CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

# QUALITY, ACCEPTABILITY AND SHELF LIFE OF CHICKEN NUGGETS PREPARED FROM DIFFERENT CHICKEN MEAT TYPES

**Opeyemi Abiala✉, Babatunde Omojola and Moses Abiala**

[1]*Department of Animal Science, Faculty of Agriculture, University of Ibadan, Oyo State, Nigeria.*
[2]*Department of Biological Sciences, College of Basic and Applied Sciences, Mountain Top University, Prayer City, Ogun State, Nigeria.*
✉*leadroleva@gmail.com*

https://doi.org/10.34302/crpjfst/2023.15.1.12

**Article history:**
Received:
25 October 2022
Accepted:
25 December 2022

**Keywords:**
*Chicken nugget,*
*Meat,*
*Proximate composition,*
*Chicken quality,*
*Broiler*

**ABSTRACT**

Quality, acceptability, and shelf-life of chicken nuggets prepared from different chicken meat types (broiler, spent layer and cockerel) were investigated. Raw chicken nugget pieces (n = 60, per chicken meat type) were deep-fried and representative samples were analysed for proximate composition, total cholesterol, lipid oxidation and microbial load. Product yield was calculated, and samples were assessed for sensory properties. Broiler chicken nugget had outstanding ($P<0.05$) crude protein content and product yield in comparison to spent layer and cockerel chicken nuggets. Interestingly, spent layer chicken nugget had remarkable ($P<0.05$) low ether extract and cholesterol content in comparison to other chicken meat types. Apart from the variation in the shelf-life based on microbial load especially from day 10 to 15, the chicken nuggets from different chicken meat types were equally accepted. Thus, spent layer and cockerel chicken meat types could also be useful raw materials for production of chicken nuggets. Most importantly, spent layer could be a ready choice for the production of products with reduced fat and cholesterol content which could be a more acceptable choice for the ever-increasing health conscious consumers.

## 1. Introduction

Globally, the production and consumption of poultry meat has increasingly progressed and in many nations of the world, per capita consumption (Yogesh et al., 2012) of poultry meat continues to grow. On similar note, poultry meat relevance have been applauded by United Nations Food and Agricultural Organization that speak of it as a readily available, inexpensive food especially in developing countries where it help in meeting up short falls in essential food nutrients. Its consumption also improves the quality of diets consumed in certain ages and conditions such as during pregnancy, lactation, and geriatric ages and during growth and development in young children (Cricelli et al., 2015).

Poultry products are universally popular, due to the fact that they are not subject to cultural or religious constraints and the meat itself is perceived as wholesome, healthy and nutritious, being relatively low in fat and with more desirable unsaturated fatty acid content (Khaksar et al., 2010; Issara et al., 2014). In addition, the bland flavour and soft texture characteristics of poultry meat makes it readily acceptable by meat processors for the development of further processed products (Petracci and Bianchi, 2012). This is as a result of its high soluble collagen, light colour as well as low-fat and high-protein content. Their ability to retain water (the one naturally present or added during processing) and the ability to achieve the desired final texture which in return increases meat water holding capacity (WHC) has made poultry meat highly sought after in the development of meat products (Cricelli et al., 2015).

Among the poultry meat products is chicken nugget. It is a ready – to – eat emulsion based food item that is gaining popularity with consumers. It is made from breast meat of broiler chickens and often battered or breaded before being deep-fried or baked. (Shai, 2015). However, due to the very tender nature of broiler chicken meat, many consumers are interested in the use of other chicken meat types which could improve the firmness and overall acceptability of chicken nuggets made from it (Mir et al., 2017). Thus, the use of other chicken meat types such as spent layers and cockerels in chicken nugget formulations need to be considered.

Recently, due to food insecurity, many countries have developed interest in processing spent layer meat into a more sustainable and profitable meat products (Petracci and Bianchi, 2012). In Brazil, a study at University of Sâo Paulo revealed that the meat of spent layer add healthier value to the mortadella-type sausage due to the fact that, the end product contains high polyunsaturated fatty acids and with a good polysaturated-to-saturated fatty acid ratio (Souza et al., 2011; Haris, 2019). Regarding cockerel, apart from the fact that it is hardy, tasty and well accepted, the meat is low in fat and cholesterol in comparison to broilers meat (Nonye, 2021). On this note, considering the health benefit in terms of low fat content and consumer preference for taste, spent layers and cockerels were considered as raw materials for chicken nugget in this study. We evaluated the quality, acceptability and shelf life of the chicken nuggets prepared from broiler, spent layers and cockerels.

