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COOKING METHODS REVEALED DIFFERENCES IN QUALITY CONTENT OF PREPARED SOYABEAN EXTENDED CHICKEN NUGGETS

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ABSTRACT: *Soyabean extended chicken nuggets (SECN) were prepared, separately fried, grilled and roasted. The cooked nuggets were formulated as diets and fed to weaning rats (n=50) using standard casein and nitrogen free diets as controls. Quality attributes were assessed based on physico-chemical, sensory properties, proximate compositions, amino acids, total cholesterol and shelf stability in terms of lipid oxidation and microbial load as well as the effect of the feed on growth performance of weaned albino rats. Apart from slight variation (P<0.05), fried SECN, followed by grilled SECN improved yield, flavour, overall acceptability, crude protein and amino acid content in comparison to roasted SECN. The reduced lipid oxidation, total cholesterol and microbial load further enhanced the quality of fried SECN. Similarly, fried SECN was considered as the best based on daily feed intake, weight gained, feed conversion ratio, protein efficiency ratio and biological value. Thus, among the different cooking methods, deep-frying enhanced the quality of SECN better than other cooking methods as reflected in growth performance of weaned albino rats. Therefore, to harness acceptability of chicken nuggets, soyabean protein extender which is known for its ability to improve product firmness, chewiness and emulsion stability could be used alongside appropriate cooking methods to prepare chicken nuggets with excellent structural and nutritional qualities readily acceptable by consumers.*

KEY WORDS: chicken nuggets, soyabean, cooking methods, product yield and biological value

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INTRODUCTION

Among the poultry meats, chicken meat developed into chicken nuggets has gained popularity due to the variety of benefits such as reduced preparation time, their low cost, and long shelf life under frozen storage condition. Moreso, chicken nuggets have become an important ready for sale and to eat food served at almost all fast food restaurant chains (Abd-El-Aziz et al., 2021). As a result of this, there is an increasing demand for chicken nuggets with respect to preference for quality, taste and health value (Yogesh et al., 2013). This has led to the use of binders and extenders not only to meet up with consumers demand but also to decrease the cost of production (Yeater et al., 2017).

Well known among the extenders are plant proteins (Kyriakopoulou et al., 2021) which are of great importance in decreasing global shortage of animal protein and increased availability of wholesome food products culturally acceptable (Asgar et al. 2010). On this note, legumes and oil seed proteins cannot be under estimated because of their high protein content (Kyriakopoulou et al., 2021). So far, soyabean, is the most widely used legume based plant protein extender (Kurek et al., 2022; Ma et al., 2022) for chicken nuggets specifically in meeting demands for human consumption and palatability. In addition, the use of soybean plant proteins will not only reduce formulation costs but will also protect against cardiovascular diseases, increase bone mass and lowers blood lipid profile (Kurek et al., 2022). Also, soyabean plant protein has the potentials to improve product quality by helping to retain moisture during cooking, freezing, thawing and reheating (Riaz, 2005). However, there are a number of challenges confronting the use of these plant proteins, one of which is the presence of anti-nutrients in them. This obstacle can be successfully handled through the use of certain cooking methods which could help inactivate these anti-nutrients (Asgar et al., 2010).

Cooking contributes greatly to stability of meat and meat products, it plays vital role in providing variety of meat products which can be achieved by modifying cooking procedures. On the other hand, it influences odour compound formation which is the main cause of deterioration, undesirable odours, rancidity, texture modification, nutritional losses and toxic compound production in meat and its products (Pathera, 2016). Each cooking method has its own advantages and disadvantages depending on the type of product being processed. These various cooking methods through heat treatments further influences the organoleptic characteristics which include colour, flavour, texture, aroma, juiciness, tenderness and overall acceptability (Wo1oszyn et al.,2020; Honegger et al., 2022). Furthermore, cooking often affects the quality of dietary protein's primary structure which then influences its nutritional value and functionality upon gastrointestinal digestion (Danowska, 2009; Gerber et al., 2009; Cox et al., 2012). Better understanding of the complexity of the various cooking methods and its influence on the nutrient composition of meat and its product may contribute largely to increasing or decreasing consumer's expectation and acceptance of more convenient and healthy cooking choices (Alina et al., 2012; Honegger et al., 2022). Thus, the overall quality of nugget can be significantly affected by processing methods, raw materials and ingredient factors, thereby making nuggets with high nutritional value, low cholesterol, good textural properties, nice flavour and taste profile the favourite choice of consumers (Ismed et al., 2009). Therefore, this study was conducted to determine the effect of different cooking methods on yield and overall quality of chicken nuggets extended with soyabean flour.

MATERIALS AND METHODS

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Meat source and preparation

Ten of live broiler chickens weighing between 1.5-2kg were purchased from a reputable farm in Ibadan. 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.

