Scientific Research Publishing

Food and Nutrition Sciences, 2021, 12, 805-817
https://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

Evaluation of Nutritional Value and Acceptability of Chicken Nuggets Produced by Chicken Wings and Dehydrated Shellfish

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How to cite this paper: Abd-El-Aziz, N.A., El Sesy, T.A. and 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

Received: July 5, 2021
Accepted: August 1, 2021
Published: August 4, 2021

Abstract

Our study investigated the effect of utilizing chicken wings and dehydrated shellfish to produce chicken nuggets rich in protein, minerals and vitamins. The proximate composition, nutritional value, physical and sensorial properties were evaluated. The differently prepared chicken nuggets were supplemented with dehydrated shellfish CN 0%, CN 2%, CN 4% and CN 6%. There was a significantly reduction in moisture and an increasing in protein content ($P < 0.05$) in all Chicken Nuggets (CN) in comparison to the control. Fat content was significantly higher in CN 0% than CN 2%, CN 4% and CN 6%. Ash content was increasing with added dehydrated shellfish, while the reduction in carbohydrates and total calories of the different chicken nuggets were noticed with the significant gradual rise in pH values, TBA values showed no significant difference ($P < 0.05$) between chicken nuggets. Results showed that using dehydrated shellfish in preparing chicken nuggets caused a marked rise in its content of Ca, Fe, Na, K, Zn, Mg and Mn levels, CN 0% had the lowest concentration of all minerals, and had lower values of vitamins A, E and D but CN 6% had higher values of vitamins A, E and D. Control Nuggets (CN 0%) had the lowest value of yellowness and highest value of lightness but CN 6% had the highest value of yellowness and, the lowest value of lightness. The redness had a slightly reduction. All samples showed slight changes in hardness, cohesiveness, springiness, gumminess and chewiness were noticed. An increase in WHC, pick-up, and cooking loss of chicken nuggets with dehydrated shellfish was noticed. Panelists accepted all prepared chicken nuggets and the chicken nuggets CN 4% had the highest score compared with other chicken nuggets prepared.

Keywords

Chicken Nuggets, Chicken Wings, Shellfish, Nutritional Value

1. Introduction

Poultry meat and chicken products have an important place in human diet, due to their positive nutritional characteristics as low lipid content, proteins of high biological value, essential amino acids and a natural source of vitamins B_2, B_3, and B_6 and minerals such as Fe, P, K, Zn, and Se [1].

Recently, the high percentage of chicken meat and chicken products are consumed in the form of "fast food" or "ready-to-eat" products, such as chicken nuggets, due to the variety of benefits such as reduced preparation time, their low cost, and long shelf life under frozen storage.

Chicken nuggets are tasty products, favorite for children and adults, and are an important food served at almost all fast food restaurant chains increasing the demand for chicken nuggets led to the development of "value" nuggets, which replaces chicken meat with binders and extenders to decrease the cost of production [2]. Nuggets have been produced using other sources of protein, such as goat [3]. Therefore, to improve the nutritional profile of chicken products, these foods can be reformulated with health-promoting ingredients, such as fiber and vegetables, and components considered as harmful to health, like fat and additives, can be reduced or eliminated [4].

Recently, chicken wings have become a successful example of economically processed poultry products, due to their cheap price. Chicken wings contain about 7.3% fat [5]; therefore, lipid oxidation is a critical problem for marketing them. So we should remove fat before using to prepare chicken nuggets. These can be used as functional ingredients and have a great impact on the technological, nutritional, and health-promoting properties of chicken products [6].

Shellfish is a major component of seafood production. Shellfish, in general, contain appreciable quantities of digestible proteins, essential amino acids, bioactive peptides, long-chain polyunsaturated fatty acids, other carotenoids; vitamin B_{12} and other vitamins; minerals, including copper, zinc, inorganic phosphate, sodium, potassium, selenium, iodine, and also other nutrients [7].