## 2. Materials and methods

### 2.1. Meat source and preparation

Ten each of live broiler, spent layer and cockerel chickens weighing between 1.5-2kg were purchased from Zartech Farms in Ibadan, Nigeria. The birds were slaughtered, dressed and cut into primal parts. The breast meat were trimmed of skin, external fats and visible connective tissues. The meat samples were kept in the refrigerator (before chicken nugget preparation) at 4°C to keep the microbial load relatively low.

### 2.2. Preparation of non-meat ingredients

The dry spices (curry, thyme and red pepper) were sorted of extraneous matters, ground individually into powdery form and sieved through a 2 mm diameter sieve and kept in well covered containers until use. The fresh spices which include garlic and onion bulbs were cleaned, ground separately in a blender (model PNA 00582NW) and used on wet basis. Others which include powdered milk, soya oil, curing salt (NaCl), sugar, monosodium glutamate, and dry white corn seeds used for corn flour preparation were obtained. The dry corn seeds were sorted carefully to remove any extraneous matter such as stones, glass beads and dirt before grinding using grinder (Model BLSTMG, PN, 133093-002). The coarse particles were removed using a sieve of 2 mm mesh diameter. The fine powder was kept in an air- tight container until use. The chicken nugget recipe (g/100g) were as follows; chicken meat (70%), vegetable oil (7%), corn flour (10%), powdered milk (4%), curing salt

(0.8%), sugar (0.1%), ice flakes (6.0%), seasoning (2.1%).

## 2.3. Chicken nugget preparation

The recipe was used for chicken nugget production following standard procedures as described by Suradkar et al. (2013*)*. Chilled breast meat from each chicken type were ground using a Super Wolf (MADO MEW 513, Maschinferfabrik Domhan, Gmbh, Germany) grinder through 3mm sieve plate. Dry ingredients such as corn flour and powdered milk were added to each portion of the ground meat types. Slurry of curing salt, soya oil, ice water and seasoning as shown above was prepared and also added to each portion of the ground meat types. The ingredients were thoroughly mixed with the ground meat manually until a desired consistency was obtained. Batter from each chicken type was moulded into a round shape of 20 g per sample. A total of sixty chicken nugget pieces were prepared per chicken type. Chicken nugget samples were coated with rusk (ground oven dried bread) and then frozen at 10°C for 15 minutes. Raw chicken nuggets were deep fried using soya oil to a core temperature of 72°C using a probe type meat thermometer Model No 3504-66. The cooked chicken nuggets were kept at 4°C and sampled every five days throughout a period of 15 days for evaluation. The experiment was a complete randomized design (CRD). Each chicken meat type represent a treatment, making a total of three treatment. Each treatment was replicated six times.

## 2.4. Sensory evaluation of chicken nuggets produced from different chicken types

This was conducted using a 20 member semi-trained taste panels at each stage according to the method described by AMSA (1995). The taste panelists were made up of male and female students and workers in the Department of Animal Science, University of Ibadan in the age range of 25-45 years. Unsalted cracker biscuit and water were provided for mouth cleansing in between treatments. The room was well ventilated and devoid of all forms of distractions that could affect panelist. Chicken nuggets were blind coded and the orders of serving were randomized. Chicken nuggets were assessed using a 9- point hedonic scale for colour, juiciness, flavour, aroma, hotness, tenderness and overall acceptability.

## 2.5. Cholesterol content of chicken nuggets prepared from different chicken types

Cholesterol of the chicken nugget was carried out by adding 5 mL of chloroform into a conical flask containing 5 g of the sample and then ground. Additional 5 mL of chloroform and 10 mL of distilled water were added and mixed thoroughly. The mixture was poured into a separating flask and the lower layer was released into a test tube. 1mL of acetic anhydride and 1ml of concentrated sulphuric acid ($H_2SO_4$) were poured into the separated solution. Green colour was observed at the interface. Absorbance wavelength of the solution was measured in spectrophotometer at 640 nm (Nawar et al., 1991).