Preparation of non-meat ingredients

The non-meat ingredients were purchased from commercial markets in Nigeria accordingly. The dry spices (curry, thyme and red pepper) were sorted of extraneous matters, pulverised individually and sieved through a 2 mm diameter sieve and kept in well covered containers until use. The fresh spices which included 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 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.

Chicken nugget preparation

A total of sixty chicken nugget pieces were prepared per treatment as described by Suradkar et al. (2013). Chicken nugget samples were coated with rusk (ground oven dried bread) and then frozen at 10°C for 15 minutes. Raw chicken nuggets were subjected to three different cooking methods which include deep-frying using soya oil, grilling and roasting to a core temperature of 72°C using a probe type meat thermometer Model No 3504-66. The chicken nugget recipe (g/100g) are as follows; chicken meat (70%), vegetable oil (7%), corn flour (10%), milk (4%), curing salt (0.8%), sugar (0.1%), ice flakes (6%), seasoning (2.1%).

Colour properties

Colour measurement was carried out using a Hunter Colorimeter model 45/0-L mini scan XE PLUS (Hunter Associates Labs, Reston, VA, USA) on the basis of three variables, namely, L, a, and b (American Meat Science Association-AMSA, 1991). The instrument was calibrated against a standard black as well as white reference tiles. The samples were placed in a transparent Petri dish and positioned directly on the light path to measure the colour parameter values of L, a and b. Four colour readings were taken from each chicken nugget sample and the average was used for analysis.

Yield, pH and sensory evaluation of prepared chicken nuggets

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. pH was carried out using 1g of chicken nugget samples which was homogenized in 9 mL distilled water for a period of 5 minutes. A pH meter (Model H18424 Micro-Computer, Havana Instruments, Romania) was inserted into each of the homogenate and pH for each sample was measured thrice and average value recorded (Marchion and de Felico, 2003). Sensory evaluation 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

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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, orders of serving were randomized and were assessed using a 9-point hedonic scale for colour, juiciness, flavour, aroma, hotness, tenderness and overall acceptability.

Proximate composition of chicken nuggets

Proximate analysis of all samples were determined according to AOAC (2000). Moisture, crude protein, crude fat, and ash content of cooked nuggets were determined. Moisture was determined using hot air oven. Crude protein was analyzed by kjeldhal's apparatus. Fat and ash contents were determined by using Soxhlet apparatus and muffle furnace, respectively.

Determination of amino acids

Essential amino acids were determined by the spectrophotometric method using ninhydrin chemical reaction according to Moore and Stein (1954). Percentage amino acid (%) was calculated as; Amino acid (%) = Absorbance of sample x Gradient factor x Dilution factor/10,000.

Thiobubaturic acid reactive substances (TBARS) content

The degree of lipid oxidation was determined for each meat and meat product samples at days 0, 5, 10 and 15. TBARS assay was done using the method of Zeb and Ullah (1990). Briefly, 5g of each sample was weighed into the conical flask, 10 mL of distilled water was added and homogenized for 2 min. To each homogenate, 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 secs and stored in the dark for 1 hr to develop the colour (slightly reddish). Absorbance wavelength was measured at 530 nm using a UV-Vis spectrophotometric CE1020 model, cecic-UK. The results were expressed as mg malonaldehyde (MDA) per kg products using the formulae: TBA = K + OD5 nm, where K = 9.242.

Cholesterol content

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. Other protocols were followed as described by (Nawar et al., 1991). Absorbance wavelength of the solution was measured in spectrophotometer at 640 nm.

Microbial load

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Three different culture media were used to carry out the microbial analysis of chicken nugget samples. These were nutrient agar, MacConkey agar and potato dextrose agar. Microbial assay was carried out using pour plating method (Reynolds, 2000) and the plates were incubated at 37±2^{o}C for 48 hours. Coliforms, bacterial and fungi loads were determined from plates bearing the colonies. All analysis were carried out in triplicates for day 0, 5, 10 and 15.

Preparation of experimental diets and experimental design

Preparation of experimental diets was done using chicken nuggets subjected to different cooking methods as described above while other feed ingredients used for the experimental diets were purchased from reputable stores at Ibadan, Oyo State Nigeria (Table S1). For the experimental design, fifty weaning albino rats with weights ranging between 60-62 g were purchased from Department of Biochemistry, University of Ibadan. The rats were allocated to five treatments of ten rats per treatment in a completely randomized design with each rat representing a replicate. Rats in each experimental treatment were housed singly in metabolic cages and allowed access to one of the five experimental diets which are stated as follows: T1, control diet (standard casein diet); T2, diet containing roasted soyabean extended chicken nugget (RSECN); T3, diet containing fried soyabean extended chicken nugget (FSECN); T4, diet containing grilled soyabean extended chicken nugget (GSECN); T5, nitrogen free diet (NFD). The rats were fed *ad-libitum* while they had free access to fresh cool water. The weight of each animal was taken at the beginning and at the end of the 21 days feeding trial.

