Akimova et al., 2023; Purwasih et al., 2019; Cornelia and Gozali, 2018).** Indeed, the original of cookie word (which was used in North America) is *'koekje'* (Dutch word), which means a little cake, while in Britain, they are known as biscuits (which are smaller and crisper). Cookies are not known as a staple food like bread; however, they are largely consumed by people of all ages (**Stroher et al., 2012**). Cookies are usually made from wheat flour. It is known that wheat proteins are considered nutritionally poor, and food products based on cereals are associated with high calorie and lack some essential amino acids like threonine and lysine according to **Jean et al., (1996).** Furthermore, wheat cookies with hydrogenated shortening contain high levels of trans fatty acids **(Dinç et al., 2014),** which correlate to cardiovascular disease risk **(Block et al., 2008).** Previous studies developed cookies with chicken by-products like chicken bone, feet, and neck bone flour **(Cornelia and Gozali, 2018; Purwasih et al., 2019).** On the other hand, chicken heads are commonly discarded or converted into feeds because consumers do not consider chicken heads as a desired raw material for other food applications (**Ee et al., 2019**). To date, no study has used chicken head powder to fortify cookies.

Therefore, this work aimed to evaluate the nutritional value of chicken secondary products and to study the effect of their substitution on the physical, chemical, and sensory properties of the developed cookies.

MATERIALS AND METHODS

Materials

Chicken secondary products (heads and feet) were obtained from the slaughterhouse (Giza, Egypt) immediately after slaugh-tering, and the samples (heads and feet) were transferred to an ice box to the Meat and Fish Technology laboratory at the Food Technology Research Institute. Other ingredients like wheat flour, powdered milk, soft sugar, chicken eggs, margarine, salt, and baking powder were obtained from the local market (Giza, Egypt). Furthermore, the chemicals in this study were purchased from El-Ghom-horya Company for Trading Drugs, Chemicals, and Medical Instruments, Cairo, Egypt

Methods

Samples preparation

Firstly, the chicken heads and feet were washed and drained. The nails and the thin yellow skin layer of chicken feet were removed and rewashed with cold water, and cut into small pieces. Subsequently, both of them were boiled at 100°C for 10-15 minutes and allowed to cool. In the case of chicken heads, the beaks were removed after boiling. Meanwhile, the bones were manually removed from the chicken feet. The resulting products were then spread on stainless steel trays and dried in an air oven (70 ± 1°C) for 16–18 hours until a constant weight was reached. The dried material was ground to fine powder using a food processor (Inalsa make), sieved, and stored (Fig. 1).

Preparation of cookies

Cookies (six types) were made by using wheat flour, various levels of chicken head powder (CHP) or chicken feet powder (CFP) were used to substitute the shortening content, besides sugar, and Spice mix (10% Caraway Seeds,10% Black Pepper,15% Cumin Seeds,15% Coria-nder,10% Aniseeds, 5% Cloves, 7% Mace, 5% Cardamon Dry, 7% Capsicum, 5% Dry Ginger Powder, 5% Cinnamon, 3% Nutmeg) were used according to the formulation given in the Table 1. All the ingredients were mixed in the bowl mixer for 2-3 minutes to make a homogenous emulsion. Then the prepared emulsion was put into cookies cookie-dropping bag having a stainless-steel nozzle of the desired shape at the end. The emulsion was dropped in trays and baked in a preheated hot air oven at 160 ºC (for 15-20 min. or till golden brown), then cooled and packed **(Berwal and Khanna, 2013).**

Analytical methods

Proximate composition analysis of raw materials and cookies samples

Moisture, protein, crude fat, and ash contents were determined in raw materials and cookies samples **(AOAC, 2000)**. Meanwhile, total carbohydrates were calculated by difference. Furthermore, the method of **Livesy (1995)** was used to calculate the caloric value.

Determination of mineral content in cookies samples

To determine calcium, magnesium, iron, copper, and zinc contents, the instrument

ICAP6200 (Inductively Coupled Plasma Emission Spectrometry) was used according to the method of **Isaac and Johnson (1985**). Sodium and potassium contents were determined according to **Chapman and Pratt** (**1961**) by using a flame photometer, Corning 400 instrument, whereas phosphorus content was determined by spectrophotometer (**Jackson, 1967**).

Determination of amino acids content in raw materials and cookies samples

The amino acid profile of samples was determined by using a Biochrom 20 automatic high-performance amino acid analyzer (according to the method described in **AOAC, 2000)**.

Fatty acids content in cookies samples

Methyl esters of fatty acids were prepared from total lipid (according to **ISO 12966-2, 2017).** The fatty acid methyl esters were created by using isooctane and methanolic potassium hydroxide, then the resultant solution was injected into the gas chromatograph. Fatty acid methyl esters were injected into (HP 6890 series GC) apparatus provided with a DB-23 column (60m x 0.32mm x 25µm). N2 was a carrier gas with a flow rate of 1.5 ml/ min, splitting ratio of 1:50. The injector temperature was 250˚C, and that of the Flame Ionization Detector (FID) was 280˚C. The temperature setting was as follows: 150˚C to 210˚C (at 5˚C/min), then kept at 210˚C (for 25 min.), while the peaks were identified by using standard methyl esters.