## 2.6. Proximate composition and product yield of chicken nuggets

Proximate analysis of all samples were determined according to AOAC (2000). Product yield was determined by measuring the difference in the sample weight before and after cooking. Product yield (%) = [Weight of cooked nugget / Weight of uncooked nugget] X 100.

## 2.7.Thiobubaturic acid reactive substances (Tbars) content in prepared chicken nuggets

The degree of lipid oxidation was determined for each meat and meat product sample at days 0, 5, 10 and 15. Thiobubatunic Acid Reactive Substances (TBARS) assay was done using the method of Zeb and Ullah (1990). 5g of each sample were weighed into the conical flask, 10 mL of distilled water was added and homogenized for 2 minutes. 2 mL of 10% Trichloroacetic Acid (TCA) was added and each was filtered through Whatman No 1 filter paper. Freshly prepared Thiobubatunic Acid (TBA) was added to each sample filtrate on ratio 1:1. A blank of 10 mL distil water, 2 mL of 10 % TCA and freshly prepared TBA were prepared in another conical flask. The solutions of each sample and the blank were stirred for 4 -5 seconds and stored in the dark for 1 hour to develop the colour (slightly reddish). Absorbance wavelength was measured using an (UV-Vis spectrophotometric CE1020 model, cecic-UK) at 530 nm. The results were expressed as mg malonaldehyde (MDA) per kg products using the formulae: TBA = K + OD5 nm, where K = 9.242.

### 2.8. Microbial load of of chicken nuggets prepared from different chicken types

Three different culture media were used to carry out the microbial analysis of chicken nugget samples. These were the nutrient agar, MacConkey agar and potato dextrose agar. Microbial assay was carried out using pour plating method and the plate was incubated at 37°C for 48 hours. Bacterial and fungi counts were determined from plates bearing the colonies. All analysis were carried out in triplicates for days 0, 5, 10 and 15.

### 2.9. Statistical analyses

Experimental treatments were compared using SAS software, version 9.1 (SAS Institute, Cary, NC, USA). For each of the experiment, replicated data sets were subjected to the analysis of variance (ANOVA) technique according to the experimental design to find out the significance of the treatments. ANOVA was also used to determine the effect of treatments and error associated with each experiment. Mean comparison of traits was used and carried out by protected LSD (p = 0.05; Students-Newman-Keuls Test) where the error mean square served as the standard error of differences between mean.

## 3. Results and discussions

### 3.1. Proximate composition of prepared chicken nggets

There were significant ($P<0.05$) variation in the proximate composition and total cholesterol content across the chicken nuggets prepared from broiler, spent layer and cockerel (Table 1). Specifically, the broiler meat had the highest moisture content (43.10%) and spent layer chicken nugget had the lowest (42.31%). The moisture content obtained for the chicken nugget from the different chicken meat types were higher than that of Ismed et al. (2009) from commercial chicken nuggets and also lower in comparison to that of Darwish et al. (2011) that had 52.4% in cooked beef burger. The differences in the moisture content obtained could be as a result of the differences in the WHC (Abd-El-Aziz et al., 2021) of the different chicken meat types used in this study.

The broiler chicken nugget had high crude protein content in comparison to the spent layer and cockerel chicken nuggets, this could be linked to both physical and chemical properties of the raw broiler chicken meat. At least to a certain extent, the spent layer (Souza et al., 2011) and cockerel chicken nuggets were comparatively similar to that of broiler chicken nugget. This suggest that when occasion arises, preference for protein from spent layer and cockerel chicken nugget could be considered. Interestingly, the chicken nuggets from spent layer had the lowest cholesterol content in comparison to broiler and cockerel chicken nuggets. This observation in the diet of birds have the potential to influence the amount of fat deposition especially in the raw meat (Souza et al., 2011; Verma et al., 2012; Kim et al., 2015). This implies that the low total cholesterol content of raw meat from spent layer could have resulted in a lower cholesterol content of cooked chicken nugget samples prepared from it.