Data collection and analysis from the rat study

Feed intake known as the feed consumed was calculated by subtracting the weight of the feed offered to the rats from the weight of the left over feed. For the body weight changes, rats were weighed before the experiment started to know the initial weight and were subsequently weighed at the end of each week. Body weight changes were calculated by subtracting the weights in the preceding week from weights of succeeding week. Feed conversation ratio, this was expressed as ratio of the average feed intake to the weight gain over same period. The protein efficiency ratio was determined as the ratio of grams of body weight gain to the grams of protein consumed and was calculated as protein efficiency ratio = Weight gain (g)/ Protein intake (g). Most importantly was the biological value and was unfolded as the percentage of absorbed nitrogen retained in the body for protein synthesis. The biological value determined as *N intake – (Feacal N – Urinary N) X 100/ N intake – Feacal N.*

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.

RESULTS AND DISCUSSION

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Colour differences

Cooking method is generally known to be a major factor that influences colour change (Table 1) in meat and meat products (Moya et al., 2021). Grilled SECN had the higher colour value, followed by roasted SECN and the lowest was recorded for fried SECN. On the other hand, there was no significant (P<0.05) differences in relation to colour across fried, grilled and roasted SECN. Colour of meat products could be affected by the amount of many factors which include water. This suggest that the higher value recorded for grilled SECN could be attributed to the moisture content (Ngoka et al., 1982; Mir et al., 2017).

Yield, pH and sensory evaluation of SECN prepared using different cooking methods

The yield, pH and sensory evaluation of SECN were reported in Table 1. The fried cooking method enhanced the SECN in comparison to grilled and roasted. This implies that the fried SECN were able to retain more fat and sufficient amount of water which could have improved yield of fried SECN and in-return higher economic value and an increase in amount of marketable products produced (Yogesh et al., 2013). The pH values of chicken nuggets as influenced by different cooking methods fell within the ideal pH for emulsified products which ranges between 5.8 - 6.3. Higher value of 6.39 was recorded in grilled chicken nuggets followed by 6.37 and 6.30 in fried and roasted samples. Meat with high pH has been reported to have better water retention capacity which in-turn brings about a positive influence on the products over all quality (Yogesh et al., 2013). The high pH value observed for grilled SECN has a direct relationship with the meat quality attributes which include colour as observed in our study. A direct correlation has been reported for the colour of the breast fillets and the pH of the meat (Flectcher, 1995). Apart from flavour and over all acceptability that were significantly (P<0.05) different in favour of fried SECN, other sensory properties such as aroma, juiciness, tenderness and hotness of the SECN were significantly (P<0.05) similar for all the cooking methods. On a more specific note, it was observed that the fried nuggets samples were better in terms of flavour even from the panelists as frying is known to enhance flavour in meat/meat products (Mir et al., 2017). This also could have contributed to an increase in the overall acceptability of the fried chicken nuggets samples with value 7.60 recorded in this study which is similar to the results by Yogesh et al. (2013) who reported similar observation for cooked chicken nuggets.

Profiles of proximate compositions

Mean values of moisture, crude protein, ether extract, ash content, crude fibre and nitrogen free extract are presented in Table 2. Fried and grilled SECN had higher moisture content in comparison to the low moisture recorded for roasted SECN. This however could be as a result of presence of crust formation during the frying and grilling process which could have brought about an increase in the rate of moisture retention as rate of evaporation is lowered during this period (Alfaia et al., 2010). In addition, the report of Mir et al. (2017) agreed with our observation that increase in the water content of muscles have the potentials to improve the quality and economical value of meat. The crude protein content of roasted SECN was lower in comparison to grilled and fried SECN. This suggest that the rate of denaturation of protein during roasting was faster which could have led to reduction in the crude protein content recorded in the roasted chicken nugget samples. The ether extract (fat) content of the fried chicken nuggets was higher in all the cooking methods used for SECN preparation. This is expected as frying of SECN samples could have contributed to higher values recorded for

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fried samples in this study. The ash content of grilled gave the highest value of 4.05%. This result supported the findings of Anabela et al. (2015) that grilling allows for higher ash retention than boiling or roasting.

Amino acid contents

Deeper understanding of heat treatments, its complexity and effects on meat product and nutrient present in them may improve consumer's expectation and acceptance of more convenient and healthy cooking methods. In all the amino acids assayed for, it was observed that isoleucine, methionine and tryptophan were higher in the grilled chicken nuggets compared to other cooking methods. Histidine content was similar for roasted, grilled and fried chicken nugget samples. Furthermore, grilled and fried chicken nuggets maintained similar values for leucine and lysine, , while they were of lower values for roasted chicken nuggets (Table 3). This could be attributed to the fact that grilling enhanced better hydrolysis of these amino acids which could have led to the higher content of amino acids. However, for roasted SECN samples, reduction in their amino acid content could be as a result of formation of hard and dry surface on the products, making the proteins hard to hydrolyse during amino acid analysis. (Fillion and Henry, 1998; Domínguez et al., 2022).