Sensory evaluation:

Sensory evaluation of cookies samples was conducted by ten consumers (staff members in the Meat and Fish Technology Research Department, Food Technology Research Institute, Agriculture Research Center). The panelists were familiar and had experience with these products. To evaluate the sensory attributes of color, taste, odor, texture, appearance, and overall acceptability of the prepared samples, the panelists used a 9-point hedonic scale, the no.1 implies extremely dislike, while no. 9 means highly liked (**Gelman and Benjamin, 1989).**

Physical characteristics

***Thickness, width, and spread ratio of cookies samples*:**

The Thickness (cm), width (cm), and spread ratio of cookies samples were evaluated in three cookies, while averages were recorded. Spread ratio was calculated as follows: Spread ratio =Width/ Thickness (**Rao and Manohar, 1997)**

***PH measurement*:**

The pH values of the cookie samples were determined according to **Turhan et al. (2005)** using an ICM 41150 pH meter instrument on homogenate samples (10 g of sample was mixed with 100 ml of distilled water).

***Color measurement*:**

The Color of cookies samples was performed with Lovibond Tintometer (The Tintometer LTD., Salisbury, UK). Data were further converted into CIE units by graphs of visual density **(Huffman and Egbert, 1990).**

Whereas ΔE value (color difference) represents the color difference between samples and the control according to Purlis et al. (2007) as the following equation:

$$\Delta E = \sqrt{\left(L_0^* - L^*\right)^2 + \left(a_0^* - a^*\right)^2 + \left(b_0^* - b^*\right)^2}$$

***Texture profile*:**

Cookies hardness was determined using a Texture Profile Analyzer (TPA) by a universal testing machine (Conetech, B type, Taiwan) provided with software. Hardness was calculated from TPA graphics in Newton (N).

RESULTS AND DISCUSSION

The analysis results of raw ingredients were reported **in Table 2.** The table revealed that the moisture content of wheat flour (WF), chicken heads powder (CHP), and chicken feet powder (CFP) were 13.19 ± 0.31%, 25.36 ± 6.84%, and 30.59 ± 1.95%, respectively. Similarly, **Berwal and Khanna (2013)** found that moisture content in refined wheat flour was 13.3±0.02%. Regarding ash content, Table 2 shows that the ash content of CFP recorded the highest ash value (6.39±0.94%), while wheat flour recorded the lowest value (0.69±0.024). Whereas **Cornelia and Gozali (2018)** found higher ash content in chicken bone flour (27.05-31.5%) than our findings, because we removed bones during the preparation of CFP. Furthermore, **Berwal and Khanna (2013)** found that ash content recorded 0.59 and 3.39% in wheat flour and chicken meat mince, respectively.

Table 2 shows that the protein content of chicken feet flour recorded the highest value (44.2%), while wheat flour recorded the lowest value. In this concept, **Gál et al. (2020)** showed that chicken feet are rich in gelatin and fat. Higher values of protein content in chicken bone flour were illustrated in another study (Cornelia and Gozali, 2018). Whereas **Berwal and Khanna (2013)** found lower protein content in chicken meat mince when compared to this study. On the other hand, the fat content of chicken feet flour recorded the highest value (16.35%) among all the studied samples, while wheat flour recorded the lowest value. This study was by **Cornelia and Gozali (2018),** who found that fat content in chicken bone flour ranged from14.59±1.10% to 16.03±0.61%. Furthermore, Table 2 illustrates that carbo-hydrate content recorded its highest value in wheat flour; however, the caloric value of wheat flour recorded the lowest value.

It could be seen from **Fig.2** that CHP and CFP contained higher levels of essential amino acids when compared to wheat flour. The most abundant amino acid in wheat flour was leucine (0.67%), followed by phenylalanine (0.51%). On the other hand, in CHP and CFP samples, arginine (3.77% and 6.15%, respectively) was the most abundant amino acid, followed by leucine (3.15% and 3.55%, respectively). Whereas Edris et al. (2012) showed lower contents of arginine (3.18%) and phenylalanine (1.94%) in chicken thigh, when compared with our findings. Indeed, histidine (which is recommended for children's growth according to

Ogungbenle et al. (**2013**) recorded its highest level in sample CFP (0.97g/ 100 g sample). Although lysine content is known to be deficient in wheat flour (0.22%), samples CHP and CFP exceeded the previous value.

The data from **Fig.2** encouraged us to use CHP and CFP during making cookies. Various levels of CHP and CFP are used in making cookies and presented **in Fig.3** to optimize the addition levels of chicken head powder (CHP) and chicken feet powder (CFP) in cookies**.** The data showed a non-significant **(*p* > 0.05)** decrease in all sensory parameters (taste, color, odor, texture, appearance, and overall acceptability) scores of cookies incorporated with 10% CHP or 10% CFP, when compared to the control sample. However, the same scores decreased significantly when the percentages of CHP and CFP increased in cookies to 20% and 30%. A similar observation was reported by **Berwal and Khanna (2013**) in sensory quality parameters when they used ground chicken meat during the manufacturing of cookies. Another study found that substitution of wheat flour with chicken bone flour during the making of cookies resulted in a darker color, foreign aroma, and an unexpected taste when compared to the control (**Cornelia and Gozali, 2018**). Whereas in our study, CHP or CFP was used to substitute shortening (not wheat flour), which resulted in more acceptance between panelists when compared with those previous studies. Furthermore, our data showed that the effect of CHP incorporation on the sensory properties of cookies was slightly better than that of CFP. Indeed, the statistical analysis of sensory evaluation data showed that using 10% CHP (sample H10) or 10% CFP (sample F10) was the optimum level, because this addition level caused non-significant differences in taste, color, texture, and appearance in both formulas, when compared to control samples. So, this level was chosen while making cookies in this study.

