PAPER

NUTRITIONAL AND QUALITY CHARACTERISTICS OF CHICKEN NUGGETS INCORPORATED WITH DIFFERENT LEVELS OF FROZEN WHITE CAULIFLOWER

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ABSTRACT

In the current study chicken nuggets were formulated with 5, 10, 15 and 20% of frozen white cauliflower as fat replacer instead of chicken skin. Phenolics, total flavonoids and 1,1-diphenyl-2-picrylhydrazyl (DPPH) antioxidant activity of cauliflower were determined. The proximate composition, physicochemical characteristics and sensory properties of formulated chicken nuggets were evaluated. No significant variations ($P \geq 0.05$) were recorded in the overall acceptability scores among chicken nugget batches. The incorporation of frozen cauliflower as fat replacer agent up to 20% had significant and positive effects on the acceptability and overall quality of chicken nuggets.

Phenolics content, total flavonoids of cauliflower extract were 6.76 and 1.65 mg/g,respectively. The DPPH free radicals scavenging activity of cauliflower extract was 54.9%. Chicken nuggets formulated with various levels of cauliflower had higher ash, fiber and carbohydrates contents but their fat and energy contents were lower, compared to control nuggets. No significant ($P \geq 0.05$) variations in pH values among the control samples and those samples incorporated with different levels of frozen white cauliflower. The highest values (95.60, 96.40 and 96.64%) of cooking yield were recorded for nugget

samples incorporated with 10, 15 and 20% of cauliflower, respectively. The lightness values of chicken nuggets significantly decreased with decreasing chicken skin content. Nuggets samples formulated with 20% cauliflower as fat replacer had significantly the highest value of redness (a* value). No significant differences ($P \geq 0.05$) in b* value (yellowness) were found among formulated chicken nugget samples.

Keywords: chicken, white cauliflower, nuggets, chicken skin, sensory properties

1. INTRODUCTION

Fried foods such as potato chips, tortilla chips, fried fish, fried snack products, French fries, chicken nuggets have gained worldwide popularity (OSORIO-YÁÑEZ, *et al*., 2017). Chicken nugget is one of the favorite products that consumes as fast food all over the world.

Chicken nugget products are a reformulated meat product with breaded coatings. The major composition of nugget is chicken meat, protein from vegetarian source, gum and a fair amount of chicken skin (LUKMAN *et al*., 2009; MARIKKAR *et al*., 2011). The quality and nutritional characteristics of chicken nugget significantly affected by factors such as processing treatments, raw material and additives (YOGESH *et al*., 2013). Supplementation of meat products with protein sources, legumes, and oilseed products has the ability to reduce the cost of products (ASGAR *et al*., 2010), and to improve nutritional, functional and sensory characteristics of these product. In recent times, some efforts were conducted to formulate modified meat products by changing in the contents of fat and fatty acids, and/or by inclusion of functional ingredients into meat products or by removing or reducing the substrates that are considered as a hazard to the human health (JIMENEZ-COLMENERO *et al*., 2001; FERNANDEZ-LOPEZ *et al*., 2005). Vegetables and fruit contain more than one type of bioactive compounds. Diets with high levels of vegetables and fruit have a good protection against cancers (VALCKE *et al*., 2017) and cardiovascular disease (DOS SANTOS *et al*., 2017). Cauliflower (*Brassica oleracea* var. botrytis L.) is one of the most popular vegetables grown all over the world and has a wide diversity of uses as a dish or as an ingredient in soups or salads. Cauliflower is a good source of vitamins, folic acid as, dietary fibers, proteins, mineral elements, eg, phosphorus, magnesium manganese, potassium, and iron (AHMED AND ALI, 2013; KAPUSTA-DUCH *et al*., 2017).

The main objective of the current study was to evaluate the effect of the incorporation of different levels of cauliflower on the nutritional and sensory characteristics of chicken nuggets.

2. MATERIALS AND METHODS

Fresh, boneless, skinless, chicken breast fillets and chicken skin were obtained from poultry slaughterhouse, Giza, Egypt. Cauliflower, freshly harvested, free from insect and mechanical damage was purchased from the local market in Giza Governorate, Egypt (JANUARY, 2018). Sodium tripolyphosphate was obtained from El-Gomhouria Company for Trading Chemicals and Medical Appliances (Building 23, El-Sawah Street, Al Ameria, Cairo, Egypt. Dried bread crumbs (6.8% moisture, 12.59% protein, 3.94% fat, 0.96% ash, 0.82 fiber and 81.69% carbohydrates,) were purchased from Modern Bakeries (Rich Bake) company, 6th of October City, Giza, Egypt. Refined salt, white pepper powder, fresh garlic paste and fresh onion were obtained from local market, Giza, Egypt.

2.1. Preparation of Frozen cauliflower

The cauliflower florets were cut into small bite-sized pieces (about five cm in diameter and five cm in length), blanched for three min in boiling water containing 0.5% sodium acid pyrophosphate. Blanched cauliflower samples were drained on a stainless sieve until cold, packed in polyethylene bags, and stored at -25°C for further uses.

2.2. Chicken nugget formulations

Chicken nugget samples were prepared according to the previous procedures described by ARSHAD *et al.*, 2017, using the ingredients listed in Table 1. Chicken breasts were cut into smaller chunks (2 cm height × 2 cm width × 2 cm length). Chicken breast chunks were ground twice in meat grinder (Moulinex - Model ME605131). Frozen cauliflower and seasonings (refined salt, white pepper powder, fresh garlic paste and fresh onion) were added into the formulations (Table 1). The mixture was minced twice in the above-mentioned grinder. The mixture was weighed and formed into nugget pieces (25 g weight, 1.5 cm thick, 8 cm length, and 3.5 cm width). The formulated nuggets were pre-dusted (with wheat flour), batter-coated and breaded (with dried bread crumbs). The breaded nuggets were pre-fried in sunflower oil at 175±5°C for 59 seconds. Fried nuggets were drained on absorbent paper towels, and cooled to room temperature (25°C). The samples were packed in polyethylene bags, and stored at -25°C. Hygienic practices were applied during the preparation, packaging and storage processes of the chicken nugget products.

