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Physico-chemical, Sensory and Lipid Profile of Low-fat Chicken Nuggets Incorporated with Carrageenan as Fat Replacer

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ABSTRACT

The study was planned to explore the utility and optimum level of carrageenan as fat replacer in emulsion based low-fat chicken nuggets, which were formulated with 15% added water and only 5% added fat while incorporating carrageenan at three levels viz. 0.3% (Treatment-I), 0.6% (Treatment-II) and 0.9% (Treatment-III), respectively. These treatment low-fat chicken nuggets and control chicken nuggets having 15% added fat in the formulation were analysed for physico-chemical, sensory as well as lipid profile following standard procedures and compared amongst themselves. Cooking yield and moisture percentage of low-fat chicken nuggets were significantly higher ($p<0.05$) than high-fat control product. Fat and moisture retention also improved significantly ($p<0.05$) in low-fat chicken nuggets incorporated with carrageenan as compared to control. Shear force value of treatment product with 0.3 and 0.6% carrageenan was comparable to control product, which increased further with 0.9% carrageenan. Flavour, texture and overall acceptability scores of low-fat chicken nuggets followed a declining trend with increase in carrageenan level in the formulation. However, low-fat chicken nuggets with 0.6% carrageenan were adjudged as best among the treatment products and were similar to high-fat control in sensory rating. When these two products were further compared for lipid profile, the total lipids and cholesterol contents of low-fat chicken nuggets with 0.6% carrageenan were 43.14 and 45.22 % less than control nuggets.

Key words: Meat, low-fat, low-cholesterol, fat retention, sensory acceptability

INTRODUCTION

Fat is an important component of human diet. It is a good source of energy, essential fatty acids and also carries fat soluble vitamins (Mela, 1990). Dietary saturated fat especially animal fat has been associated with the development of hypertension and cardio-vascular diseases, besides obesity. This factor has prompted the consumers to be concerned about the quantity and quality of fat (Bruhn *et al*., 1992). However, reduction of fat in meat product has immediate bearing on the product yield, flavour, juiciness, texture etc. Various technological strategies including fat modulation are being devised to overcome these problems and assuring low-fat meat products with desired palatability to the consumers.

Uses of hydrocolloid gums have shown some promise because of their binding ability and acceptable flavour (Bloukas *et al*., 1997). Carrageenan is a sulfated high molecular weight polysaccharide gum extracted from red seaweed and is approved for use in meat product by USDA

(1973). Incorporation of carrageenan has been attempted in ground beef patties (Egbert *et al.*, 1991; Brewer *et al.*, 1992), low-fat frankfurteurs (Mittal and Barbut, 1994), low-fat ground pork patties (Kumar and Sharma, 2004), low-fat sodium-reduced sausages (Garcia-Garcia and Totosaus, 2008) etc. as fat replacer. Seol *et al.* (2009) studied the antimicrobial effect of carrageenan-based edible film in fresh chicken breast.

Chicken nuggets are ready-to-eat, emulsion based food item that are gaining popularity with the consumers in the market place. The fat content in the product usually exceeds 15%, which is desired to be reduced to low-fat level (<10%). The present study was conducted to explore the utility and optimum level of carrageenan in low-fat chicken nuggets and to compare the physico-chemical, sensory and lipid profile of low-fat (treatment) chicken nuggets with high-fat (control) product.

MATERIALS AND METHODS

Chicken meat: Dressed chicken obtained from spent hens, weighing 4 kg. In each of the three trials, were procured from Central Avian Research Institute, Izatnagar in 2009. These were kept overnight in refrigerator and manually deboned on the subsequent day separating lean meat and fat. The lean meat was packaged in polyethylene bags (200 guage) and stored frozen at-18°C for further use.

Product preparation: Lean meat was first passed through 8 mm plate and then through 4 mm plate of meat mincer. The fat was minced only once with 4 mm plate. The formulation of the product is presented in Table 1. The control product contained 15% added chicken fat and 5% added water, whereas low-fat product contained 5% added chicken fat and 15% added water. This replacement was effected with the help of carrageenan, which was incorporated at three different levels viz., 0.3% (Treatment-I), 0.6% (Treatment-II) and 0.9% (Treatment-III) respectively. Meat emulsion was prepared by first chopping minced meat with salt, water, hexametaphosphate, sodium nitrite for 2.5 min and subsequent chopping was done after addition of fat and other ingredients until uniform dispersion and desired consistency of emulsion was achieved.