Figure 4 shows that the control sample recorded the highest thickness. In contrast, the addition of 10% CHP or CFP (samples H10 and F10, respectively) significantly decreased thickness ($p < 0.05$) compared to the control (wheat cookies), which achieved a maximum value of 0.966 cm. Similar findings were reported by **Thongram et al. (2016),** who found that cookie thickness ranged from 0.57 to 0.94 cm. Furthermore, no significant differences were observed among the samples in terms of width. However, the incorporation of CHP or CFP significantly increased the spread ratio ($p < 0.05$), from 4.08 in the control to 7.13 in sample H10, while sample F10 recorded a value of 7.09. The lower spread ratio observed in the control sample could be attributed to the higher fiber content in wheat flour compared to poultry by-products. As reported by **Agrahar-Murugkar et al., (2014),** increased fiber content can retard cookie spread, leading to greater thickness and reduced diameter—an effect observed in the control sample. Conversely, the increased spread ratio in cookies containing CHP or CFP may be due to the higher protein content in these powders, which can lead to gluten dilution **(Sahni et al., 2018).** Our findings suggest that the addition of CHP positively impacts cookie quality. In support of this, Suriya et al. (2017) reported that higher spread ratios are associated with improved consumer acceptability of cookies.

The pH data values **(Table 3)** indicated that the control sample recorded 7.33±0.03. Although the addition of CHP (sample H10) significantly decreased the pH to 7.12±0.025, sample F10 recorded the highest value at 7.46±0.04; this increase could be attributed to the high content of basic amino acids (arginine, histidine, and lysine) in CFP (see Fig. 2) used to make sample F10. Additionally, **Kumar et al. (2023)** observed a significant increase in pH value when poultry byproducts powder was incorporated into pet food compared to the control sample. Table 3 displays the color of the cookies. The data revealed that the control sample had the highest L* value, while the addition of heads and feet powder reduced the L* values; similarly, Kumar et al. (2023) found that the lightness value decreased significantly ($P < 0.05$) with greater additions of poultry by-products powder in pet food. Furthermore, sample F10 had a lower L* value than sample H10 due to sample F10 having a higher pH value compared to sample H10. In this context, **Anadon (2002)** referred to the negative relationship between meat color and pH value. Additionally, sample F10 recorded the highest redness (a*) value, followed by the control sample. The elevated redness (a*) value of sample F10 could be attributed to the conversion of myoglobin in chicken byproducts powder to brown-colored metmyoglobin during the baking process **(Kumar et al., 2023).** While the control sample registered an a* value of 15.12, **Uthumporn et al. (2015)** noted that cookie color develops during the baking process due to the Maillard reaction and caramelization. Conversely, the b* and ΔE* values increased in cookies with the addition of CHP and CFP, with the highest yellowness (b*) recorded for sample H10. The rise in b* value may be due to the baking process, which caused the degradation or formation of certain color pigments **(Asadi et al., 2021)**. Subsequently, the ΔE values indicated lower color change in sample H10 compared to sample F10. Several factors influenced the browning reaction in cookies, including sugars, types of amino compounds, pH, water activity, and temperature **(Jan et al., 2016).**

The ingredients used in cookie manufacturing significantly affect hardness, as reported by Suriya et al. (2017). This property is closely tied to the interaction between protein and starch during processing and baking **(De Simas et al., 2009; Varastegani et al., 2015).** Texture Profile Analysis (TPA) data (Fig. 5) indicated that the hardness and adhesiveness values of samples H10 and F10 were significantly higher than those of the control, which recorded the lowest hardness value (31.45 N). The hardness increase in the fortified cookies could be attributed to the reduced fat content due to the partial substitution of shortening with CHP or CFP. This observation aligns with the findings of **Kumar et al., (2023),** who noted that a higher hardness is typically linked to lower fat content. Additionally, elevated protein content and stronger protein–protein interactions may contribute to firmer texture formation **(Cheng and Bhat, 2016; Sahni and Sharma, 2023),** potentially explaining the increase in hardness values observed in samples H10 (71.26 N) and F10 (44.28 N). In line with these findings, Sahni and Sharma (2023) reported that including legume protein isolates increased cookie hardness. Similarly, **Cornelia and Gozali (2018)** found that adding chicken bone flour during cookie preparation led to increased textural hardness. As for adhesiveness (i.e., the tendency of a material to stick to another surface), values were higher in cookies containing CHP and CFP (24.10 mJ and 23.40 mJ, respectively). This increase could be attributed to the presence of proteins, particularly gelatin, known for their strong adhesive properties **(Thomas et al., 2023).** Furthermore, sample F10 exhibited lower hardness and adhesiveness values than sample H10. This can be explained by the higher moisture and fat content in sample F10 compared to H10 (Table 4), both of which are known to reduce textural firmness and stickiness.