Quality of chicken nugget based on lipid oxidation

TBARS is widely used as an index for lipid oxidation of meat and meat products. There were significant ($P<0.05$) differences in the lipid oxidation among the different cooking methods and over the days of storage. From days 0 to 15, fried SECN had significantly lower ($P<0.05$) TBARS, followed by grilled SECN while roasted SECN had the highest from day 0 – 15. These values obtained were however within the acceptable limit of 1- 2.0 mg/MDA/kg (Kerth and Rowe, 2016) making all fit for consumption all through the storage days (Table 4). The low content of TBARS in fried samples, could be corroborated to the influence of soya oil which contains vitamin E, an antioxidant which could have suppressed the rate of lipid oxidation in the samples (Wann et al., 2021; Grootveld, 2022). The values recorded were similar to values obtained by Alfaia et al. (2010) who unfolded that roasting of burgers increased their level of lipid oxidation.

Quality of chicken nugget based on total cholesterol

Total cholesterol levels as affected by different cooking methods revealed that grilled and roasted chicken nugget samples had significant ($P<0.05$) lower total cholesterol content (Sam et al., 2021) compared to fried chicken nuggets (Table 4). This agreed with that of Yun-Sang Choi et al. (2010) where lower cholesterol content was obtained in Frankfurter samples containing rice bran with reduced fat. Frankfurter samples had cholesterol content which decreased by 45 – 50% compared to the control samples. Higher content of cholesterol in the fried samples could be due to the deep fat frying that was employed.

Shelf-life of chicken nuggets based on microbial load as influenced by cooking methods

In all the samples assessed, low microbial loads were observed (Table 4). Specifically, grilled SECN had significantly lower ($P<0.05$) microbial loads followed by fried SECN and roasted SECN. With respect to storage days, the microbial loads increase at day 5, then a decrease at day 10 followed by an increase at day 15. Similar trend was revealed based on interaction between cooking methods and storage days. Though, the microbial loads were at the

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acceptable limit (Ashok et al., 2016), however, the variation suggest production of certain metabolites which may have altered microbial succession (Rouger et al., 2017). Interestingly, coliforms (Martin et al., 2016) were not found at all. This implies that the absence of coliforms however indicate that chicken nuggets prepared using different cooking methods were all safe and fit for consumption up to the 15th day of production as their microbiological condition is good (Ashok et al., 2016).

Growth performance of weaned rats fed differently with processed SECN

Feed intake

The everyday intake of rats were 6.00, 7.52, 9.04, 8.00 and 2.00g for casein, roasted, fried, grilled SECN and nitrogen free diets respectively. However, fried SECN gave the highest ($P<0.05$) daily feed intake, followed by grilled SECN, roasted SECN, casein diet (control) and nitrogen free diet (Table 5). It was also observed that there was a difference ($P<0.05$) in the total feed intake when SECN was processed using different cooking methods were fed to albino rats. The daily feed intake of rats on diet containing fried chicken nuggets was higher compared to other diets. Higher feed intake by animals fed fried SECN indicated that the diet was more accepted by rats compared to other diets. Animals consume more when feed is of high flavour and palatability (Chikwendu and Obizoba, 2003; Pekel et al., 2020) as observed in our sensory evaluation study (Table 1) for flavour and over all acceptability.

Weight gain

Feed intake however had a strong influence on the weight gained by experimental animals as the highest value was again recorded in rats fed fried chicken nugget meal, followed by rats fed grilled chicken nugget and roasted chicken nugget meals compared to control diet (Table 5). It could as well be inferred that frying improved protein availability to a favourable level which in turn led to remarkable feed intake and body weight changes. This suggest that the weight gained by animals were partly influenced by feed intake probably due to the quality of feed consumed alongside with protein intake.

Feed conversion ratio, protein efficiency ratio and biological value

Feed conversion ratio and protein efficiency ratio follows similar significant ($P<0.05$) pattern (Table 5) which shows that rats on fried SECN was the best, followed by grilled, casein, roasted and the least for those on nitrogen free diets. Thus, the feed conversion ratio showed that fried chicken nugget meal was the best diet in terms of feed since it gave the lowest feed conversion ratio value. This could also be as a result of well-balanced amino acid profile of the meal which could have contributed to higher biological utilization of the diet to ascertain the nutritive value of proteins in relation to their essential amino acid. Rats on control diet (casein diet) was outstanding in comparison to other diets. However, in all the cooking methods employed, fried chicken nugget meals competed favourably with control diets while roasted chicken nugget meals had significant ($P<0.05$) lower biological values. These values, however implies that cooking methods had strong influence on the rate of protein digestibility and absorption in the body of the experimental animals. This agreed with the results of Tornberg (2005) that quality of dietary protein's primary structure is often influenced by various heat treatments which could affect their nutritional value and functionality upon gastro intestinal digestion.