Therefore, the aim of this study was to utilize the chicken wings in processed chicken nuggets and use shellfish as a source of protein, vitamins and mineral, to produce healthy and economic products. The proximate compositions, nutritional value, physical and sensorial properties of these products were evaluated after preparation.

2. Material and Methods

2.1. Material

Fresh chicken wings, bread crumbs, wheat flour, fresh onions, fresh whole eggs,

refined fine iodized common salt, black pepper, full cream cow milk and corn oil, were purchased from Alexandria local market, Egypt. Shell fish [undulate venus (*Paphia undulata*)], was obtained from Alexandria fish market.

2.2. Methods

2.2.1. Technological Methods

Preparation of the chicken wings: The chicken wings washed and steamed at 100˚C for 15 minutes. to easily remove skin and separation chicken meat and cool at 4˚C.

Preparation of shellfish: Undulate venus (*Paphia undulata*) was soaked in tap water for 8 h with changing water every one hour, washed to remove mud, drained, steamed at 100˚C for 10 minutes, cooled at room temperature to separation edible part, dehydrated at 55˚C for 17 h and ground 2 times using Luska chopper.

Preparation of the chicken nuggets: Deboned skinless chicken wings meat were ground and well mixed with 5% bread crumbs, 4% of minced fresh onion, 0.1% salt and 0.1% black pepper. Four different formulations of the chicken nuggets were prepared as follows: control containing zero% ground dehydrated shell fish, (CN 0%) three samples containing 2%, 4% and 6% of ground dehydrated shell fish (CN 2%, CN 4% and CN 6%). The mixture of chicken nuggets was spread in a thin layer (10 mm thickness), frozen (2 h) and shaped into discs of 3 cm diameter. The chicken nuggets were breaded using the following three step procedure: first they were coating with thin layer of wheat flour, and then immersing in mixture of 3:20 w/v whole liquid eggs to sterilizing liquid milk, following by coating with thin layer of fine ground bread crumbs. The breaded chicken nuggets kept at 4˚C for at least 45 minutes before frying. The breaded chicken nuggets were frying at 180˚C for approximately 4 - 5 minutes, until an internal temperature of 80˚C was reached.

Cooking loss of chicken nuggets: The breaded chicken nuggets were frying in pan at 140˚C until center temperature reached 80˚C, then cooled to room temperature (22˚C ± 3˚C). The cooking loss was calculated using the following equations as mentioned by [8].

$$\text{Cooking loss } (\%) = \frac{w_1 - w_2}{w_1} \times 100$$

where:

w_1: weight of chicken nuggets sample before cooking;

w_2: weight of chicken nuggets sample after cooking.

Pick-up of coating: The pick-up coating was calculated according to [9].

$$\text{Pick-up coating} = \frac{\text{weight with coating} - \text{weight without coating}}{\text{weight with coating}} \times 100$$

2.2.2. Analytical Method

1) Physicochemical properties: The colour values, lightness (L^*), redness (a^*)

and yellowness (b^*), of food samples were evaluated using a Hunter Lab Ultra Scan, VIS model, colorimeter (USA). The instrument was standardized during each sample measurement with a black and white tail (L^* = 94.1, a^* = 1.12, b^* = 1.26). Mean of five readings of each colour index of Hunter scale (L^*, a^*, b^*) were recorded [10].

Texture Profile Analysis (TPA) of chicken nuggets was performed using TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by [11]. Force time deformation curves were obtained during applying a 5 kg load cell, at a 1 mm/s cross head speed. The following texture attributes were calculated hardness, cohesiveness, springiness, gumminess and chewiness, hardness = maximum force required to compress the sample, springiness (mm) = ability of sample to recover its original form after a deforming force was removed cohesiveness = extent to which sample could be deformed prior to rupture the total energy required for first compression and the total energy required for the second compression); gumminess = force necessary to disintegrate a semisolid sample for swallowing, chewiness = work to masticate the sample for swallowing

Water Holding Capacity (WHC) of chicken nuggets was determined using filter paper press method [12].