Table 1. Chicken nugget formulations.

Ingredients (%)	Control	Formula 1	Formula 2	Formula 3	Formula 4
Chicken breast	70	70	70	70	70
Chicken skin	20	15	10	5	-
Frozen cauliflower	-	5	10	15	20
Crushed ice	5	5	5	5	5
Refined salt	1.5	1.5	1.5	1.5	1.5
Fresh garlic paste	0.5	0.5	0.5	0.5	0.5
Fresh onion	2.5	2.5	2.5	2.5	2.5
White pepper powder	0.30	0.30	0.30	0.30	0.30
Sodium tripolyphosphate	0.20	0.20	0.20	0.20	0.20

2.3. Frying (cooking) process

Two kilograms of sunflower oil were placed in frying pan, preheated and maintained at 180±5°C for 5 minutes before frying process. Frozen chicken nuggets were fried for 5 minutes. Fried nuggets were drained on absorbent paper towels, and cooled to 50°C for sensory evaluation. Other portions of samples were allowed to cool to room temperature (25°C) before further tests.

2.4. Total phenolics, total flavonoids and antioxidant activity of cauliflower extract

2.4.1 Preparation of crude extract of frozen white cauliflower

Frozen white cauliflower was subjected to water extraction.10 g of frozen white cauliflower was extracted using 100 ml deionized water for 5 h at ambient temperature (25°C). The mixture was mixed and homogenized in stainless steel blender. The resulting mixture was filtered through Whatman No 40 paper. The collected filtrates were packed in teflon tubes and kept at -25°C for further use. Total phenolic content, total flavonoids

content and antioxidant activity by 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay of cauliflower extract were determined according to the procedures described by Ahmed and Ali (2013). The content of phenolics was expressed as milligram of gallic acid equivalents per g of extract. Flavonoid contents were expressed as mg of catechin equivalents per g of extract. Antioxidant activity was expressed as the inhibition (%) of the absorbance at 515nm using a UV-Vis spectrophotometer (Lambda 9; Perkin Elmer, Shelton, CT, USA).

2.5. Physicochemical properties and nutritive value of formulated nuggets

2.5.1 Determination of chemical composition

The content of moisture, ash, fiber, protein and fat were assayed according to the official procedure described by AOAC (2005). Total carbohydrate percentage was calculated by difference. Total caloric (Kcal/100g sample) were calculated according to CHOI *et al*, 2010 as follow, for fat (9 kcal g^{-1}), protein (4.02 kcal g^{-1}), and carbohydrates (3.87 kcal g^{-1}).

2.5.2 Determination of cholesterol

Cholesterol content was determined according to the previous procedures described by TURHAN *et al.* (2007). The concentration of cholesterol was expressed as mg/100 g, dry weight basis of nugget samples.

2.5.3 pH

The pH value was determined by mixing a 10 g of nugget sample with 100 ml of deionized water. The mixture was filtered through Whatman filter paper number 1, and the pH of the filtrate was measured at room temperature (YOGESH *et al*., 2013) using a pH meter (Shanghai Second Analytical Instrument Factory, Shanghai, China).

2.5.4 Colour properties

Nugget's colour was measured using a Minolta Colourimeter (Model CR-400, Minolta, Japan, calibrated using a standard white porcelain plate L*=97.75, a*=-0.48,b*=+2.31), with a measuring area of 8 mm diameter). The Nugget samples were placed in a Transparent plate and placed directly on the path of light to determine the colour parameter values of L*, a* and b*(NGADI *et al*., 2007)

2.6. Cooking properties

2.6.1 Cooking yield

The percentage of cooking yield was calculated according to the following equation (YOGESH *et al*., 2013).

Cooking yield percentage = (weight of fried (cooked)/
weight of raw (uncooked) nugget) x 100

2.7. Sensory characteristics

Sensory evaluation of fried chicken nuggets was carried out by a fifteen of trained judges from who are belonging to Food Technology Research Institute, Agriculture Research Center, Giza, Egypt). All judges are knowledgeable about the properties of chicken nuggets and familiar with chicken and meat products. The panelists were seated in individual cabins in a temperature-controlled room at 25°C lighted by daylight fluorescent lights. Rectangular strips approximately 2×2× 4 cm^3 were served to the panelists. Chicken nugget samples were evaluated for appearance, juiciness, texture, flavour and overall acceptability by using 9-point hedonic scale, 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely (YOGESH *et al*., 2013). Cups of drinking water were provided for judges to clean their mouth between samples.

2.8. Statistical analysis

Results are expressed as mean±SD. Data were statistically analyzed according to the procedures described by (GOMEZ and GOMEZ, 1984). SPSS Version 18.0 (SPSS Inc., Chicago, IL, USA) was used to analyze data. Duncan's Multiple Range mean separation was performed where the ANOVA procedure showed significance.