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CONCLUSION

Among the different cooking methods, deep-frying revealed products with a higher product yield, flavour and overall acceptability. Also, the proximate compositions, amino acid contents and shelf-life stability in-terms of low lipid oxidation and microbial load as well as good growth performance contributed to high quality of fried SECN in comparison to grilled and roasted. Thus, the use of different cooking methods specifically deep-frying will not only uncover enhanced quality attributes but will also promote meat in-take to achieve targeted protein in-take through fried SECN by consumers.

Data availability

Not applicable for this study

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Conflict of interest disclosure

The authors declare that they have no conflicts of interest.

Ethics approval statement

Not applicable for this study

REFERENCES

Abd-El-Aziz, N.A., El Sesy, T.A., & Hashem, S.M. (2021). Evaluation of Nutritional Value and Acceptability of Chicken Nuggets Produced by Chicken Wings and Dehydrated Shellfish. *Food and Nutrition Sciences, 12,* 805-817. https://doi.org/10.4236/fns.2021.128060.

Alfaia, C. M., Alves, S. P., Lopes, A. F., Fernandes, M. J., Costa, A. S., Fontes, C. M., Castro, M. L., Bessa, R. J., & Prates, J. A. (2010). Effect of cooking methods on fatty acids, conjugated isomers of linoleic acid and nutritional quality of Beef intra-muscular fat. *Meat Science, 84* (4), 769-777.

Alina, A. R., Nurul, A. H. M., Siti, A. M., Shazamawati, Z. H., Nurulhuda, M. S.,Ummi Syuhada, H. S., & Imtinan, A. K. (2012). Effect of grilling and roasting on the fatty acids profile of chicken and mutton. *World Applied Sciences Journal, 17,* 29-33.

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

Anabela, F. L., Riscado, C. M., Alfaia, P. M., Prates, A. M., & Lemos, J. P. (2015). Influence of household cooking methods on amino acids and minerals of Barossa-PDO Veal. *Meat Science, 99,* 38-43.

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

 Article DOI: 10.52589/AJAFS-UKDNF8DU
DOI URL: https://doi.org/10.52589/AJAFS-UKDNF8DU

Asgar, M. A., Fazilah, A., Nurul, H., Bhat, R., & Karim, A. A. (2010). Nonmeat protein alternatives as meat, extension meat analogues. *Comprehensive review in food science and food safety, 9,* 513-529.

Ashok, K., Pathera, C.S., Yadav, R. S., & Singh, P. K. (2016). Effect of cooking methods on lipid oxidation, microbiological and sensory quality of chicken nuggets under refrigerated storage, *Cogent Food & Agriculture, 2,* (1), 1232472, DOI: 10.1080/23311932.2016.1232472.

Chikwendu, N., & Obizoba, I. C. (2003). Nutritional evaluation of protein quality of ground bean (*Kershingiella geocarpa*) based diets Nigeria). *Nutrition Science, 24,* 64-68.

Cox,S., Abu-Ghannam, N., & Gupta, S. (2012). Effect of processing conditions on phytochemical constituents of edible irish seaweed *Himanthalia elongata. Journal of Food Processing and Preservation, 36*(4), 348-363.

Danowska, M. (2009). The influence of cooking method on the quality of pork patties. *Journal of Food Processing and Preservation, 33*(4), 473-485.

Domínguez, R., Pateiro, M., Munekata, P. E. S., Zhang, W., Garcia-Oliveira, P., Carpena, M., Prieto, M. A., Bohrer, B., & Lorenzo, J. M. (2022). Protein Oxidation in Muscle Foods: A Comprehensive Review. Antioxidants, 11, 60. https://doi.org/ 10.3390/antiox11010060.

Fillion, L., & Henry, C. (1998). Nutrient losses and gains during frying: A review. *International Journal of Science and Nutrition, 49,* 157-168.

Fletcher, D. L., 1995. Relationship of breast meat color variation to muscle pH and texture. Poultry Sci. 74 (Suppl 1):120. (Abstr.).

Gerber, N., Scheeder, M. R. L., & Wenk, C. (2009). The influence of cooking and fat trimming on the actual nutrient intake from meat. *Meat Science, 81*(1), 148-154.