Proximate composition results **(Table 4)** showed that substituted fat with chicken head and feet powder during making cookies caused a significant increase in moisture content from 11.86% in the control sample to 15.43% in sample F10, while moisture content increased non-significantly ($P > 0.05$) in sample H10. A previous study by **Cornelia and Gozali (2018)** mentioned that feet flour and chicken neck had a non-significant ($P > 0.05$) effect on moisture content. On the other hand, our findings were consistent with the observation of **Berwal and Khanna (2013**). Whereas ash content increased significantly (from

1.64% in the control to 2.22% and 3.42% in H10 and F10 samples, respectively) after substitution of shortening with CHP or CFP, which referred to the mineral's enhancement in developed cookies. Similar trends were observed by **Cornelia and Gozali (2018)**. Likewise, **Purwasih et al., (2019**) showed that feet and necks could increase the ash level in cookies. Furthermore, protein content increased significantly when using CHP or CFP during cookie making, and sample F10 recorded the highest value (17.30%). Likewise, previous studies showed that the use of chicken feet, neck, or bone flour raised protein content in cookies (**Purwasih et al., 2019; Cornelia and Gozali, 2018**). The high protein content in sample F10 explained the high moisture content in the same sample, due to the role of protein content in enhancing water binding capacity after processing, which resulted in higher moisture content **(Sahni et al., 2018**). The current results were per **Arise et al., (2021).** They showed similar trends in moisture, ash, and protein content when they used Bambara groundnut protein isolate (BPI) during the making of cookies, when compared with the control. Regarding fat content, the data in Table 4 shows a significant ($p < 0.05$) decrease in fat content by using CHP or CFP as fat substitutions, which was expected. Our findings were following **Nasonova and Tunieva (2019**), who found that the addition of different types of fat replacers, like soy protein and collagen protein, instead of backfat, reduced the content of fat in cooked sausages. Furthermore, **Purwasih et al., (2019**) found that the average fat content in cookies ranged from 21.47 to 26.10%. On the other hand, caloric values of cookies (Table 4) decreased with CHP and CFP addition, when compared with the control (which recorded the highest caloric value). Our data referred to the high nutritional values of the developed cookies, as well as recorded lower caloric values.

Table 5 shows the macro (calcium, phosphorus, magnesium, and sodium) and micro (iron, zinc, copper, and manganese) mineral content of cookie samples. The results showed that the cookies supplemented with 10% CHP, or 10% CFP, caused an increase in calcium content ($p < 0.05$), while sample H10 recorded the highest value (3937.07 mg/100g). The increase in calcium content in these cookies samples could be attributed to the high content of calcium in chicken head bone **(Cornelia and Gozali, 2018)** showed that calcium content in chicken bone ranged from 14368 ± 1.55 to 18061.12 ± 54.20 mg/100 g. These results were by a previous study which was conducting by **Purwasih et al., (2019).** So, consumption of cookies samples containing chicken secondary products will increase daily calcium intake. Whereas **Katiyar (2022)** showed the calcium and its roles in the human body, which include bone and tooth structure, blood coagulation, muscle contraction, nerve current transmission, and glycogen synthesis. The cookies made from 100% wheat flour had the highest content of phosphorus (82.11 mg/100g) and magnesium (4.01 mg/100g), followed by sample H10. Moreover, sodium contents increased significantly ($p > 0.05$) with CHP or CFP addition during making cookies, while sample F10 recorded the highest level (1631± 13.15). Furthermore, the control sample recorded the highest iron value (2.27), followed by sample F10. Likewise, **Arise et al. (2021**) found that wheat cookies (100% wheat) were rich in iron content. whereas sample H10 recorded the highest content of zinc (0.99mg/ 100g).

Fig.6 shows the content of amino acids in cookies. It could be seen from the figure that samples H10 and F10 recorded higher values of non-essential amino acids like proline, serine, glutamic acid (the most abundant amino acid), glycine, alanine, and arginine, when compared to the control. On the other hand, cookies samples H10 and F10 recorded higher values of essential amino acid contents like histidine, phenylalanine, lysine, threonine, valine, leucine, and isoleucine when compared with control cookies. Indeed, histidine (which is recommended for children's growth according to **Ogungbenle et al. (2013)** recorded its highest level in sample H10. Whereas lysine content reported in this study exceeded the recommended intake for children and adults. Although threonine is known to be deficient in cereal proteins, cookies fortified with CHP or CFP had higher content of threonine, when compared to the control. Meanwhile, sample F10 contained the highest value of threonine, which could be because threonine is participating in the creation of collagen **(Saleeva et al., 2018**); and chicken feet proteins contain collagen. Furthermore, this study revealed that leucine was the most abundant essential amino acid in the cookies samples. Our findings were in line with **Berwal and Khanna (2013),** who found that incorporation of chicken in cookies raised lysine and threonine contents when compared to the control. The good nutritional attributes of cookies made with CHP or CFP could be attributed to the amino acid profile of chicken secondary product powder **(Fig.2)**. Furthermore, control cookies had the highest content of methionine (0.45g/ 100g). Moreover, **Sahni and Sharma (2023**) found lower contents of amino acids in cookies made from wheat flour, when compared to this study. Fig. 6 shows that sample F10 contained the highest content of hydrophilic (2.91 g/ 100g sample), hydrophobic (5.44 g/100g sample), basic (1.54 g/100g sample) and acidic (4.42 g/100g sample) amino acids when compared with other samples, while control sample recorded the lowest value. Hydrophobic amino acids could function as antioxidants by raising peptides' solubility in lipids, and that will increase the interactions with free radicals **(Arise et al., 2016**). Furthermore, **Yin et al., (2023**) show that the flavor amino acids were classified as umami-taste amino acids, such as glutamic and aspartic, whereas sweet-taste amino acids like alanine, serine, glycine, proline, threonine, and glutamine, all recorded their highest content in sample F10. Thus, the cookies made with CHP or

CFP could enhance the essential amino acids content in the human diet.