3. RESULTS AND DISCUSSIONS

3.1. Sensory characteristics of chicken nuggets formulated with different levels of frozen cauliflower

In order to determine the acceptability of the chicken nugget formulations, sensory evaluation tests were carried out. The transformed data of appearance, juiciness, texture, flavor and overall acceptability of cooked (fried) chicken nuggets formulated with different levels of cauliflower are presented in Table 2. The appearance scores of cooked chicken nuggets ranged from 7.50 to 8.19. Nugget samples incorporated with 20% of frozen cauliflower showed the lowest ($P \leq 0.05$) scores of appearance. However, no significant differences were observed in appearance values between control samples and those nugget samples formulated with 5, 10 and 15% of frozen cauliflower. No significant ($P \geq 0.05$) variations were detected in juiciness value between control samples formulated with 20% of chicken skin and those batches formulated with 5, 10 and 15%of frozen cauliflower as fat replacer. On the contrary, the lowest juiciness value was recorded for those samples containing 20% of frozen cauliflower. This findings attributed to the effect of frying process on reduction of the moisture content of fried food and increase the crispy and hardness of fried vegetables. A critical aspect of battered and breaded chicken products is the contrast between the crispy and oily outer layer and the soft cooked interior (DOBRASZCZYK *et al*., 2006). Crispy texture of fried food products determines the consumer acceptability. The texture of cooked chicken nugget significantly affected by the addition of cauliflower as fat replacer. Chicken nuggets formulated with various levels of cauliflower had significantly ($P \leq 0.05$) higher texture scores than control samples without cauliflower addition. The highest ($P \leq 0.05$) scores of texture were recorded for chicken nuggets incorporated with 15 and 20% cauliflower as fat replacer followed by those samples containing 10 and 5% cauliflower. On the other hand, control samples

formulated with chicken skin had significantly ($P \leq 0.05$) the lowest score of texture (7.81). Additions of carrot and sweet potato were found to be effective in improving texture scores (BHOSALE *et al*., 2011). The highest flavour scores (8.22 and 8.14) were recorded for control sample and those samples incorporated with 5% frozen cauliflower. The perception of fat in food is a complex process involving many sensory modalities (texture, aroma and flavour) (FERON AND POETTE, 2013). No significant variations were detected in flavor scores among nugget batches formulated with 10, 15 and 20%of frozen cauliflower as fat replacer. The increasing of consumer awareness about healthy foods led the efforts made by the food manufacturers to develop new items of food with positive properties. Some efforts have been made to produce alternative meat products by changing in the amounts of lipid contents, by inserting of with bioactive compounds or plant-based phytonutrients into meat products (JIMENEZ-COLMENERO *et al*., 2001; FERNANDEZ-LOPEZ *et al*., 2005). No significant variations ($P \geq 0.05$) were recorded in the overall acceptability scores among chicken nugget batches. Generally speaking, the incorporation of frozen cauliflower as fat replacer had positive effects on the acceptability and overall quality of chicken nuggets.

Table 2. Sensory characteristics of cooked (fried) chicken nuggets formulated with different levels of cauliflower (n= 15).

Parameters	Control	Formula 1	Formula 2	Formula 3	Formula 4	LSD at 0.05
Appearance	8.19^{a}±0.2	8.15^{a}±0.1	8.05^{a}±0.1	8.00^{a}±0.2	7.50^{b}±0.3	0.30
Juiciness	8.17^{a}±0.14	8.09^{a}±0.18	8.04^{a}±0.24	7.90^{a}±0.10	7.45^{b}±0.15	0.28
Texture	7.81^{b}±0.18	8.10^{ab}±0.13	8.15^{ab}±0.25	8.20^{a}±0.14	8.20^{a}±0.20	0.27
Flavor	8.22^{a}±0.10	8.14^{a}±0.06	7.80^{b}±0.12	7.69^{b}±0.15	7.56^{b}±0.18	0.25
Overall acceptability	8.14^{a}±0.16	8.12^{a}±0.14	7.98^{a}±0.10	7.92^{a}±0.09	7.51^{a}±0.14	0.33

Means in a line with different letters are significantly different ($P \leq 0.05$).
LSD, Least significant difference at $p \leq .05$ according to Duncan's multiple-range test.

3.2. Total phenolics, total flavonoid and antioxidant activity by DPPH of crude extract of frozen white cauliflower

The nutraceutical quality depends on the proximate composition, particularly, the quantity of the phenols and flavonoids. Table 3 shows total phenolics, total flavonoid and antioxidant activity by DPPH of crude extract of frozen white cauliflower. The amount of total phenolics found in crude extract of frozen white cauliflower was 6.76 mg / g. Studies found that phenolics are strictly responsible for antioxidant activity of vegetarian sources. These compounds can contribute candidly to scavenge free radicals (AHMED AND ALI, 2013; ARSHAD *et al*., 2017). The total concentration of flavonoids for crude extract of cauliflower was 1.65 mg/g. It has been proven that flavonoid compounds possess antioxidant, antimicrobial, free radicals scavenging and antitumor activities (FERNANDEZ-LOPEZ *et al*., 2005). The crude extract of white cauliflower exhibited remarkable free radicals scavenging activity was 54.9%. The high level of phenolic compounds in white cauliflower makes it as a potential ingredient for meat and chicken products to improve their nutritive value and enhance their ability to scavenge free radicals.

Table 3. Total phenolics, total flavonoid and antioxidant activity by DPPH of crude extract of frozen white cauliflower.

Properties	White cauliflower extract
Total phenolics (mg/g)	6.76±0.39
Flavonoids (mg/g)	1.65±0.08
Free radical scavenging (%)	54.9±1.08

Data are expressed as the mean±standard deviation.