The ether extract of chicken nuggets from broiler chicken meat had the highest value. This is however expected as broiler chicken meat are known for more accumulation of fat which could have resulted in higher value recorded. Spent layer chicken nugget, followed by cockerel chicken nugget had well pronounced nitrogen free extract in comparison to broiler chicken nugget with unremarkable nitrogen free extract. This agreed with the work of Reddy et al. (2016) that documented similar observation for spent layer meat against broiler meat types.

### 3.2. Yield, pH and acceptability of prepared chicken nuggets

Product yield is one of the very crucial factors in meat industry as it predicts the behaviour of a product when cooked. (Pietrasik and Li-chan, 2002; Souza et al., 2011). In this study, yield (%) of chicken nuggets from broiler meat were significantly ($P<0.05$) higher (80.14 %) than spent layer (77.89 %) and cockerel (78.50 %) which were comparably similar (Figure 1). This implies higher product yield (%) obtained in chicken nuggets prepared from broiler chicken meat could be linked to the ability of the chicken nugget to retain more moisture and fat during cooking thereby making it of higher economic value as the amount of marketable product produced is more than that of chicken nuggets prepared from cockerel and spent layers.

Next, we determined the pH. There were no significant ($P< 0.05$) differences in the values recorded for pH (emulsion and cooked nuggets) across the treatments (Figure 1). Most importantly, the pH values of the cooked chicken nuggets were higher than that of the emulsion (Verma et al., 2015). Though, not as high as 6.90 which could result in a number of negative changes, the most visible is seen in colour and microbiological stability of such product. (Aidani et al., 2014).

In order to assess acceptability of chicken nuggets from the different chicken meat types, sensory evaluation was carried out using scientific approach which include measuring, analysing and interpreting food characteristics as perceived by sense of smell, touch, sight and others (Grammatina et al., 2012). When meat goes into the mouth, certain characteristics which include juiciness, aroma, texture and flavour are factors that affects product organoleptic quality. All chicken nuggets produced from different chicken meat types were significantly ($P< 0.05$) similar and accepted. Specifically and without exception, aroma, colour, flavour, juiciness, tenderness and hotness enhanced sensory acceptability of nugget samples (Table 2). More often, consumers score chicken product acceptability based on colour (Rosli et al., 2011). Meat colour also depends on a number of factors which include chemical characteristics of meat pigment, its concentration, physical characteristics and presence of nonmeat ingredients, air, humidity, storage temperature, packaging method and type of package used (Sayago-Ayerdi et al., 2009). The aroma, flavour, juiciness and tenderness of chicken nuggets are known to increase with more fat in meat product. In all the eating qualities assessed for in this study, the panelists did not record significant ($P<0.05$) difference in the eating qualities of chicken nuggets (Raeisi et al., 2021) from different chicken meat types which probably is an indication that any of the chicken type could be used for nugget preparation without any adverse effect on eating quality.

### 3.3. Quality and shelf life of chicken nuggets as affected by chicken types and storage days

Lipid oxidation leads to lipid degeneration and development of oxidative rancidity in meat and its products (Jimenez et al., 2016). In this study, Lipid oxidation in terms of TBARS values were estimated over a period of 15 days. TBARS values increased as storage days increased. Chicken nuggets from broiler chicken meat were observed to have lower values from day 0 to 10. At day fifteen, the lowest TBARS values were obtained in chicken nugget prepared from spent layers with value 0.0378 mg/MDA/kg. However cockerel chicken nuggets had the highest TBARS which ranged from day 0 – 15 (Table 3). Worthy to note that all values recorded were lower than the threshold value of TBARS of 2.0

mg/MA/kg recommended by Witte et al. (1970). This could be attributed to the antioxidative property of soyabean oil which was used in frying the chicken nugget samples as it is known for its vitamin E content. Hence, all chicken nuggets estimated for TBARS are fit for consumption till day 15th of storage.