Grootveld, M. (2022). Evidence-Based Challenges to the Continued Recommendation and Use of Peroxidatively-Susceptible Polyunsaturated Fatty Acid-Rich Culinary Oils for High-Temperature Frying Practises: Experimental Revelations Focused on Toxic Aldehydic Lipid Oxidation Products. *Frontier in Nutrition, 8,* 711640. doi: 10.3389/fnut.2021.711640.

Honegger, L. T., Bryan, E. E., Price, H. E., Ruth, T. K., Boler, D. D., & Dilger, A. C. (2022). The Effect of Cooking Method and Cooked Color on Consumer Acceptability of Boneless Pork Chops. *Foods, 11*, 106. https://doi.org/10.3390/foods 11010106.

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

Kerth, C. R., & Rowe, C. W. (2016). Improved sensitivity for determining thiobarbituric acid reactive substances in ground beef. *Meat Science*, *117*, 85-88.

Kurek, M. A., Onopiuk, A., Pogorzelska-Nowicka, E., Szpicer, A., Zalewska, M., & Półtorak, A. (2022). Novel Protein Sources for Applications in Meat-Alternative Products—Insight and Challenges. *Foods, 11,* 957. https://doi.org/10.3390/ foods11070957.

Kyriakopoulou, K., Keppler, J. K., & van der Goot, A. J. (2021). Functionality of Ingredients and Additives in Plant-Based Meat Analogues. *Foods, 10,* 600. https:// doi.org/10.3390/foods10030600.

Ma, K. K., Greis, M., Lu, J., Nolden, A. A., & McClements, D. J., Kinchla, A. J. (2022). Functional Performance of Plant Proteins. *Foods, 11,* 594. https://doi.org/10.3390/ foods11040594.

Marchion, A. F., & deFelicio, P. C. (2005). Quality of hold boar and commercial prok. *Science Agriculutre (Piracicaba, Braz), 60* (1): 1-10.

Article DOI: 10.52589/AJAFS-UKDNF8DU
DOI URL: https://doi.org/10.52589/AJAFS-UKDNF8DU

Martin, N. H., Trm, A., & Wiedmann. M. (2016). The evolving role of coliforms as indicators of unhygienic processing conditions in dairy foods. *Frontier in Microbiology, 7,* 1549. doi:10.3389/fmicb.2016.01549.

Melton, S. L. (1999). Current status of meat flavour. In: Xiong YL, Ho CT, Shahidi F, editors. *Quality Attributes of Muscle Foods.* Kluwer Academic/Plenum Publishers; New York. pp. 115–130.

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

Moore, S., & Stein W. H. (1954). A modified ninhydrin reagent for the photometric determination of amino acids and related compounds. *Journal of Biology and Chemistry, 211,* 907-913.

Moya, J., Lorente-Bailo, S., & Ferrer-Mairal, A. *et al.* (2021). Color changes in beef meat during pan cooking: kinetics, modeling and application to predict turn over time. *European Food Research and Technology, 247,* 2751–2764. https://doi.org/10.1007/s00217-021-03821-y.

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

Ngoka, D. A., Froning, G. W., Lowry & S. R., et al. (1982). Effects of sex, age, pre slaughter factors, and holding conditions on the quality characteristics and chemical composition of turkey breast muscles. *Poultry Science, 61,* 1996–2003. doi: 10.3382/ps.0611996.

Pathera, A. K., Riar, C. S., Yadau, S., & Singh, P. K. (2016). Effect of cooking methods on lipid oxidation, microbiological and sensory attributes of chicken nuggets in refrigerated conditions. *Cogent Food and Agriculture, 2, 1232472.*

Pekel, A.Y., Mülazımoğlu, S.B., & Acar, N. (2020). Taste preferences and diet palatability in cats. *Journal of Applied Animal Research,* 48 (1), 281-292.

Reynolds J. 30 September (2005). Serial dilution protocols. ASM MicrobeLibrary. http://www.microbelibrary.org/library/laboratory-test/2884-serial-dilution-protocols.

Riaz, M. (2005). Soy applications in food. Page155-184 in Textured soy protein utilization in meat and meat analog products. CRC Press.

Rouger, A., Tresse, O., & Zagorec, M. (2017). Bacterial Contaminants of Poultry Meat: Sources, Species, and Dynamics. *Microrganisms, 5*(3), 50.

Sam, F. E., Ma, T. Z., Atuna, R.A., Salifu, R., Nubalanaan, B. A., Amagloh, F. K., Han, S. Y. (2021). Physicochemical, Oxidative Stability and Sensory Properties of Frankfurter-Type Sausage as Influenced by the Addition of Carrot (Daucus carota) Paste. *Foods, 10,* 3032. https://doi.org/10.3390/ foods10123032.

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

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 Nutrition and Safety, 3*(3), 119-126.

Tornberg, E. (2005). Effect of heat on meat proteins – implication on structure and quality of meat products. *Meat Science, 70,* 493 – 508.