3.3. Chemical compositions, energy content and cholesterol content of raw and cooked chicken nuggets formulated with different levels of cauliflower

The proximate composition of raw and cooked chicken nuggets incorporated with different levels of cauliflower is shown in Tables 4. Moisture content of nugget samples was significantly affected by addition of various levels of frozen cauliflower into chicken nugget formulas. Moisture content of raw chicken nuggets ranged from 61.73 to 66.08%. Significant differences ($p \leq 0.05$) were observed in the moisture content between nugget samples formulated with cauliflower and those control samples (without cauliflower addition). Nugget samples formulated with frozen cauliflower had significantly ($P \leq 0.05$) higher moisture content than control samples without cauliflower. The highest ($P \leq 0.05$) moisture content (66.08%) was recorded for chicken nuggets incorporated with 20% cauliflower, followed by nuggets samples containing 15% cauliflower (65.76%). The lowest content of moisture was observed for control samples (61.73%). At the same time, no significant differences ($P \geq 0.05$) in moisture content were observed among chicken nuggets incorporated with 20, 15 and 10% of frozen cauliflower as fat replacer. The increases in moisture content in nuggets incorporated with cauliflower may be attributed to the ability of cauliflower fiber to hold water. Pectic-polysaccharide-rich fiber of cauliflower has been used as a water holding agent for enhancing the quality properties of model foods (MCKEE, and LATNER, 2000). Fat content of raw chicken nuggets ranged from 0.31 to 13.20%. Fat content of chicken nugget samples was markedly affected by the addition of frozen cauliflower as fat replacer. Substitution of chicken skin with different levels of frozen cauliflower caused significant decreases in fat content of nugget samples. Fat content of chicken nuggets incorporated with 20, 15, 10, and 5% of cauliflower as fat replacer were about 42.58, 3.91, 1.96 and 1.31 times as low as in control samples which containing 20% chicken skin as source of fat, respectively. The amount of fat recovered from chicken skin ranged from 22.6 to 38.9% of the initial weight of skin, according to the extraction conditions (PIETTE *et al.*, 2001). These levels of fat representing 51.5 to 89.6% of the fat initially contained in chicken skin. Blanched cauliflower contains low levels of fat ranged from 1.93 to 2.20% of the dry weight. (AHMED AND ALI, 2013), this low level of fat in cauliflower contributes well in reducing fat content of chicken nuggets formulated with different levels of cauliflower. No significant differences ($P \geq 0.05$) in protein content were observed among chicken nuggets formulated with different levels of cauliflower and control samples without cauliflower addition.

Table 4. Chemical compositions, energy content and cholesterol content of raw and cooked chicken nuggets formulated with different levels of frozen cauliflower.

Parameters	Control	Formula 1	Formula 2	Formula 3	Formula 4	LSD at 0.05
Chemical composition of raw chicken nuggets *(n= 5)*						
Moisture (%)	61.73^{c}±0.63	63.31^{b}±0.80	65.08^{a}±0.92	65.^{76a}±1.01	66.08^{a}±0.79	1.514
Fat (%)	13.20^{a}±0.72	10.01^{b}±0.11	6.71^{c}±0.31	3.37^{d}±0.29	0.31^{e}±0.08	0.688
Protein (%)	17.85^{a}±1.03	17.90^{a}±2.02	17.95^{a}±3.01	18.09^{a}±1.08	18.23^{a}±1.03	3.30
Ash (%)	1.68^{b}±0.21	1.76^{b}±0.17	1.88^{ab}±0.22	1.95^{ab}±0.09	2.17^{a}±0.13	0.307
Crude fiber (%)	0.92^{e}±0.07	1.81^{d}±0.13	2.47±^{c}0.02	3.09^{b}±0.19	3.78^{a}±0.24	0.322
Carbohydrates (%)^{b}	4.62^{e}±0.28	5.21^{d}±0.36	5.91^{c}±0.13	7.74^{b}±0.21	9.43^{a}±0.32	0.497
Energy content (Kcal per 100 g)	208.42^{a}±0.71	182.20^{b}±0.38	155.41^{c}±0.85	133.00^{d}±0.77	112.56^{e}±0.32	1.16
Cholesterol(mg/ 100g)	113.89^{a}±1.98	86.79^{b}±2.08	63.42^{c}±1.31	29.11^{d}±0.94	ND^{e}	2.65
Chemical composition of cooked (fried) chicken nuggets (*n= 5*)						
Moisture (%)	51.74^{c}±0.94	53.70^{b}±1.08	55.42^{ab}±0.87	56.24^{ab}±0.66	56.26^{a}±0.82	1.80
Fat (%)	20.31^{a}±0.17	16.53^{b}±0.31	12.81^{c}±0.33	9.97^{d}±0.69	6.85^{e}±0.43	0.76
Protein (%)	19.59^{a}±1.19	19.60^{a}±1.68	19.92 ^{a}±2.02	20.13^{a}±0.69	20.16^{a}±1.87	2.85
Ash (%)	1.79^{b}±0.16	2.15^{a}±0.23	2.28^{a}±0.08	2.46^{a}±0.17	2.51^{a}±0.12	0.292
Crude fiber (%)	1.08^{e}±0.09	1.76^{d}±0.11	2.61^{c}±0.06	3.07^{b}±0.10	3.84^{a}±0.14	0.18
Carbohydrates (%)^{b}	5.49^{e}±0.41	6.27^{d}±0.37	6.96^{c}±0.19	8.13^{b}±0.32	10.38^{a}±0.09	0.53
Energy content (Kcal per 100 g)	282.78^{a}±0.69	251.82^{b}±0.47	222.29^{c}±0.76	202.11^{d}±0.47	182.86^{e}±0.39	1.04
Cholesterol (mg)	125.50^{a}±1.07	94.86^{b}±0.67	68.12^{c}±2.54	32.58^{d}±1.46	ND ^{e}	2.59

[a]Data are expressed as the mean±standard deviation. Values followed by the same letter [(a-e)] are not significantly different (P≤0.05).

[b]By difference.

[c]LSD, least significant difference.