Fatty acid composition **(Table 6)** revealed that the predominant saturated fatty acids (SFAs) in cookies samples were palmitic acid (16:0), followed by stearic acid (18:0). The highest content of palmitic acid was found in control cookies, while cookies containing CHP recorded the highest content of stearic acid. Furthermore, oleic acid (18:1n-9) represented the major monounsaturated fatty acid (MUFA). Linoleic acid (18:2n-6) was the most abundant polyunsaturated fatty acid (PUFA), followed by linolenic acid (18:3n-3), and both recorded their highest values in sample H10. On the other hand, trans fatty acids (which are an indicator of hydrogenated fat according to **Ahmadi and Marangoni, 2009),** like Linolelaidic acid, recorded its lowest value (0.243) in sample H10. Indeed, higher levels of trans fatty acids in food will increase the risk of several diseases (**Mozaffarian et al., 2006**). Moreover, the trans fatty acids up to 0.5 g/100 g of biscuits are considered insignificant (**Amrutha Kala, 2014).** The substitution of shortening by CHP or CFP had a positive effect on the ratio between the unsaturated fatty acids and saturated fatty acids, and this ratio recorded its highest value in sample H10 (0.904). Whereas **Stroher et al. (2012)** found that the ratio between PUFA and SFA was higher than 0.45 in salty cookies and butter cookies.

CONCLUSION

This study evaluates the sensory properties and nutritional quality of cookies supplemented with chicken secondary products. Cookies containing 10% chicken head powder showed no significant differences in any sensory parameters compared to the control sample. The addition of chicken head powder (CHP) and chicken feet powder (CFP) during cookies preparation improved the protein and ash contents while reducing fat and caloric values. Moreover, cookies supplemented with 10% CHP exhibited the highest calcium and zinc contents. Amino acid profiling revealed that the protein quality of cookies enriched with CHP or CFP was superior to that of the control. Additionally, cookies containing CHP recorded the highest levels of essential fatty acids. Overall, this study demonstrates that incur-porating chicken secondary products enhances the nutritional quality of cookies. The resulting products may help increase protein and calcium intake, potentially reducing the risk of malnutrition and bone loss, particularly among children- while also contributing to environmental sustainability by reducing poultry industry waste.

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Zhumanova G; Zinina O; Rebezov M; Shariati MA; Moldabayeva Z; Khayrullin M; Baybalinova G; Toleubekova S and Mirasheva G (2022):
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Table 1: Formulation of developed cookies processed with various levels of chicken heads and feet powder.

Samples / Ingredients	C(Control)	H10	H20	H30	F10	F20	F30
Refined wheat flour (g)	100	100	100	100	100	100	100
Chicken head powder(g)	-	10	20	30	-	-	-
Chicken feet powder (g)	-	-	-	-	10	20	30
Shortening (g)	40	30	20	10	30	20	10
Sugar powder (g)	25	25	25	25	25	25	25
Whole liquid egg (g)	15	15	15	15	15	15	15
Spice mix* (g)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Salt (g)	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Baking powder (g)	1	1	1	1	1	1	1
Milk (buffalo) (ml)	25	25	25	25	25	25	25
Vanilla essence (drops)	5	5	5	5	5	5	5
Coloring agent (Chocolate solution 1%) (ml)	3	3	3	3	3	3	3

*Spice mix: 10% Caraway Seeds (*Ajwain*),10% Black Pepper (*Kali Mirch*),15% Cumin Seeds (*Zeera*),15% Coriander (*Dhania*),10% Aniseeds (*Soanf*), 5% Cloves (*Laung*), 7% Mace (Javitri), 5% Cardamon Dry (*Budi Elaichi*), 3% Cardamon Dry (*Chhoti Elaichi*), 7% Capsicum (*Mirch Powder*), 5% Dry Ginger Powder (*Soanth*), 5% Cinnamon (*Dalchini*), 3% Nutmeg (*Jaifal*).

Table 2: Gross chemical composition and caloric value of wheat flour, chicken head powder, and chicken feet powder.

Samples / Parameters%	WF	CHP	CFP
Moisture	13.19 ^{b} ±.311	25.36 ^{a} ±6.84	30.59 ^{a} ±1.95
Ash*	0.69 ^{c} ±0.024	2.81 ^{b} ±0.222	6.39 ^{a} ±0.94
Protein*	11.10 ^{c} ±0.36	37.0 ^{b} ±0.28	44.20 ^{a} ±0.25
Fat*	1.34 ^{c} ±0.06	13.51 ^{b} ±0.55	16.35 ^{a} ±0.14
Carbohydrates**	86.87 ^{a} ±0.35	46.67 ^{b} ±0.86	33.05 ^{c} ±0.95
Caloric value*	403.9 ^{b} ±0.23	456.3 ^{a} ±3	456.16 ^{a} ±3.1

WF: Wheat flour; CHP: Chicken heads powder; CFP: Chicken feet powder.; * g/ 100g on dry weight basis; **Carbohydrates calculated by differences; $^{a-c}$ Means ±SD (standard deviation) of triplicate with different small letters in the same row differ significantly at $p<0.05$.