Thereafter, microbial quality of the cooked chicken nuggets were assessed (Egan et al., 2007). Microbiological results revealed that different chicken types influenced microbiological state of the chicken nuggets. Specifically, there were differences (P<0.05) in the values obtained for coliform, total bacteria and moulds across the treatments and over the period of storage which lasted for 15 days. It was observed that the microbial load increased with days of storage. On a more specific note, from day 5 – 15, cockerel chicken nuggets had highest coliform load in comparison to broiler and spent layer chicken nuggets. The broiler chicken nuggets attracts less bacterial load from day 0 – 15 compared to spent layer and cockerel chicken nuggets with more bacterial load over the period of 15 days. Surprisingly, chicken nugget from spent layers did not attract mould at all from days 0 - 15 (Table 4) while cockerel chicken nugget had more mould counts, followed by that of broiler chicken nugget (Sugiharto, 2019). This however could be attributed to the pH of the cooked nuggets as lower pH values have been reported to contribute to reduction in microbial activity in meat and meat products and vice versa (Aidani et al., 2014). However, the microbial load obtained for all chicken types are within the acceptable limits of 6.0 $\log_{10}$ cfu/g as reported by Shapton and Shapton (1991).

**Table 1.** Proximate of nutrient composition and cholesterol content of chicken nugget prepared from different chicken types

| Parameters | Broiler | Spent layer | Cockerel | SEM |
|---|---|---|---|---|
| Moisture (%) | $43.10^{c}$ | $42.31^{a}$ | $42.96^{b}$ | 0.007 |
| Crude protein (%) | $32.92^{a}$ | $32.20^{b}$ | $32.20^{b}$ | 0.006 |
| Ether extract (%) | $9.80^{a}$ | $9.42^{b}$ | $9.70^{a}$ | 0.015 |
| Ash (%) | $4.01^{a}$ | $3.60^{b}$ | $3.61^{b}$ | 0.002 |
| Crude fibre (%) | $0.89^{b}$ | $0.92^{a}$ | $0.89^{b}$ | 0.002 |
| Nitrogen Free Extract (%) | $9.28^{a}$ | $11.55^{c}$ | $10.64^{b}$ | 0.017 |
| Cholesterol (mg/100g) | $1.76^{a}$ | $1.34^{b}$ | $1.48^{a}$ | 0.010 |

$^{abc}$: Means in the same row with varying superscripts are significantly (*P*<0.05) different according to Student-Newman- Keuls Test (n=3). SEM: Standard Error of Mean

**Table 2.** Sensory evaluation of chicken nugget prepared from different chicken types

| Parameters | Broiler | Spent layer | Cockerel | SEM |
|---|---|---|---|---|
| Aroma | 4.75 | 4.63 | 4.75 | 0.172 |
| Colour | 4.70 | 4.63 | 4.28 | 0.288 |
| Flavour | 4.80 | 4.75 | 5.73 | 0.151 |
| Juiciness | 3.65 | 4.48 | 4.33 | 0.136 |
| Tenderness | 5.05 | 4.90 | 4.45 | 0.153 |
| Ropiness | 6.05 | 5.45 | 6.45 | 0.118 |
| Overall Acceptability | 6.48 | 6.45 | 5.98 | 0.104 |

$^{abc}$: Means in the same row with varying superscripts are significantly (P<0.05) different according to Student-Newman- Keuls Test (n=3). SEM: Standard Error of Mean