[d]ND, refers to not detected.

Generally, control samples contain considerably lower ash content than those samples formulated with frozen cauliflower ($P \leq 0.05$). Ash content of formulated chicken nuggets ranged from 1.68 to 2.17%. The highest ($P \leq 0.05$) ash content (2.17%) was recorded for chicken nuggets incorporated with 20% cauliflower. However the lowest content (1.68%) was recorded for control sample without cauliflower addition. Ash content of chicken nuggets formulated with 20, 15 and 10% of cauliflower as fat replacer were about 1.29, 1.16 and 1.11 times as great as in control samples which containing 20% chicken skin as source of fat, respectively. Fiber content of formulated chicken nuggets ranged from 0.92 to 3.78%. Nuggets formulated with different levels of cauliflower had higher levels of fiber than control samples. Control samples without cauliflower addition had significantly ($P \leq 0.05$) the lowest level (0.92%) of fiber content. The highest ($P \leq 0.05$) content of fiber (3.78%) was recorded for chicken nuggets formulated with 20% cauliflower followed by those samples formulated with 15% cauliflower (3.09%). This finding attributed to the fact

that cauliflower is a good source of dietary fiber. In this regard, Ahmed and Ali, 2013 reported that blanched cauliflower florets contain 11.52 -12.74% crude fiber on a dry weight basis. Carbohydrate content of nugget samples varied from 4.62 to 9.43%. Control sample had lower levels of carbohydrates than those samples formulated with different levels of cauliflower. Carbohydrate content of chicken nuggets incorporated with 20, 15, 10, and 5% of frozen cauliflower as fat replacer were about 2.04, 1.67, 1.29 and 1.12 times as high as in control samples containing 20% chicken skin as source of fat, respectively. Carbohydrate content of blanched cauliflower florets was estimated to be about 50% of the total dry weight (AHMED AND ALI, 2013). Energy content (Kcal) of formulated chicken nuggets ranged from 112.56 to 208.42 per 100g. The highest content of energy (208.42 Kcal) was recorded for control sample formulated with 20% of chicken skin as source of fat. The lower values of calories were recorded for those samples formulated with different levels of cauliflower. Calories (Kcal) of chicken nuggets incorporated with 20, 15, 10, and 5% of cauliflower as fat replacer were about 1.85,1.65, 1.34 and 1.14 times as low as in control samples which containing 20% chicken skin as source of fat, respectively. Foods with a lower level of fat provide fewer calories than foods with a higher level of fat. These findings attributed to the fact that one gram of lipids provides 9 kcal, while one gram of protein or carbohydrates provides 4 kcal. Cholesterol content (mg/100 g) of formulated chicken nuggets ranged from not-detectable level to 113.89. Control samples formulated with chicken skin contain the highest levels (113.89 mg/100 g) of cholesterol. Skin of poultry has the greatest cholesterol level compared with poultry meat or poultry fat. In this regard, Mendez-Lagunas *et al*., 2015 reported that the cholesterol content of chicken skin was 131 mg/100 g of raw wet tissue. BRAGAGNOLO (2009) reported also that raw poultry meat has approximately 27 to 90 mg cholesterol/100 g, while cooked poultry meat has around 59 to 154 mg/100 g. Samples formulated with various levels of cauliflower had significantly ($P \leq 0.05$) lower levels of cholesterol than control samples without cauliflower addition. Cholesterol level of the formulated chicken nuggets can be arranged in the decreasing order as follows: control samples > nuggets with 5% cauliflower > nuggets with 10% cauliflower > nuggets with 15% cauliflower > nuggets with 20% cauliflower. As cauliflower florets are vegetarian diets, they are eaten as cholesterol free diets. Several studies proved that incorporation of vegetarian based foods into diets could promote health and reduce the risk of cholesterol and heart disease (SADLER, 2004). Moisture content of cooked nuggets was considerably lower than that of raw (un-cooked) for all the nugget samples. This decrease in water content may be attributed to the fact that frying process resulted in water expulsion from chicken samples where the frying temperature is higher than the boiling temperature of water. Moisture content of cooked chicken nuggets ranged from 51.74 to 56.24%. The lowest moisture content was observed for cooked control nuggets formulated without cauliflower addition. Cooked nuggets formulated with different levels of cauliflower contain higher level of moisture than control samples. This finding attributed to the capacity of cauliflower fibers to hold water during frying process. Fat content of cooked-fried chicken nuggets ranged from 6.85 to 20.31%. Cooked control samples contain significantly ($P \leq 0.05$) the highest level of fat (20.31%). Fried items uptake fat during frying process, which is a health concern as excessive lipid consumption can contribute to obesity and heart disease (WOLFRAM 2003). Cooked nuggets formulated with different levels of frozen white cauliflower have lower amounts of fat than control samples formulated with 20% chicken skin. Fat content of cooked chicken nuggets formulated with 5, 10, 15 and 20% of frozen white cauliflower were about 1.22, 1.58, 2.03 and 2.96 times as low as in control samples formulated with 20% chicken skin as source of fat, respectively. This finding attributed to the fact that certain cruciferous