2) Chemical analysis:

Proximate composition: Moisture, crude protein, crude fat and ash contents of chicken nuggets were determined according to the [13] while carbohydrates were calculated by difference.

Thiobarbituric Acid (TBA) was calorimetrically estimated according to [14] using UV-VIS Spectrophotometer Laxo alpha 1102, suit and expressed as mg malonaldehyde per kilogram fat or sample.

pH was determined using pH meter type MVX100 Beckman (USA) at room temperature (22˚C ± 3˚C) as described in [13].

Heavy metals: Pb, Cd and Cu concentration in chicken nuggets sample were determined after digestion using ICP-OES according to the method of [15].

Minerals determination: Ca, Fe, Na, K, Zn, Mg and Mn were determined using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-OES) according to standard method US EPA Meth d 200.7 and US EPA Method 6010 C.

Vitamins: Vitamin A, E, and D were determined by HPLC System Controller (SCL-6A) using a Shimadzu CTO 6-A column supplies with a SPD-6AV detector (Japan), under high-pressure solvent delivery unit (LC-20AD) according to [16]. 20 µl sample volume was run at a flow rate of 2 ml/min for 15 minutes at 20˚C. Vitamin A, E and vitamin D were identified and quantified by comparing their retention times to known previously injected standards.

2.2.3. Sensory Evaluation

Colour, texture, taste, odour and overall acceptability of cooked chicken nuggets were organoleptically evaluated using 10 trained panelists from, Food Science

and Technology Department, Faculty of Agriculture, Alexandria University. They were asked to rate their acceptabilities of cooked chicken nuggets products according to nine point scale, ranging from the like extreme 9 to dislike extreme 1 point as described by [17].

2.2.4. Statistical Analysis

Data was statistically analyzed using Statistical Package for Social Sciences (SPSS) software version 22. The level of significant difference was determined at $P \leq 0.05$. Mean ± Standard Deviation (SD) of mean was used.

3. Results and Discussion

3.1. Chemical Composition

3.1.1. Heavy Metals Concentration

Table 1 showed the concentration of Pb, Cd, and Cu in shellfish (*Paphia undulata*) before use in chicken nuggets preparation, there was no detection of Pb and Cd but, Cu concentration was 2.77 mg/kg. These indicated that all heavy metals were less than the maximum permissible level proposed by [18] [19] and [20]. So this product was safe to use in processing chicken nuggets.

3.1.2. Proximate Composition

Results in Table 2 showed significantly reduction in moisture content indifferent chicken nuggets treatments. moisture was observed ranged from 57.92 in CN0% to 62.64%, in CN6%, these differences in moisture due to addition dehydrated shellfish to the raw material, contain small quantity of dehydrate shellfish by 2%, 4% and 6%, reflected lower moisture content of dehydrated shellfish. [21] showed that nuggets with reduced fat content (25%) and the addition of wheat flour (10% to 20%), found moisture contents varying between 57.40% and 61.12%, higher moisture values being found for the treatments with the addition of wheat flour.

On dry weight basis, the four prepared chicken nuggets with dehydrated shellfish were rich in protein values were 27.97%, 37.87%, 40.56% and 41.49%, respectively for the different prepared chicken nuggets supplemented with dehydrated shellfish, CN 0%, CN 2%, CN 4% and CN 6%. There was significantly increasing in

Table 1. Heavy metals concentration (mg/kg) in edible portions of shellfish (*Paphia undulata*) before use as ingredient in chicken nuggets.

Heavy metals	Concentration (mg/kg) Wwb*	Maximum Permissible level (mg/kg)	Recommended by
Lead (Pb)	N.D***	2.0 0.1	FAO (1992) EOSQC (1993)**
Cadmium (Cd)	N.D	3.0 0.1	FAD (2001) (EOSQC, 1993)
Copper (Cu)	2.77	30.0	FAO (1992)

*Wet weight basis. **Egyptian Organization for Standardization and Quality Control (EOSQC, 1993). ***not detected.