Table 3: pH and color values of cookies samples

sample	pH	L*	a*	b*	ΔE*
C	7.33±0.03b	49.76±0.13a	15.12±0.03b	18.87±0.01c	-
H10	7.12±0.025c	41.41±0.02 b	13.62±0.017c	30.01±0.04a	14±0.11b
F10	7.46±0.04a	39.48±0.017c	16.54±0.026a	29.16±0.026b	14.61±0.11a

C, H10, F10 cookies samples made according to the formula in Table 1. [a-c] Means of triplicate ±SD (standard deviation) with different small letters on columns differ significantly at p<0.05.

Table 4: Gross chemical composition and caloric value of cookies

Parameters	C	H10	F10
Moisture	11.86±0.44b	12.21±0.69b	15.43±0.91a
Ash*	1.64±0.1c	2.22±0.08b	3.42±0.11a
Protein*	12.60±0.81c	15.40±0.34b	17.30±0.25a
Fat*	20.83±0.34a	16.06±0.22c	16.68±0.34b
Carbohydrates*	64.93±1.21a	66.32±0.37a	62.60±0.61b
Caloric value*	497.59±1.31a	471.42±1.40b	469.72±1.62b

C, H10, F10 cookies samples made according to formula in Table 1.; * g/ 100g on dry weight basis; **Carbohydrates calculated by differences; [a-b] Means of triplicate ±SD (standard deviation) with different small letters in the same row differ significantly at p<0.05.

Table 5: Mineral content of cookies (mg/ 100g on a dry weight basis)

Minerals	C	H10	F10
Ca	610.82 [c] ±2.0	3937.07 [a] ±4.27	842.01 [b] ±2.53
P	82.11 [a] ±0.84	77.1 [b] ±0.27	73.82 [c] ±1.87
Mg	4.01 [a] ±0.087	3.71 [b] ±0.141	3.62 [b] ±0.044
Na	362.18 [c] ±8.29	1499.64 [b] ±18.17	1631.32 [a] ±13.15
Fe	2.27 [a] ±0.088	1.8 [c] ±0.055	1.94 [b] ±0.036
Zn	0.68 [b] ±0.05	0.99 [a] ±0.11	0.62 [b] ±0.044
Cu	0.15 [a] ±0.017	0.11 [b] ±0.01	0.11 [b] ±0.026
Mn	0.6 [a] ±0.03	0.53 [b] ±0.036	0.52 [b] ±0.017

C, H10, F10 cookies samples made according to the formula in Table 1; [a-b] Means of triplicate ±SD (standard deviation) with different small letters in the same row differ significantly at p<0.05.

Table 6: Fatty acids (%) composition of cookies.

Fatty acids	C	H10	F10
caproic acid (C6:0)	0.309	0.423	0.396
caprylic acid (C8:0)	0.309	0.436	0.451
capric acid (C10:0)	0.631	0.787	0.731
lauric acid (C12:0)	1.426	1.882	1.697
Myristic acid (C14:0)	3.045	3.58	3.522
pentadecanoic acid (C15:0)	0.48	0.305	0.313
Palmitic acid (C16:0)	41.67	38.31	39.563
Myristoleic acid (14:1)	0.212	0.282	0.274
Heptadecanoic acid (C17:0)	0.218	0.265	0.278
Stearic acid (C18:0)	5.33	5.924	5.612
Arachidic acid (C20:0)	0.315	0.292	0.291
Behenic Linolenic acid (C22:0)	0.121	0.139	0.1297
Palmitoleic acid (C16:1T)	0.112	0.288	0.17
Palmitoleic acid (C16:1)	0.576	1.365	1.814
Cis-10-Heptadecanoic acid (C17:1)	0.119	0.122	0.124
Oleic acid (C18:1)	34.66	34.603	34.358
UNKNOWN	0.301	0.365	0.254
Linolelaidic acid (C18:2trans)	0.341	0.243	0.507
Linoleic acid (C18:2) *	9.468	9.829	8.578
C18:3n6	0	0	0.088
Linolenic acid (C18:3n3) *	0.382	0.562	0.377
Cis-11- Eicosenoic acid (C20:1)	0.19	0	0.284
Total saturated fatty acids (SFA)	53.854	52.343	52.9837
Total unsaturated fatty acids (USFA)	46.06	47.294	46.486
USFA/ SFA	0.855275	0.90354	0.877364
Total essential fatty acids*	9.85	10.391	8.955
C, H10, and F10 cookies samples were made according to a formula in Table 1.			