vegetables of the genus *Brassica* including cauliflower, contain little fat and energy (MUKHERJEE *et al.*, 2008). A critical element of deep-fat fried food is the high level of fat that is absorbed during the frying process, reaching in some cases up to 40% of the total weight of fried product. Several investigations have reported that excess consumption of fat is a key dietary contributor to coronary heart disease and perhaps cancer of the breast, colon, and prostate (KOENE *et al.*, 2016). No significant differences ($P \geq 0.05$) in protein content were observed among cooked chicken nuggets. Ash content of cooked nuggets varied from 1.79 to 2.51%. Increased ash content was noticed in all the cooked nuggets when compared to raw chicken nuggets. Losses of moisture, occurring during frying process resulted in higher ash content in cooked nuggets as compared to the uncooked nuggets Cooked nuggets formulated with different levels frozen white cauliflower contain greater levels of ash than control samples without cauliflower addition. No significant ($P \geq 0.05$) differences in ash content were observed among cooked samples formulated with various amounts of cauliflower. Fiber content of cooked nuggets ranged from 1.08 to 3.84%. As expected nuggets formulated with frozen white cauliflower had higher levels of fibers than control sample without cauliflower addition. Fiber content of cooked nuggets formulated with 20, 15, 10, and 5% of frozen white cauliflower were about 3.55, 2.84, 2.41 and 1.62 times as high as in control samples containing 20% chicken skin as source of fat, respectively. Incorporation of dietary fiber into foods may be an effective power for enhancing functional and nutritional properties as reported earlier, There is a dramatic rise in the demand of food items with high levels of fiber and low levels of lipids as they are very efficient in lowering of fat absorption by the product, particularly fatty acids and cholesterol (BORDERIAS *et al.*, 2005), that could be useful in reducing obesity. Cooked chicken nuggets formulated with frozen white cauliflower had significantly ($P \leq 0.05$) higher values of carbohydrates than control samples without cauliflower addition. The highest value (10.38%) of carbohydrates was recorded for nugget samples incorporated with 20% of frozen cauliflower. Energy content (Kcal) of cooked chicken nuggets ranged from 182.86to 282.78. As expected, control samples are higher in energy content than those samples formulated with frozen white cauliflower. In the current study, reducing the content of chicken skin from 20% to 0% and replacing it with frozen-blanched cauliflower caused significant ($p \leq 0.05$) decreases in energy content of cooked nuggets. At a 25% chicken skin replacement, the energy content was reduced by 10.94%, while the nuggets sample in which 100% chicken skin was replaced, the energy content was reduced by 35.33%. The inverse relation between fat content and energy content was observed in different types of meat products formulated with dietary fiber (MÉNDEZ-ZAMORA *et al.*, 2015; KEENAN *et al.*, 2014). Cholesterol content (mg/100 g) of cooked nuggets varied from not-detectable concentration to 125.50. Frying process caused significant ($P \leq 0.05$) increases in cholesterol content of formulated chicken nuggets. The cholesterol content in the control (cooked) sample was the highest, amounting 125.50 mg / 100 g. Cholesterol levels were higher in fried chicken nuggets compared to un-fried samples. These increases in cholesterol content may attributed to the loss of moisture content during frying process, which leading to changes in cholesterol levels (PADIANI *et al.*, 2002; TURHAN *et al.*, 2007). In this regards, MEDINA *et al*. (2015) reported that frying process caused significant increases in cholesterol content of the refrigerated nuggets; they added also that such changes in cholesterol as a consequence of frying could also be related to the slight dehydration caused by the heat treatment. The cholesterol content of chicken nuggets decreased with respect to the incremental addition of frozen cauliflower as a chicken skin substitute ($P \leq 0.05$), cholesterol content of cooked chicken nuggets supplemented with 5, 10 and 15% of frozen white cauliflower were about 1.32, 1.84 and 3.85 times as low as in

control samples incorporated with 20% chicken skin as source of fat, respectively. Cholesterol has not been detected in nugget samples formulated with 20% frozen white cauliflower as fat replacer. Incorporation of hydrated potato flakes as a type of carbohydrates-based fat replacers caused significant reduction in cholesterol content of beef patties (ALI *et al.*, 2011).

3.4. Physicochemical characteristics of cooked chicken nuggets formulated with different levels of frozen cauliflower

3.4.1 pH

No significant differences in pH values between control samples and those samples incorporated with different levels of frozen cauliflower. This means that the reduction in chicken skin content and the addition of frozen white cauliflower did not affect ($P \leq 0.05$) the pH of formulated chicken nuggets (Table 5). KIM *et al.*, 2015 showed that the pH has not been significantly altered for chicken nugget formulated with various contents of chicken skin and wheat fiber mixture. The value of pH affects the ability of meat and meat products to retain moisture. Water-holding capacity (WHC) of meat reaches a minimum when the pH value is at the isoelectric point of meat proteins. WHC is an important factor for meat products as it affects both the yield and the quality attributes of the end product (YOGESH *et al.*, 2013).

Table 5. pH, cooking yield and color measurements of cooked chicken nuggets formulated with different levels of frozen cauliflower (n= 5)

Parameter	Control	Formula 1	Formula 2	Formula 3	Formula 4	LSD at 0.05
pH	6.1^{a}±0.01	6.1^{a}±0.01	6.1^{a}±0.03	6.1^{a}±0.02	6.1^{a}±0.04	0.029
Cooking yield	93.44^{b}±1.02	94.28^{ab}±0.90	95.60^{a}±0.51	96.4^{a}±0.38	96.64^{a}±0.28	1.24
L (lightness)	69.55^{a}±1.2	67.10^{ab}±1.8	66.60^{ab}±0.90	64.90^{b}±2.2	64.80^{b}±0.60	2.67
a (redness)	4.50^{b}±0.1	4.61^{b}±0.3	4.61^{b}±0.4	4.73^{b}±0.2	7.74^{a}±0.30	0.50
b (yellowness)	29.50^{a}±0.9	29.50^{a}±1.10	30.00^{a}±0.75	30.05^{a}±1.3	30.10^{a}±0.80	1.80

Data are expressed as the mean±standard deviation. Values followed by the same letter are not significantly different ($P \leq 0.05$).
LSD, least significant difference.