Table 2. Effect of addition dehydrated shellfish on proximate composition, pH and TBA mg malonaldehyde/Kg of chicken nuggets.

Component (%)	CN 0%	CN 2%	CN 4%	CN 6%
1-Moisture	$62.64^{a} \pm 0.06$	$61.55^{b} \pm 0.45$	$60.65^{c} \pm 0.31$	$57.92^{d} \pm 0.34$
2-Proximate composition (%) on dry weight basis				
Crude protein	$27.97^{c} \pm 0.50$	$37.87^{b} \pm 0.57$	$40.56^{a} \pm 0.55$	$41.49^{a} \pm 0.60$
Crud fat	$16.63^{a} \pm 0.52$	$14.76^{b} \pm 0.55$	$14.84^{b} \pm 0.39$	$14.91^{b} \pm 0.29$
Ash	$1.33^{d} \pm 0.12$	$1.78^{c} \pm 0.08$	$2.07^{b} \pm 0.10$	$2.81^{a} \pm 0.11$
Carbohydrate*	$54.07^{a} \pm 0.91$	$45.59^{a} \pm 0.91$	$42.53^{c} \pm 0.71$	$40.79^{c} \pm 0.32$
Total caloric value (kcal/100g)	477.83	466.68	465.92	469.31
Percentage of protein calories to total cal	23.41	32.38	34.82	35.36
pH value	$6.12^{c} \pm 0.01$	$6.17^{a} \pm 0.01$	$6.14^{b} \pm 0.01$	$6.14^{b} \pm 0.01$
TBA**	$0.45^{a} \pm 0.05$	$0.49^{a} \pm 0.02$	$0.51^{a} \pm 0.01$	$0.49^{a} \pm 0.01$

Control Chicken Nuggets 0% dehydrated shellfish (CN 0%), Chicken Nuggets with 2% shellfish (CN 2%), Chicken Nuggets with 4% dehydrated shellfish (CN 4%), Chicken Nuggets with 6% dehydrated shellfish (CN 6%) *Calculated by difference. **mg malonaldehyde/Kg sample. Data as mean ± SD. Means in the same column sharing the same letters are not significantly different at $P \leq 0.05$ level.

protein content ($P < 0.05$) in all chicken nuggets in comparison to the control. This means that addition of dehydrated shellfish increased protein content in nuggets and protein content increasing with increasing contain ratio of dehydrated shellfish that due to its high protein contain. Protein content in chicken nuggets comes mainly from raw meat so a higher amount of raw meat used in the formulation will result in higher protein content.

[22] reported that the removal of fat from chicken skin using sodium bicarbonate increased the protein content in bologna sausage.

[23] indicated that *Paphia undulata* contains higher protein contents, especially sarcoplasmic protein and myofibril protein, and it's a good source of protein, consisting of approximately 68.77% crud protein (dry weight basis). According to [24] chicken proteins have a high biological value due to their quantity and quality, containing types and ratio of amino acids very similar to those required for maintenance and growth of human tissue.

Fat content ranged from 14.76% to 16.63%. It was significantly higher in CN 0% than CN 2%, CN 4% and CN 6%. This difference was attributed to addition of dehydrated shellfish, the major source of fat in such chicken nuggets was milk fat and egg during breading process. [25] showed that the lipid contents of several shellfish have very low lipid contents.

Also four chicken nuggets prepared with dehydrated shellfish content ash ranged from (1.33% to 2.81%), carbohydrates from (40.79 to 54.07) and total calories of the different chicken nuggets varied from 465.92 to 477.83 Kcal/100g food. The percent protein derived calories were ranged from 23.41% to 35.36% among the different chicken nuggets prepared with dehydrated shellfish are low in calories due to their low lipid and carbohydrate contents [7].

The proximate composition of commercial chicken nuggets ranged of moisture (34.71% - 56.51%), protein (12.52% - 16.62%), fat (18.14% - 25.00%), Ash

(1.20% - 1.58%) and carbohydrate content (7.52% - 26.49%) [26].