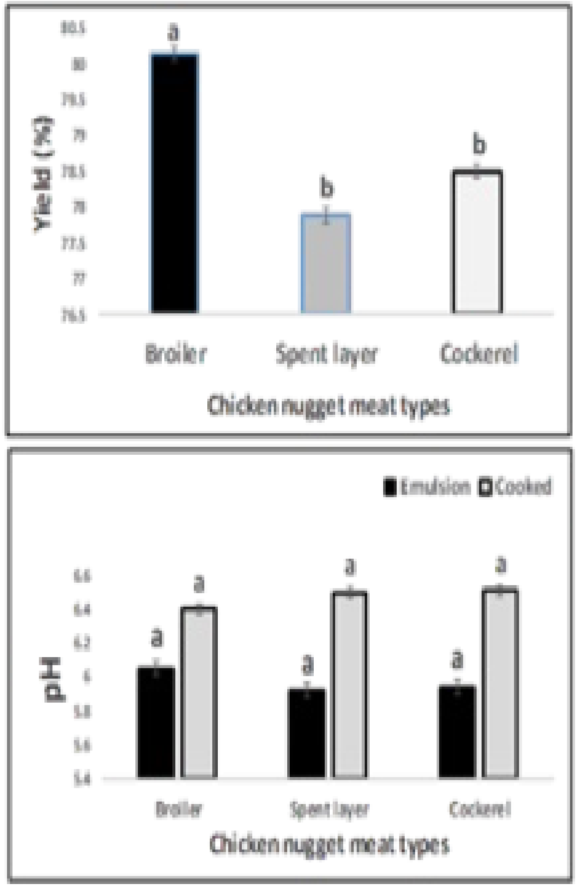


**Figure 1.** Yield (%) and pH (emulsion and cooked) of chicken nuggets from different chicken meat types. Means values with different letters among the treatments are significantly ($P$<0.05) different.

**Table 3.** Lipid oxidation of chicken nugget prepared from different chicken types

| Treatment | TBARS (mgMA/1000g) |
|---|---|
| Broiler | $0.0226^{b}$ |
| Spent layer | $0.0233^{a}$ |
| Cockerel | $0.0236^{a}$ |
| Standard Error of Means | 0.00004 |
| Time (Days) | |
| 0 | $0.0093^{d}$ |
| 5 | $0.0171^{c}$ |
| 10 | $0.0276^{b}$ |
| 15 | $0.0387^{a}$ |
| Standard Error of Means | 0.00006 |
| Interaction between chicken types and time (Days) | |
| Broiler 0 | $0.0095^{f}$ |

| | |
|---|---|
| 5 | 0.0168[e] |
| 10 | 0.0255[d] |
| 15 | 0.0385[ab] |
| Spent layer 0 | 0.0090[f] |
| 5 | 0.0175[e] |
| 10 | 0.0288[c] |
| 15 | 0.0378[b] |
| Cockerel 0 | 0.0093[f] |
| 5 | 0.0170[e] |
| 10 | 0.0285[c] |
| 15 | 0.0398[a] |

[abc…f] Means in the same column with varying superscripts are significantly (P<0.05) different according to Student-Newman-Keuls Test (n=3).

**Table 4.** Microbial counts (cfu/g x $10^3$) of chicken nugget as affected by chicken types and storage days

| **Treatment** | Coliform | Total Bacteria | Mould |
|---|---|---|---|
| Broiler | 0.500 [b] | 4.458[b] | 0.625[b] |
| Spent layer | 0.625[ab] | 5.500[a] | 0.000 [c] |
| Cockerel | 0.875[a] | 5.833[a] | 1.000[a] |
| SEM | 0.0625 | 0.1749 | 0.0442 |
| **Time (Days)** | | | |
| 0 | 0.000 [c] | 2.167[c] | 0.000 [c] |
| 5 | 0.333[b] | 2.833[c] | 0.500[b] |
| 10 | 1.000[a] | 4.500[b] | 0.500[b] |
| 10 | 1.333[a] | 11.556[a] | 1.167[a] |
| SEM | 0.0833 | 0.2332 | 0.0589 |
| **Interaction between chicken types and time (Days)** | | | |
| Broiler 0 | 0.000 [c] | 2.000[e] | 0.000 [d] |
| 5 | 0.000 [c] | 3.000[de] | 0.500[cd] |
| 10 | 1.000[ab] | 3.500[cde] | 0.500[cd] |
| 15 | 1.000[ab] | 9.300[b] | 1.500 [ab] |
| Spent layer 0 | 0.000 [c] | 2.500[de] | 0.000 [d] |
| 5 | 0.500[bc] | 3.000[de] | 0.000 [d] |

| | | | | |
|---|---|---|---|---|
| | 10 | $1.000^{ab}$ | $4.500^{cd}$ | $0.000^{d}$ |
| | 15 | $1.000^{ab}$ | $12.000^{a}$ | $0.000^{d}$ |
| Cockerel | 0 | $0.000^{c}$ | $2.000^{e}$ | $0.000^{d}$ |
| | 5 | $0.500^{bc}$ | $2.500^{de}$ | $1.000^{bc}$ |
| | 10 | $1.667^{a}$ | $5.500^{c}$ | $1.000^{bc}$ |
| | 15 | $1.500^{a}$ | $13.333^{a}$ | $2.000^{a}$ |

$^{abce}$: Means in the same column with varying superscripts are significantly (P<0.05) different according to Student-Newman- Keuls Test. The results shown are means ± standard error (n=3).