3.4.2 Cooking yield

Table 5 illustrates the impact of substitution of chicken skin with different proportions of frozen white cauliflower on the cooking yield of chicken nuggets. Cooking yield of formulated chicken ranged from 93.44 to 96.64%. Generally, these high values of cooking yield may be attributed to the fact that significant amounts of fat were absorbed from frying media during cooking (frying) process (MELLEMA, 2003). Cooked chicken nuggets formulated with frozen white cauliflower had significantly ($P \leq 0.05$) higher cooking yield values than control samples without cauliflower addition. The lowest value (93.44%) of cooking yield was recorded for control samples. The addition of frozen cauliflower had

positive effects for the cooking yields of the nuggets (Table 5). These increases in cooking yield may be attributed to the ability of cauliflower florets fibers to hold moisture and lipids during frying process. It was proved that the yield percentages of cooking depends on cooking temperature, time of cooking, the amounts and type of additive, as well as the type of fat and dietary fiber in the meat products (CHOI *et al.*, 2014; KEENAN *et al.*, 2014; MÉNDEZ-ZAMORA *et al.*, 2015).

3.4.3 Color measurement of chicken nuggets formulated with different levels of frozen cauliflower

Measurement of texture and colour using instrumental methods can provide quantified indicators for determining processing operations to improve and enhance quality properties of finished products (NGADI *et al.*, 2007). The surface color is one of the major physical attributes that determine consumer's acceptability of finished products (SYUHAIRAH *et al.*, 2016). The L* values of formulated cooked nuggets ranged from 64.80 to 69.55. The L* value of control chicken nuggets was higher ($P \leq 0.05$) than chicken nuggets formulated with different levels of frozen cauliflower (Table 5). The lightness values of nuggets were clearly affected ($P \leq 0.05$) by the percentage of incorporated fats. Colour lightness of nuggets significantly ($P \leq 0.05$) reduced with decreasing the content of chicken skin (Table 5). The results showed also that the increase in level of cauliflower incorporation results in linear decrease of the lightness values of nugget samples. The lower values were recorded for nugget samples incorporated with 15 and 20% of frozen white cauliflower. However, those samples formulated with 5 and 10% of frozen white cauliflower as fat replacer showed slight decreases in lightness values,which might be due to the presence of moderate amount (15 and 10%) of chicken skin. The a* value of formulated cooked nuggets ranged from 4.50 to 7.74. The addition of frozen cauliflower at 5, 10 and 15% as fat replacer had no significant effect on the a* value of the formulated samples. Nuggets samples formulated with 20% cauliflower as fat replacer had significantly the highest value of redness (a* value). Redness may not be a desirable colour in fried food products in general (KROKIDA *et al.*, 2001). However redness in cooked meat products is a desirable factor for consumer preferences (YOGESH *et al.*, 2013). No significant ($P \geq 0.05$) differences in b* value (yellowness) were found among formulated chicken nugget samples (Table 5).

4. CONCLUSION

In conclusion, sensory evaluation results revealed that chicken nuggets supplemented with different levels of cauliflower had overall palatability that was similar to control samples with 20% chicken skin. Ash, fiber and carbohydrates contents in chicken nuggets formulated by incorporating 20% of frozen cauliflower were higher compared to control samples without cauliflower addition. It was observed also that the addition of cauliflower reduced the fat content of reformulated nuggets. The highest cooking yield was found in the sample containing 20% of cauliflower as fat replacer.

REFERENCES

Ahmed F. A. and Ali Rehab F. 2013. Bioactive compounds and antioxidant activity of fresh and processed white cauliflower. Biomed. Res Int. 367819:1-9.

Ali RehabF M., El-Anany A.M. and Gaafar A.M. 2011. Effect of potato flakes as fat replacer on the quality attributes of low-fat beef patties. Advance Journal of Food Science and Technology 3(3):173-180.

AOAC. 2005. Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists; Arlington, VA, USA.

Arshadn M.S., Imranm A., Nadeem M. T., Sohaib M., Saee, F., Anjum F. M., Kwon J. and Hussain S. 2017. Enhancing the quality and lipid stability of chicken nuggets using natural antioxidants. Lipids in Health and Disease 16:108,1-9.

Asgar M.A., Fazilah A., Nurul H., Bhat R. and Karim A.A. 2010. Non meat protein alternatives as meat extenders and meat analogs. Comprehensive Reviews in Food Science and Food Safety 9:513-529.

Bhosale S. S., Biswas A. K., Sahoo J., Chatli M. K., Sharma D. K. and Sikka S.S. 2011. Quality Evaluation of Functional Chicken Nuggets Incorporated with Ground Carrot and Mashed Sweet Potato. Food Sci. Tech. Int. 17(3):233-239.

Borderıas A. J., Sanchez-Alonso I. and Perez-Mateos M. 2005. New applications of fibres in foods: addition to fishery products. Trends Food Sci. Technol. 16:458-465.

Bragagnolo N. 2009. Cholesterol and cholesterol oxides in meat and meat products. In: Nollet LML, Toldra F, editors. Handbook of muscle foods analysis. Florida: CRC Press. p 187-219.

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

Choi Y.S., Kim H.W., Hwang K.E., Song D.H., Choi J.H., Lee M.A. and Kim C.J. 2014. Physicochemical properties and sensory characteristics of reduced-fat frankfurters with pork back fat replaced by dietary fiber extracted from makgeolli lees. Meat Sci. 96:892-900.

Dobraszczyk B.J., Ainsworth P., Ibanoglu S. and Bouchon P. 2006. Baking, extrusion and frying. In: ''Food Processing Handbook'' (J.G. Brennan, ed.), pp. 237-290. Wiley-VCH, Weinheim.