3.1.3. pH and TBA

The results in Table 2 showed that pH values, ranged from 6.12 to 6.17 in different in chicken nuggets prepared with dehydrated shellfish. Significant gradual rise in pH value, of all chicken nuggets was noticed. These values were within the normal limits for such products and they were in the agreement with the data found by [27] in fish nuggets. The pH of an uncooked chicken nugget ranged from 6.30 to 6.38 [28].

The TBA values of chicken nuggets prepared with dehydrated shellfish were showed no significant difference among the treatments ($P > 0.05$) ranged from 0.45 to 0.51 mg malonaldhyde/Kg sample, CN 0% presented the lowest TBA value and it was no significant difference ($P < 0.05$) showing that the addition of dehydrated shellfish.

3.1.4. Mineral Content

Data in Table 3 showed that using dehydrated shellfish in preparing chicken nuggets caused a marked rise in its content of Ca, Fe, Na, K, Zn, Mg, and Mn, levels, CN 0% had the lowest concentration of all minerals (55.91, 1.58, 202.24, 201.60, 1.5, 21.08 and 0.22 mg/100g) respectively but CN6% had the highest concentration (89.51, 6.61, 263.02, 303.15, 4.23, 39.30 and 0.46 mg/100g) respectively. It is clear from the data that an addition dehydrated shellfish caused increasing in Fe, Zn and Mn, with ~167%, 182% and 109% respectively from control. Shellfish minerals contain both macroelements (sodium, potassium, calcium phosphate and magnesium, iron, selenium zinc and manganese. [29] [30] and [31], most shellfish are good sources of Na, K, Pi, Fe, Zn, Se, and Cu. Indian shrimp has Na, K, Ca, Mg, and Pi at 107, 58, 303, 250, and 176 mg/100g raw edible meat, respectively [32].

Moreover, essential minerals such as Zn and Se have been reported as having beneficial effects such as antioxidant compounds and regulators of the immune system and the body function [33].

The daily consumption of 100 g of chicken nuggets would represent 6.4% [34].

Table 3. Effect of addition dehydrated shellfish on minerals contents mg/100g of chicken nuggets.

Minerals mg/100g	CN 0%	CN 2%	CN 4%	CN 6%
Ca	55.91	66.30	87.38	89.51
Fe	1.58	2.47	5.10	6.61
Na	202.24	224.48	261.24	263.02
K	201.60	212.29	265.43	303.15
Zn	1.50	1.50	2.31	4.23
Mg	21.08	32.11	33.15	39.30
Mn	0.22	0.35	0.42	0.46

Control Chicken Nuggets 0% dehydrated shellfish (CN 0%), Chicken Nuggets with 2% shellfish (CN 2%), Chicken Nuggets with 4% dehydrated shellfish (CN 4%), Chicken Nuggets with 6% dehydrated shellfish (CN 6%).

- 9.6% of the recommended daily allowance for Zn for a healthy adult (8 - 12 mg/day). It can therefore be stated that consumption of this kind of product contributes to the recommended level of this essential minerals, as would a diet containing other products rich in Zn. From this result CN 6% had considerable value of Zn.

3.1.5. Vitamin A, E, and D

Results in Table 4 showed that chicken nuggets containing dehydrated shellfish were rich in vitamins A, E and D than chicken nuggets without dehydrated shellfish, all vitamins were increasing with increasing ratio of dehydrated shellfish was added, CN 0% had lower value of vitamins A, as (1432.35 IU/100g), E as (161.09 mg/100) and D as (201.94 µg/100g), but CN 6% had higher value of all vitamins A as (8530.95 IU/100g), E as (724.70 mg/100) and D as (885.88 µg/100g). Shellfish species contain most of the vitamins; shrimp, blue mussel, oyster, and scallop are good sources of vitamin A Shrimp recorded vitamin D3 content of about 0.06 µg/100g [35]. Therefore addition dehydrated shellfish to chicken nuggets was main reason in increasing vitamins value and producing healthy product.