The weight quantity of emulsion was filled in stainless steel moulds and steam cooked without pressure for 40 min. The meat block so obtained were cooled and cut as nuggets.

Cooking determinants: Cooking yield of chicken nuggets was determined by measuring the weight of meat blocks for each treatment and calculating the ratio of cooked weight to raw weight as percentage. The moisture and fat retention were calculated according to El-Magoli *et al.* (1996) as per following equations:

$$\text{Fat retention} = \frac{\text{Cooked wt. of meat block} \times \%\ \text{Fat in chicken nuggets}}{\text{Raw wt. of emulsion taken} \times \%\ \text{Fat in raw emulsion}} \times 100 \quad (1)$$

$$\text{Moisture retention} = \frac{\%\ \text{Cooking yield} \times \%\ \text{Moisture in chicken nuggets}}{100} \quad (2)$$

Physico-chemical analysis: The moisture, fat (ether extractable) and protein percentage of chicken nuggets were determined according to standard procedures (AOAC, 1995) using a hot air oven, soxhlet extraction apparatus and Kjeldahl assembly, respectively.

Table 1: Formulation of low fat chicken nuggets incorporating carrageenan as fat replacer

	Treatments			
Ingredients	Control	I	II	III
Lean meat	70.0	69.7	69.4	69.1
Added chicken fat	15.0	5.0	5.0	5.0
Carrageenan	---	0.3	0.6	0.9
Added water	5.0	15.0	15.0	15.0
Refined wheat flour	3.5	3.5	3.5	3.5
Condiments	3.0	3.0	3.0	3.0
Dry spices mix	1.5	1.5	1.5	1.5
Table salt	1.5	1.5	1.5	1.5
Sodium hexametaphosphate	0.5	0.5	0.5	0.5
Sodium nitrite (ppm)	150.0	150.0	150.0	150.0

The pH was determined by homogenising 20 g chicken nuggets in 80 mL of distilled water in Ultra Turrex T25 tissue hemonogenizer at 7000-10000 rpm for 1 min. The pH of suspension was measured using a digital pH meter (Model CP 901; Century Instruments Ltd., Mumbai). The shear force value of 1 cm^2 sample was recorded by Berry and Stiffler (1981) using a Warner-Bratzler Shear Press (Model: 810310307; GR Elect. Mfg. Co. USA) and expressed as kg cm^{-2}.

Sensory analysis: Chicken nuggets were evaluated for their general appearance, flavour, juiciness, texture and overall acceptability by seven experienced panelists using 8-point descriptive scale (Keeton, 1983), where eight denoted extremely desirable and one denoted extremely undesirable.

Lipid profile: Lipid contents of the samples were extracted by using method described by Folch *et al.* (1957) and total lipids were determined gravimetrically. The different components of lipids including phospholipids, cholesterol, glycolipids and free fatty acids were measured by standard procedures as described by Hanel and Dam (1955), Marinetti (1962), Roughan and Batt (1968) and Koniecko (1979) respectively, whereas the glycerides were indirectly calculated by subtracting these from the total lipid values.

Statistical analysis: The study was conducted by statistical design of 4 (treatments)×3 (replications) randomized block design. Data was subjected to one way analysis of variance. Duncan's multiple range test and critical difference were determined at 5% significance level (Snedecor and Cochran, 1995).

RESULTS

The physico-chemical properties of chicken nuggets incorporated with carrageenan and high-fat control product are presented in Table 2. There was a significant increase ($p<0.05$) in the cooking yield and moisture percentage of treatment chicken nuggets as compared to that of control nuggets. Protein percent was comparable in low-fat treatment chicken nuggets as well as high-fat control. The fat percent of control chicken nuggets was 16.52%, whereas it was less than 10% in treatment chicken nuggets. The moisture protein ratio and moisture as well as fat retention percentages of treatment chicken nuggets were significantly higher ($p<0.05$) than control product. The shear force

value of chicken nuggets incorporated with 0.6% carrageenan was comparable with control nuggets. However, it was significantly affected ($p<0.05$) at 0.9% carrageenan incorporation.