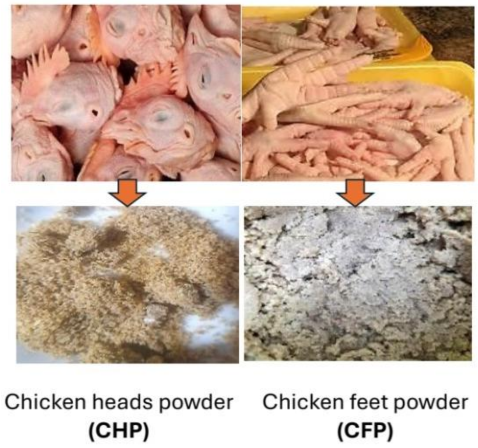

Fig. 1: Chicken heads and feet powder.

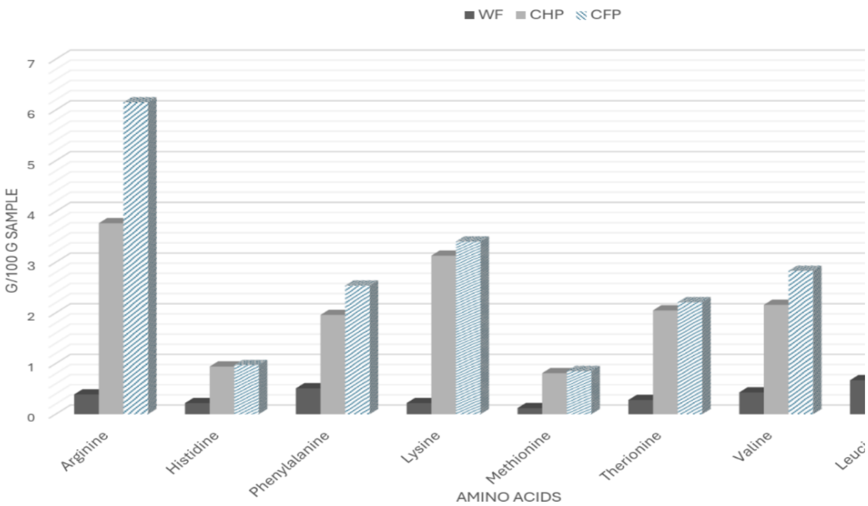

Fig.2: Essential amino acids content (g/ 100g sample) in wheat flour, chicken heads powder, and chicken feet powder.

WF: Wheat flour; CHP: Chicken heads powder; CFP: Chicken feet powder.

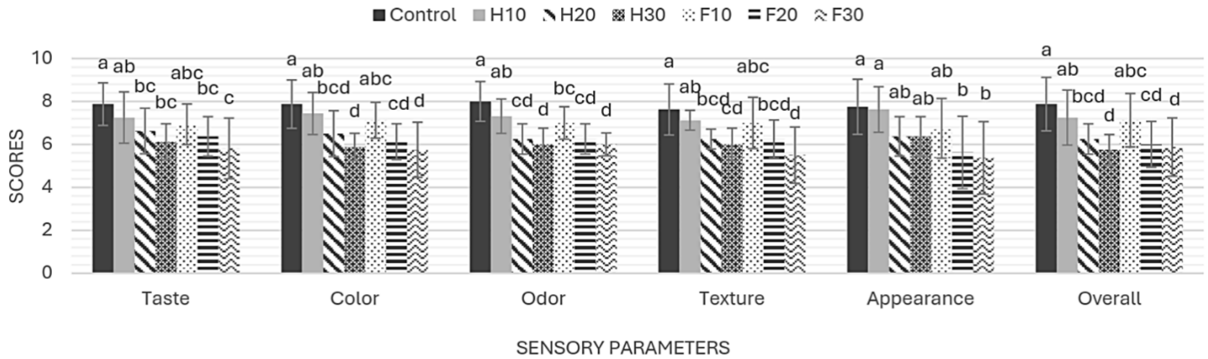

Fig.3: Sensory evaluation of cookies
C, H10, H20, H30, F10, F20, F30 cookies samples made according to the formula in Table 1. [a-d] Means ±SD (standard deviation) with different small letters on columns differ significantly at $p<0.05$.

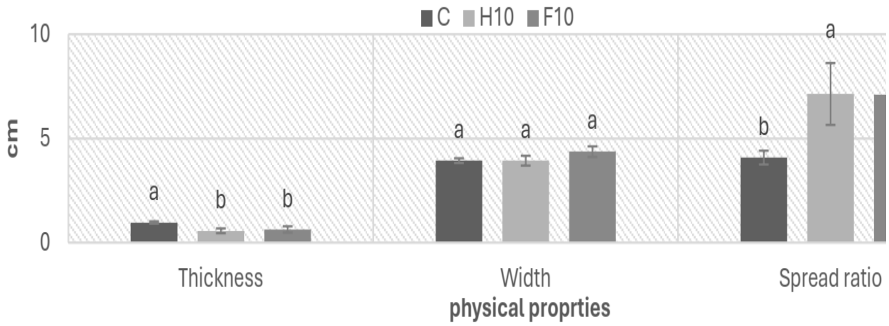

Fig.4: Thickness, width, and spread ratio of cookies.
C, H10, F10 cookies samples made according to the formula in Table 1. [a-b] Means ±SD (standard deviation) with different small letters on columns differ significantly at $p<0.05$.