3.2. Physicochemical and Sensorial Properties

Colour: Results in Table 5 showed that yellowness represented the main fraction of the actual colour of the chicken nuggets due to colour of tissue of poultry

Table 4. Effect of addition dehydrated shellfish on vitamins contents chicken nuggets.

Vitamins	CN0%	CN2%	CN4%	CN6%
Vitamin (A) IU/100g	1432.35	6741.28	8474.21	8530.95
Vitamin (E) mg/100g	161.09	184.59	246.47	724.70
Vitamin (D) µg/100g	201.94	390.20	595.11	885.88

Control Chicken Nuggets 0% dehydrated shellfish (CN 0%), Chicken Nuggets with 2% shellfish (CN 2%), Chicken Nuggets with 4% dehydrated shellfish (CN 4%), Chicken Nuggets with 6% dehydrated shellfish (CN 6%).

Table 5. Effect of addition of dehydrated shellfish on colour and texture of chicken nuggets.

Parameter	CN 0%	CN 2%	CN 4%	CN 6%
1-Colour				
Lightness (L^*)	68.28	66.17	65.85	63.96
Redness (a^*)	3.11	3.10	2.83	2.49
Yellowness (b^*)	18.29	20.79	20.80	21.29
2-Texture				
Hardness (g)	425	554	556	682
Cohesiveness	0.81	0.98	1.03	1.02
Springiness (mm)	6.68	6.04	5.67	5.56
Gumminess (g)	543	545	568	599
Chewiness (mJ)	33.6	35.6	39.2	43.6

Control Chicken Nuggets 0% dehydrated shellfish (CN 0%), Chicken Nuggets with 2% shellfish (CN 2%), Chicken Nuggets with 4% dehydrated shellfish (CN 4%), Chicken Nuggets with 6% dehydrated shellfish (CN 6%).

meat and dehydrated shellfish was added therefore yellowness increasing with increasing the addition ratio of dehydrated shellfish, and reduction on lightness and redness was noticed at the same time in chicken nuggets. When compared the Control Nuggets (CN 0%) to the other treatments found that it had the lowest value of yellowness 18.29 and had highest value of lightness (L^*) 66.28 but CN 6% had highest value 21.29. of yellowness and, had lowest value 63.96 of lightness. Redness had slightly reduction with dehydrated shellfish was added to chicken nuggets (3.11 to 2.49). In poultry products, L^* is the most important value as it measures lightness and is the easiest for consumers to detect [36]. Redness is determined by a positive value in the a^* measurement of the colour chicken nuggets with high a^* values indicate a reddish appearance of the meat block [2]. Cooked nuggets were lighter and less red than the raw nuggets, similar to what occurred during breast poultry meat cooking [37].

Texture: Data in Table 5 showed slightly changes in hardness, cohesiveness, springiness, gumminess and chewiness were noticed. Generally when dehydrated shellfish was increased, hardness, gumminess and chewiness parameters were increased, however the lowest hardness value was 425 in control (CN 0%) this means that hardness was less in chicken nuggets containing high moisture, CN 6% had highest value of hardness as (682). cohesiveness, springiness, gumminess and chewiness ranged from (0.81 to 1.03), (5.56 to 6.68), (543 to 599) and (33.6 to 43.6) respectively, and CN 0% the lowest value in all texture parameter except springiness but CN 6% was the highest one in all parameter except springiness. Due to the protein content of the various ingredients, it was expected that there would be different effects on textural properties of chicken nuggets [2]. However the changes in all parameter but chicken nuggets were still much tenderer.

Physicochemical properties: The data in Table 6 showed significant ($P < 0.05$) increase in WHC, pick-up, and cooking loss of chicken nuggets prepared with added dehydrated shellfish were ranged from (48.36 to 59.98), (29.28 to 34.21) and (4.05 to 4.63) respectively. WHC had lowest value in CN0% with highest content of fat. Water holding capacity values proportional with early content of products, where water holding capacity values were low in products high in fat. The water holding capacity functionality nature was influenced by how far effective protein matrix binding scattered excess fat and water in products

Table 6. Effect of addition of dehydrated shellfish on physicochemical properties WHC, pick-up and cooking loss of chicken nuggets.