Dos Santos Q., Melo Nogueira B. and Alvarez M.C.V. 2017. Consumption of fruits and vegetables among university students in Denmark. International Journal of Gastronomy and Food Science 10:1-6.

Fernandez-Lopez J., Zhi N., Aleson-Carbonell L., Perez-Alvarez J.A. and Kuri V. 2005. Antioxidant and antibacterial activities of natural extracts: application in beef meat balls. Meat Science 69:371-380.

Feron G. and Poette J. 2013. In-mouth mechanism leading to the perception of fat in humans: from detection to preferences. The particular role of saliva.OCL, 20, 102e107.

Gomez K.A. and Gomez A.A. Statistical Procedures for Agricultural Research. 2nd Edn., IRRI, New York, ISBN-10:0471879312, p. 680(1984).

Jimenez-Colmenero F., Carballo J. and Cofrades S. 2001. Healthier meat and meat products: their role as functional foods. Meat Science 59:5-13.

Kapusta-Duch J., Leszczyńska T., Borczak B; Florkiewicz A. and Załubska A. 2017. Impact of Different Packaging Systems on Selected Antioxidant Properties of Frozen-Stored Cauliflower (*Brassica oleracea L. var. botrytis*). Pol. J. Food Nutr. Sci. 67(3). DOI: doi.org/10.1515/pjfns-2016-0017, http://journal.pan.olsztyn.

Keenan D.F., Resconi V.C., Kerry J.P. and Hamill R.M. 2014. Modelling the influence of inulin as a fat substitute in comminuted meat products on their physicochemical characteristics and eating quality using a mixture design approach. Meat Sci. 96:1384-1394.

Koene R. J., Prizment A.E., Blaes A. and Konety S.H. 2016. Shared Risk Factors in Cardiovascular Disease and Cancer. Circulation 15, 133(11):1104-1114.

Krokida M.K., Oreopoulou V., Maroulis Z.B. and Marinos-Kouris 2001. Colour changes during deep fat frying. Journal of Food Engineering. 48:219-225.

Lukman I., Huda N. and Ismail N. 2009. Physicochemical and sensory properties of commercial chicken Nuggets. Asian Journal of Food and Agro-Industry 2:171-180.

Marikkar J.M.N., Ng S.L. and Che Man Y.B. 2011. Composition and Thermal Analysis of Lipids from Pre-Fried Chicken Nuggets. Journal of the American Oil Chemists' Society. 88(6):749-754.

Mckee L.H. and Latner T.A. 2000. Underutilized sources of dietary fiber: A review Plant Foods for Human Nutrition. 55:285-304.
Medina M., Antequera T., Ruiz J., Jiménez-Mart ín E., Pérez-Palacios T. 2015. Quality characteristics of fried lamb nuggets from low-value meat cuts: Effect of formulation and freezing storage. Food Science and Technology International 21(7):503-511.

Mellema M. 2003. Mechanism and reduction of fat uptake in deep-fat fried foods. Trend. Food Sci. Technol. 14:364-373.

Méndez-Lagunas, L.L., Siles-Alvarado S., Rodríguez-Ramírez J. and Aquino-González L.A. 2015. Fatty Acid Profile Composition of Chicken Skin. International Journal of Chemical and Biomolecular Science. 1(3):193-196

Méndez-Zamora G., García-Macías J.A., Santellano-Estrada E., Chávez-Martínez A., Durán-Meléndez L.A., Silva-Vázquez R., Quintero-Ramos A. 2015. Fat reduction in the formulation of frankfurter sausages using inulin and pectin. Food Sci. Technol. (Campinas), 35:25-31.

Mukherjee S., Gangopadhyay H. and Das D.K. 2008. Broccoli: a unique vegetable that protects mammalian hearts through the redox cycling of the thioredoxin superfamily. Journal of Agricultural and Food Chemistry. 56(2):609-617.

Ngadi M., Li Y. and Oluka S. 2007. Quality changes in chicken nuggets fried in oils with different degrees of hydrogenatation. WT-Food Sci. Technol. 40:1784-1791.

Sadler M. 2004. Meat Alternatives. Market developments and health benefits. Trends in Food Science & Technology 15:250-260.

Osorio-Yáñez C., Gelaye B., Qiu C., Bao W., Cardenas A., Enquobahrie D.A. and Williams M.A. 2017. Maternal intake of fried foods and risk of gestational diabetes Mellitus. Annals of Epidemiology 27:384e-390 e.

Piette G., Hundt M., Jacques L.and Lapointe M. 2001. Influence of extraction temperature on amounts and quality of rendered chicken fat recovered from ground or homogenized skin. Poult. Sci. 80:496-500.

Syuhairah A., Huda N., Syahariza Z.A. and Fazilah A 2016. Effects of vegetable incorporation on physical and sensory characteristics of sausages.Asian J. Poult. Sci., 10:117-125.

Turhan S., Temiz H. and Sagir I. 2007. Utilization of wet okra in low-fat beef patties. Muscle Foods 18:226-235.

Valcke M., Bourgault M.H., Rochette L., Normandin, L., Samuel O., Belleville, D., Blanchet C. and Phaneuf D. 2017. Human health risk assessment on the consumption of fruits and vegetables containing residual pesticides: A cancer and non-cancer risk/benefit perspective. Environment International 108:63-74.

Wolfram G. 2003. Dietary fatty acids and coronary heart disease. Eur. J. Med. Res. 8:321-334.

Yogesh K., Ahmad T., Manpreet G., Mangesh K. and Das P. 2013. Characteristics of chicken nuggets as affected by added fat and variable salt contents. J. Food Sci. Technol. 50:191-196. DOI: doi.org/10.1007/s13197-012-0617-z.

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