Sensory evaluation of chicken nuggets (Table 3) revealed that general appearance and juiciness of low-fat chicken nuggets was comparable with high-fat control product. The flavour scores of low-fat chicken nuggets at 0.3 and 0.6% carageenan were comparable with control product but were significantly affected ($p<0.05$) at 0.9% carrageenan incorporation. Addition of 0.9% carrageenan brought about a significant decrease ($p<0.05$) in texture scores of low-fat chicken nuggets as compared to that of 0.6% carrageenan incorporated and control products. Overall acceptability of low-fat chicken nuggets incorporated with 0.6% carrageenan was comparable with control product, whereas it differed significantly ($p<0.05$) from those of 0.3 and 0.9% incorporated products.

Table 2: Physico-chemical properties of low-fat chicken nuggets incorporated with different levels of carrageenan as fat replacer

		Low-fat treatment (Carrageenan %)		
Parameters	High-fat control	0.3	0.6	0.9
Cooking yield (%)	89.74±0.79^{b}	92.93±0.88^{a}	92.54±0.88^{a}	91.23±0.15^{ab}
Product pH	6.11±0.008	6.14±0.010	6.13±0.009	6.15±0.008
Moisture (%)	63.60±0.18^{b}	68.72±0.24^{a}	69.15±0.36^{a}	69.04±0.22^{a}
Protein (%)	18.23±0.08	18.68±0.12	18.62±0.18	18.59±0.14
Fat (%)	16.52±0.05^{a}	9.45±0.11^{b}	9.24±0.15^{b}	9.26±0.05^{b}
Ash (%)	3.06±0.11	2.98±0.08	2.98±0.09	3.04± 0.06
Moisture Protein ratio	3.49±0.04^{b}	3.68±0.03^{a}	3.71±0.03^{a}	3.71±0.02^{a}
Moisture retention (%)	57.07±0.34^{b}	63.59±0.22^{a}	64.42±0.18^{a}	64.16±0.26^{a}
Fat retention (%)	78.71±0.56^{b}	88.45±0.72^{a}	90.33±0.68^{a}	90.92±1.04^{a}
Shear force value (kg cm^{-2})	0.45±0.01^{a}	0.45±0.01^{a}	0.46±0.01^{a}	0.43±0.01^{b}

Mean±SE with different superscripts in a row differ significantly ($p<0.05$). n = 6 for each treatment

Table 3: Sensory attributes of low fat chicken nuggets incorporated with different levels of carrageenan as fat replacer

		Low-fat treatment (Carrageenan %)		
Parameters	High-fat control	0.3	0.6	0.9
General appearance	7.16±0.09	6.98±0.07	7.14±0.10	7.00±0.12
Flavour	7.21±0.07^{a}	7.07±0.09^{a}	7.12±0.09^{a}	6.78±0.11^{b}
Juiciness	7.10±0.12	7.06±0.15	7.15±0.09	7.09±0.06
Texture	7.08±0.15^{a}	6.85±0.11^{ab}	7.02±0.09^{a}	6.68±0.16^{b}
Overall acceptability	7.12±0.13^{a}	6.87±0.09^{b}	7.09±0.11^{a}	6.77±0.14^{b}

Mean±SE with different superscripts in a row differ significantly ($p<0.05$). Sensory scores on 8-point descriptive scale, where 8 = extremely desirable and 1 = extremely undesirable n = 21 for each treatment

Table 4: Lipid profile of high-fat control and low- fat chicken nuggets incorporated with 0.6% carrageenan

Parameters (mg g^{-1})	High-fat control	Low- fat treatment	% Decrease
Total lipids	160.72±0.47^{a}	91.38±0.32^{b}	43.14
Phospholipids	48.21±0.31^{a}	29.81±0.27^{b}	38.17
Glycolipids	0.39±0.015^{a}	0.25±0.11^{b}	35.90
Free fatty acids	2.46±0.05^{a}	1.39±0.02^{b}	43.49
Cholesterol	3.14±0.05^{a}	1.72±0.04^{b}	45.22
Total glycerides	106.52±0.62^{a}	58.21±0.24^{b}	45.35

Means bearing different superscripts in a row differ significantly ($p<0.05$). n = 6 observations for each treatment

Lipid profile of low-fat chicken nuggets incorporated with 0.6% carrageenan was compared with high-fat control product (Table 4). The total lipids, phospholipids, glycolipids, free fatty acids, cholesterol and total glycerides of low-fat chicken nuggets were significantly lower ($p<0.05$) as compared to the control product. The cholesterol content of low-fat chicken nuggets was only 1.72 mg g^{-1} as compared to 3.14 mg g^{-1} in control product.