## 4. Conclusions

Apart from the fact that the chicken nuggets prepared using spent layers, cockerels and broiler chicken meat had equal over all acceptability ratings, each chicken meat type showed unique attributes; cockerel chicken nugget had improved product yield, while that of spent layer chicken nugget had reduced fat and cholesterol content. The three chicken meat types can be used in the preparation of quality and acceptable chicken nuggets. The spent layer meat could be a ready choice for production of products with reduced fat and cholesterol contents. Thus, using different chicken meat types for chicken nugget would increase availability of more raw materials for food/meat processors in the production of chicken nuggets and as well help reduce seasonal overproduction of these birds by converting them into storable ready to eat products.

## 5. References

Abd-El-Aziz, N., El Sesy, T., & Hashem, S. (2021). Evaluation of Nutritional Value and Acceptability of Chicken Nuggets Produced by Chicken Wings and Dehydrated Shellfish. *Food and Nutrition Science*, *12*, 805-817.

Aidani, E., Banafisheh, A., Akbarian, M., Morshedi, A., Hadidi, M., Ghasemkhan, N., & Ackbarian, A. (2014). Effect of chilling, freezing and thawing on meat quality. A review, *International Journal of Biosciences*, *5* (4), 159-169.

AMSA. (1995). Research guidelines for cooking, sensory evaluation and instruments measurements of fresh meat national livestock and meat board Chicago, I.L., USA.

AOAC. (2000). Official methods of analysis, 19th edition AOAC international, Inc.- Washington. D.C. 1219.

Cricelli, C., Corsello, G., Marangon, F., Ferrara, N., Ghiselli, A., Lucchin, L., & Poli, A. (2015). Role of poultry meat in a balanced diet aimed at maintaining health and wellbeing. *Italian concern document food and nutrition research*, *59*, 10-20.

Darwish, A. M., Ibrahim, A. M., Atanda, O. A., & Abdul-Salam, A. A. (2011). Effects of some nutritional additives on the quality and formulation cost of Beef Burger. *World Journal of Dairy and Food Science*, *6* (2), 180-188.

de Souza, K. M. R., Araujo, R. B., dos Santos, A. L, Rodrigues, C. E. C., de Faria, D. E., & Trindade, M. A. (2011). Adding value to the meat of spent laying hens manufacturing sausages with a healthy appeal. *Brazilian Journal of Poultry Science*, *13* (1), 57-63.

Egan, M. B., Rats, M. M., Grubb, S. M., Eves, A., Lumbers, M. L., Dean, M. S., & Adams, M. R. (2007). A review of food safety and food hygiene training studies in the mercial sector. *Food control*, *18*, 1180-1190.

Haris, C. (2019). Finding the value in processing spent laying hens. The Poultry Site (downloaded September 22nd, 2021).Thepoultrysite.com/articles/finding-the-value-in-processing-spent-laying-hens.

Ismed, L., Huda, N., & Ismail, N. (2009). Physicochemical and sensory properties of commercial chicken nuggets. *Asian Jounal of Food and Agro-Industry, 2* (02), 171-180.

Issara, U., Zzaman, W., & Yang, T. A. (2014). Review on rambutan seed fat as a potential source of cocoa butter substitute in confectionary product. *International Food Research Journal 21*(1), 25-31.

Khaksar, R. M., Hosseini, H., Taslimi, A., Ramezani, A., Amiri, Z., & Sabzevari, A. (2010). Comparison of lipid changes in chicken frankfurters made by soybean and canola oils during storage. *Journal of Veterinary Research, 11* (2), 154 -163.

Kim, H. Y., Kim, K. J., Lee, J. W., Kim, G. W., Choe, J. H., Kim, H. W., Yoon, Y., & Kim, C. J. (2015). Quality evaluation of chicken nuggets formulated with various contents of chicken skin and wheat fibre mixture. *Korean Journal of Food Science and Technology, 35*, 19-26.