Wann, A.I., Percival, B.C., Woodason, K., Gibson, M., Vincent, S., & Grootveld, M. (2021). Comparative 1H NMR-Based Chemometric Evaluations of the Time-Dependent Generation of Aldehydic Lipid Oxidation Products in Culinary Oils Exposed to Laboratory-Simulated Shallow Frying Episodes: Differential Patterns Observed for Omega-3 Fatty Acid-Containing Soybean Oils. *Foods, 10,* 2481. https://doi.org/ 10.3390/foods10102481.

Wo1oszyn, J., Wereńska, M., Goluch, Z., Haraf, G., Okruszek, A., Teleszko, M., & Król, B. (2020). The selected goose meat quality traits in relation to various types of heat treatment. *Poultry Science, 99,* 7214–7224 https://doi.org/10.1016/j.psj.2020.09.062.

Yeater, M., Casco, G., Miller, R.K., & Alvarado, C.Z. (2017). Comparative evaluation of texture wheat ingredients and soy proteins in the quality and acceptability of emulsified chicken nuggets. *Poultry Science, 96,* 4430–4438 http://dx.doi.org/10.3382/ps/pex250.

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

Choi, Y. S., Choi, J. H., Han, D. J., Lee, H. Y. M. A., Jeong, J. Y., Chung, H.J., & Kim, C. J. (2010). Effects of replacing prok back fat with vegetable oils and rice bran fiber on the quality of reduced fart frankfurters. *Meat Science*. 84 (2010) 557-563.

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.

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APPENDIX

Table 1: Yield, pH and sensory evaluation of soya bean extended broiler chicken nugget prepared using different cooking methods

Parameters	Fried	Grilled	Roasted	SEM
Yield (%)	84.55^a	83.62^b	84.06^b	0.111
pH	6.37^b	6.39^a	6.30^c	0.002
Aroma	7.10^a	6.80^b	7.00^a	0.110
Colour	6.00^c	7.10^a	6.30^b	0.126
Flavour	6.50^a	6.30^b	4.10^c	0.108
Juiciness	7.00^a	6.60^b	6.10^b	0.088
Tenderness	6.60^b	6.90^a	6.40^c	0.094
Pepper	5.80^b	5.40^b	6.20^a	0.101
OA	7.60^a	6.50^b	6.40^b	0.093

^{abc}: Means in the same row with varying superscripts are significantly different ($P<0.05$)

OA, overall acceptability; SEM, standard error of means

Table 2: Proximate analysis (%) of soya bean extended broiler chicken nugget prepared using different cooking methods

Parameters	Fried	Grilled	Roasted	SEM
Moisture	43.60^b	44.17^a	41.55^c	0.019
Crude protein	32.95^a	32.55^b	32.25^c	0.031
Ether extract	9.15^a	8.20^b	7.55^c	0.013
Ash	3.90^b	4.05^a	3.85^b	0.013
Crude fibre	0.85^a	0.78^b	0.80^b	0.006
Nitrogen free extract	9.65^b	9.26^c	11.55^a	0.037

^{abc}: Means in the same row with varying superscripts are significantly different ($P<0.05$)

SEM, standard error of means

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Table 3: Essential amino acid score of soya bean extended broiler chicken nugget prepared using different cooking methods

Amino acid	Fried (%)	Grilled (%)	Roasted (%)	SEM
Histidine	7.37[a]	7.37[a]	7.37[a]	0.67
Isoleucine	27.62[a]	27.62[a]	25.78[b]	0.37
Leucine	14.73[a]	14.73[a]	12.89[b]	0.48
Lysine	11.05[a]	11.05[a]	9.21[b]	0.47
Phenylalanine	9.21[a]	9.21[a]	9.21[a]	0.57
Tryptophan	7.37[a]	7.37[a]	7.37[a]	0.52
Valine	9.21[a]	9.21[a]	9.21[a]	0.22
Methionine/Cysteine	15.84[a]	15.84[a]	14.00[b]	0.48

[abc]: Means in the same row with varying superscripts are significantly different (P<0.05)

SEM, standard error of means

Table 4: Lipid Oxidation, Total cholesterol (mg/100g) and microbial load (cfu/g x 10^3) of soya bean extended broiler chicken nuggets prepared using different cooking methods