Hardness (N)
Factorability (N)

Adhesiveness (mJ)

Resilience

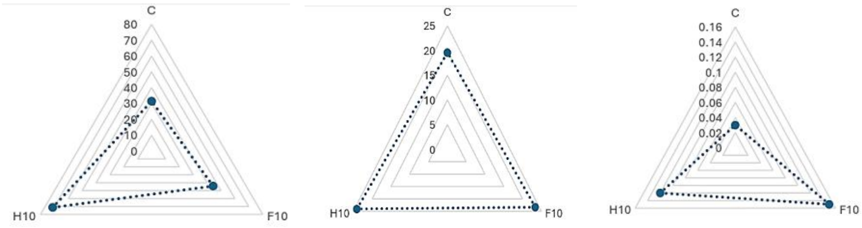

Fig.5: Texture profile analysis of cookie samples
C, H10, F10 cookies samples made according to the formula in Table 1

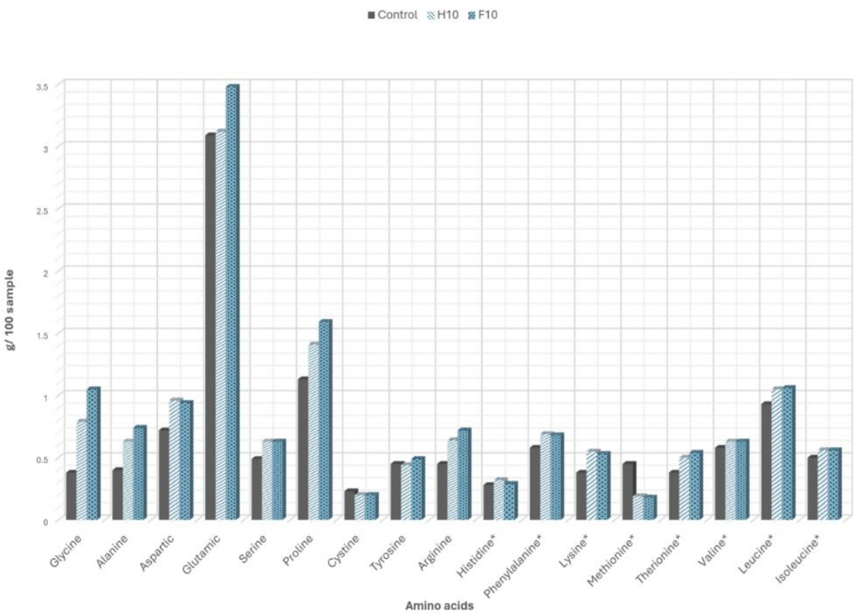

Fig.6: Amino acid contents in cookies samples.
C, H10, F10 cookies samples made according to a formula in Table 1.;
* Essential amino acids.

استخدام المنتجات الثانوية للدجاج (الرؤوس والأقدام) لتحسين الجودة الغذائية للكوكيز

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الملخص العربي

تنتج صناعة الدجاج كميات كبيرة من المنتجات الثانوية مثل رؤوس الدجاج والأقدام ، والتي عادة ما يتم التخلص منها. لذلك، كانت الأهداف المحددة الرئيسية لهذه الدراسة هي تقييم الجودة الغذائية لمسحوق رؤوس الدجاج (CHP) ومسحوق أقدام الدجاج (CFP) ، بالإضافة إلى استخدام هذه المنتجات الثانوية أثناء صناعة الكوكيز. أظهرت النتائج أن CFP يحتوي على أعلى نسبة من الرماد (٦,٣٩٪) والبروتين (٤٤,٢٠٪) والدهون (١٦,٣٥٪) مقارنة بالعينات الأخرى. علاوة على ذلك ، كانت عينات الكوكيز والتي تم استخدام ١٠٪ من CHP أو CFP أثناء تصنيعها هي المفضلة عند اجراء التقييم الحسي. أدت إضافة CHP أو CFP إلى زيادة معدل الانتشار في عينات الكوكيز بشكل كبير (p ≥ ٠,٠٥). بينما تحليل تركيب الأحماض الأمينية أوضح أن عينات الكوكيز المصنعة باستخدام CHP أو CFP (عينات H١٠ و F١٠) سجلت قيما أعلى لمحتويات الأحماض الأمينية الأساسية مثل الهيستيدين والفينيل ألانين والليسين والثريونين والفالين والليوسين والأيزولوسين عند مقارنتها بعينات الكوكيز الضابطة. علاوة على ذلك ، يمثل حمض الأوليك الحامض الدهني الأعلى بين الأحماض الدهنية غير المشبعة المحتوية علي رابطة زوجية واحدة ، بينما سجل حمض اللينوليك الحامض الدهني الأكثر وفرة بين الأحماض الدهنية غير المشبعة عديدة الروابط الزوجية، يليه حمض اللينولينيك وكلاهما سجلا أعلى قيمه لهما في العينة H١٠. بالإضافة إلى ذلك فان نفس العينة H١٠ احتوت على أقل محتوى من حمض اللينوليلاديك. إن تطوير الكوكيز باستخدام CHP أو CFP مع دقيق القمح يمكن ان يوفر طعاما غنيا بالبروتين والكالسيوم، جاهزا للأكل بين الأطفال. ان هذه الدراسة لا تعزز التركيب الغذائي للمنتج النهائي فحسب ، بل تساهم أيضا في تحقيق الاستدامة من خلال تقليل هدر الطعام.

الكلمات المفتاحية: *المنتجات الثانوية للدجاج، الكوكيز، الاحماض الامينية، الاحماض الدهنية*