Physicochemical properties	CN 0%	CN 2%	CN 4%	CN 6%
WHC (%)	$48.36^{d} \pm 0.72$	$55.35^{c} \pm 0.53$	$57.61^{b} \pm 0.62$	$59.98^{a} \pm 0.19$
Pick-up	$29.28^{d} \pm 0.05$	$30.00^{c} \pm 0.11$	$30.60^{b} \pm 0.11$	$34.21^{a} \pm 0.17$
Cooking loss	$4.05^{c} \pm 0.13$	$4.16^{bc} \pm 0.14$	$4.38^{b} \pm 0.09$	$4.63^{a} \pm 0.11$

*Data as mean ± SD. Means in the same column sharing the same letters are not significantly different at $P \leq 0.05$ level. Control Chicken Nuggets 0% dehydrated shellfish (CN 0%), Chicken Nuggets with 2% shellfish (CN 2%), Chicken Nuggets with 4% dehydrated shellfish (CN 4%), Chicken Nuggets with 6% dehydrated shellfish (CN 6%).

Table 7. Effect of addition of dehydrated shellfish on sensory properties of chicken nuggets.

Sensory properties	CN 0%	CN 2%	CN 4%	CN 6%
Odour	$8.70^{a} \pm 0.67$	$8.60^{a} \pm 0.96$	$9.00^{a} \pm 0.05$	$8.40^{a} \pm 0.69$
Colour	$8.80^{a} \pm 0.42$	$8.40^{ab} \pm 0.26$	$8.90^{a} \pm 0.32$	$7.80^{b} \pm 0.78$
Taste	$8.90^{a} \pm 0.32$	$8.20^{bc} \pm 0.91$	$8.80^{ab} \pm 0.42$	$7.60^{c} \pm 0.96$
Texture	$8.80^{a} \pm 0.63$	$8.70^{a} \pm 0.48$	$8.70^{a} \pm 0.48$	$7.70^{b} \pm 0.95$
Appearance	$8.80^{a} \pm 0.42$	$8.70^{a} \pm 0.67$	$8.80^{a} \pm 0.42$	$8.00^{b} \pm 0.52$
Overall acceptability	$8.90^{a} \pm 0.32$	$8.50^{a} \pm 0.71$	$8.40^{a} \pm 0.52$	$7.80^{b} \pm 0.79$

*Data as mean ± SD. Means in the same column sharing the same letters are not significantly different at $P \leq 0.05$ level.

[38]. Control (CN 0%) had lowest value of pick-up and cooking loss when CN 6% the highest one. Cooking loss is equivalent with emulsion stability. It is an important parameter for assessing the quality of meat products. Breakdown of emulsion occurs with increasing temperature and will increase cooking losses [39]. [40] found higher levels of cooking loss for chicken nuggets formulated with banana flour and soybean skin (1% to 5%) as compared to the control treatment.

[27] reported that the mean pick-up values differed ($P < 0.05$) among the different fish nuggets, which were between 20.07% and 27.98%.

Sensory properties: According to sensory evaluation panelists accepted the chicken nuggets (Table 7). The degree of the preference of colour, odour, taste, texture and overall acceptability was very good. Also, they showed that addition of dehydrated shellfish not impact their acceptability and preference degrees of their sensory qualities. Data in Table 7 showed the chicken nuggets CN4% had highest score compared with CN0%, CN2% and CN6%. This mean addition of dehydrate shellfish improved sensory properties of chicken nuggets prepared from chicken-wings.

4. Conclusion

Results of this study confirmed the successful use of chicken wings in producing healthier chicken nuggets and addition dehydrated shellfish show increasing in protein, minerals and vitamins; and improving physicochemical and sensory properties.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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