Treatment		TBARS (mgMA/1000g)	Total cholesterol	Bacteria load	Coliform load	Mould load
Fried		0.039±0.011[c]	1.833±0.051[a]	4.650±2.587[b]	NG	5.525±2.822[b]
Grilled		0.081±0.018[b]	1.725±0.089[b]	3.960±2.301[c]	NG	5.175±2.425[c]
Roasted		0.094±0.017[a]	1.767±0.092[b]	6.000±2.555[a]	NG	5.825±2.434[a]
SEM		0.00004	0.0049	0.0011		0.0011
Time (Days)						
0		0.050±0.017[d]	1.783±0.092	4.467±1.683[c]	NG	5.500±0.909[b]
5		0.067±0.026[c]	1.756±0.084	7.700±1.293[a]	NG	9.267±0.295[a]
10		0.078±0.026[b]	1.806±0.079	1.467±0.478[d]	NG	2.400±0.468[d]
15		0.091±0.027[a]	1.756±0.070	5.867±1.159[b]	NG	4.867±0.547[c]
SEM		0.00004	0.0049	0.0011		0.0011
Interaction						
Fried	0	0.028±0.000[k]	1.900±0.090[ab]	5.200±0.160[f]	NG	6.700±0.160[c]
	5	0.032±0.000[j]	1.767±0.080[bc]	8.100±0.160[b]	NG	9.300±0.160[a]
	10	0.043±0.000[i]	1.967±0.160[a]	1.000±0.000[j]	NG	1.900±0.150[j]
	15	0.055±0.000[h]	1.700±0.160[bc]	4.300±0.160[g]	NG	4.200±0.150[g]

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Grilled	0	0.054±0.001^{h}	1.650±0.050^{c}	2.200±0.000^{h}	NG	4.600±0.160^{f}
	5	0.077±0.001^{f}	1.700±0.090^{c}	6.000±0.000^{e}	NG	8.900±0.150^{b}
	10	0.089±0.001^{e}	1.750±0.050^{bc}	1.300±0.000^{i}	NG	2.300±0.150^{i}
	15	0.104±0.001^{b}	1.800±0.09^{abc}	6.400±0.000^{d}	NG	4.900±0.160^{ef}
Roasted	0	0.068±0.000^{g}	1.800±0.09^{abc}	6.000±0.000^{e}	NG	5.200±0.160^{de}
	5	0.092±0.001^{d}	1.800±0.09^{abc}	9.000±0.000^{a}	NG	9.600±0.150^{a}
	10	0.101±0.001^{c}	1.700±0.110^{c}	2.100±0.000^{h}	NG	3.600±0.410^{h}
	15	0.114±0.001^{a}	1.767±0.050^{bc}	6.900±0.000^{c}	NG	5.500±0.150^{d}

$^{abc....j}$:Means in the same column with varying superscripts are significantly different (P<0.05)

TBARS, thiobubaturic acid reactive substances; NG, no growth; SEM, standard error of means

Table 5: Growth performance, protein efficiency ratio and biological value of weaned rats fed differently processed soya bean extended broiler chicken nugget

Parameters	Casein	Roasted	Fried	Grilled	NFD	SEM
Feed intake (g)	6.00^{d}	7.52^{c}	9.04^{a}	8.00^{b}	2.00^{e}	0.066
Weight gain (g)	24.00^{d}	30.00^{c}	40.00^{a}	34.00^{b}	-23.00^{e}	0.380
FCR	5.26^{a}	5.27^{a}	4.74^{c}	4.94^{b}	-1.82^{d}	0.003
PER	2.10^{c}	2.00^{d}	2.80^{a}	2.70^{b}	0.00^{e}	0.005
BV (%)	90.83^{a}	71.34^{d}	87.94^{b}	78.10^{c}	0.00^{e}	0.009

^{abc}: Means in the same row with varying superscripts are significantly different (P<0.05)

NFD, nitrogen free diet; SEM, standard error of means

FCR, feed conversion ratio; BV, biological value; PER, protein efficiency ratio

Table S1: Composition of experimental diets

Ingredients	T1(SCD)	T2 (RCN)	T3 (FCN)	T4 (GCN)	T5(NFD)
Casein	11.11	-	-	-	-
Glucose	10.00	10.00	10.00	10.00	10.00
Corn starch	65.69	45.85	46.41	46.13	76.80
Vegetable oil	5.00	5.00	5.00	5.00	5.00
Non-nutritive cellulose	5.00	5.00	5.00	5.00	5.00
Oyster shell	0.50	0.50	0.50	0.50	0.50
DCP	1.50	1.50	1.50	1.50	1.50
Salt	0.20	0.20	0.20	0.20	0.20

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Vitamin premix	1.00	1.00	1.00	1.00	1.00
RCN	-	30.95	-	-	-
FCN	-	-	30.39	-	-
GCN	-	-	-	30.67	-
Calculated Nutrients:					
Energy (Kcal/kg)	3686.77	3600.55	3600.55	3600.55	3800.85
Crude Protein (%)	10.25	10.09	10.09	10.09	0.00

SCD, standard casein diet; RCN, roasted chicken nugget; FCN, fried chicken nugget; GCN, grilled chicken nugget; NFD, nitrogen free diet; DCP, dicalciumphosphate

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