Mir, N. A., Rafiq, A., Kumar, F., Singh, V., & Shuka, V. (2017). Determinants of broiler chicken meat quality and factors affecting them: a review. *Journal of Food Science and Technology, 54* (10), 2997-3009.

Nawar, W. W., Kim, S. K., Li, Y. J., & Vajdi, M. (1991). Measurement of oxidative interactions of cholesterol. *Journal of. American Oil Chemists' Society 68,* 496-498.

Nonye, B. (2021). Cockerel production, breeds and benefit of cockerel. Agric4Profits (downloaded September 22nd, 2021).agric4profits.com/cockerel-production-breeds-and-benefits/.

Petracci, M., & Bianchi, M. (2012). Functional ingredients for poultry meat prodcuts. XXIV World's Poultry Congress, 5-9. August. Salvador, Bahia, Brazil, page 1-14.

Pietrasik, Z. L., & Li-Chan, C. Y. (2002). Binding and textural properties of beef gels as affected by protein, carrageenan and microbial transglutamonase addition. *Food Research International 35,* 91-98.

Raeisi, S., Ojagh, S.M., Pourashouri, P., Salaün, F., & Quek, S. Y. (2021). Shelf-life and quality of chicken nuggets fortified with encapsulated fish oil and garlic essential oil during refrigerated storage. *Journal of Food Science and Technology,* 10.1007/s13197-020-04521-3.

Reddy, G. V. B., Mallika, E. N., Reddy, B. O., Azad, S., & Reddy, D. M. (2016). Comparison on meat quality characteristics of spent breeder, layer and broiler birds. *International Journal of Science, Environment and Technology, 5* (4), 2590-2595.

Rosli, W., Solihah, W. I., Aishah, M. A., Fakurudun, N. A., & Moshin S. S. I. (2011). Colour textural properties, cooking characteristics and be content of chicken patty added with oyster mushroom (*Pleurotus sajor-caju*). *International Food Research Journal 18,* 621-627.

SAS. (1999). Statistical analysis system Institutes. User's guide, SAS Institute Inc. Cary N.C: SAS Institute.

Sayago-Ayerdi, S.G., Brenes, A., & Goni, I. (2009). Effect of grape and antioxidant dietary fibre on the lipid peroxidation of raw and cooked chicken hamburgers. *LWT-Food Science and Technology, 42,* 971-976.

Shai, B. (2015). The Science of Poultry and meat processing. Chapter 14: pg 2-3.

Shapton, D. A., & Shapton, N. F. (1991). Principles and Practices for the safe processing of foods (PP. 377-444). Oxford: Butterworth – Heineman ltd.

Sugiharto, S. (2019). A review of filamentous fungi in broiler production. *Annals of Agricultural Science 64,* 1-8.

Suradkar, U. S., Bumla, N. A., Maria, A., Sofi, A. H., & Wani, S. A. (2013). Comparative quality of chicken nuggets prepared from broiler spent hen and combination meats. *International Journal of Food and Nutrition and Safety, 3* (3), 119-126.

Verma, A. K., Banerjee, R., & Sharma, B. D. (2015). Quality characteristics of low fat chicken nuggets: effect of salt susbstite blend and pea hull flavour. *Journal of Food Science and Technology, 52* (4), 2288-2295.

Witte, V. C., Krause, G. F., & Bailey, M. E. (1970). A new extraction method for determining 2-thiobartituric acid values of pork and beef during storage. *Journal of Food Science, 35,* 582-585.

Yogesh, K., Ahmad, T., Manpreet, G., Mangesh, K., & Das, P. (2013). Characterisitics of chicken nuggets as affected by added fat and variable salt contents. *Journal of Food Science and Technology, 50* (1), 191-196.

Zeb, A., & Ullah, F. (2016). A simple spectrophotometric method for the determination of thiobarbituric acid reactive substances in fried fast food. *Journal of Analytical Methods in Chemistry 11,* 1-5.

## Ethical Statements

The authors declare that they have no conflicts of interest

## Acknowledgements

The authors thank Mrs. Udor for her laboratory support.