DISCUSSION

The increase in cooking yield and moisture percentage of treatment chicken nuggets could be because of added water in the formulation and the ability of carrageenan particles to bind more water (Huffman *et al.*, 1992). Further, Egbert *et al.* (1991) reported that carrageenan has the ability to form complexes with water and protein. It might also be responsible for the high moisture to protein ratio in carrageenan incorporated treatment nuggets. Brewer *et al.* (1992) also found improved product yield in carrageenan incorporated low-fat sausages. A comparable protein percentage in treatment and controlled chicken nuggets could be due to almost same amount of lean meat in the formulation. The low fat percent in treatment nuggets was due to obvious difference in the formulation and conformed to the limit of less than 10% (Keeton, 1994). An apparent increase in fat percent of cooked treatment chicken nuggets could be accounted for by significantly higher retention of added as well as intramuscular fat. An increase in the shear force value of chicken nuggets prepared with 0.06% carrageenan indicated an appropriate binding and gelling attributes at this level.

The comparable flavour scores of low-fat chicken nuggets at 0.3 and 0.6% carrageenan incorporation with control product could be due to pronounced off flavour at higher levels of carrageenan in low-fat product as reported by Panin *et al.* (1974). A low texture score of low-fat chicken nuggets at 0.9% carrageenan is also confirmed by respective shear force values. It could also be explained by maximum fat mimicing property of carrageenan at a particular level (Wallingford and Labuza, 1983). Bloukas *et al.* (1997) found maximum sensory quality in low-fat frankfurteurs formulated with 0.5% carrageenan than at higher levels. Kumar and Sharma (2004) also reported an improvement in texture of low-fat ground pork patties at 0.5% carrageenan incorporation as compared to 0.25 and 0.75% carrageenan level. Present findings indicated that 0.6% carrageenan incorporation was optimum to prepare low-fat chicken nuggets of very good acceptability.

The total lipid content of low-fat chicken nuggets was reduced by 43.14% as compared to control, whereas phospholipids, glycolipids, free fatty acids and total glycerides were reduced by 38.17, 35.90, 43.49 and 45.35%, respectively. The cholesterol content of low-fat goat meat was reduced by 45.22% as compared to control.

CONCLUSION

On the basis of physico-chemical, sensory and lipid profile, it could be inferred that low-fat and low-cholesterol chicken nuggets can be successfully produced by incorporating carrageenan at 0.6% level along with just 5% fat in the formulation instead of usual 15% fat.

REFERENCES

AOAC, 1995. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemists, Washington, DC., USA.

Berry, B.W. and D.M. Stiffler, 1981. Effect of electrical stimulation, boiling temperature, formulation and rate of freezing on sensory, cooking, chemical and physical properties of ground beef patties. J. Food Sci., 46: 1103-1106.

Bloukas, J.G., E.D. Paneras and S. Papadima, 1997. Effect of carrageenan on processing and quality characteristics of low-fat frankfurters. J. Muscle Foods, 8: 63-83.

Brewer, S.M., F.K. Mackeith and K. Britt, 1992. Fat, soy and carrageenan effects on sensory and physical characteristics of ground beef patties. J. Food Sci., 57: 1051-1055.

Bruhn, C.M., A.H. Cotter, K. Diaz-Khauf, J. Sutherlin and E. West *et al.*, 1992. Consumer attitudes and market potential for foods using fat substitutes. Food Technol., 46: 81-86.

Egbert, W.R., D.L. Huffman, C.M. Chen and D.P. Dylewski, 1991. Development of low-fat ground beef. Food Technol., 45: 64-67.

El-Magoli, S.B., S. Laroria and P.M.T. Hansen, 1996. Flavour and texture characteristics of low-fat ground beef patties formulated with whey protein concentrate. Meat Sci., 42: 179-193.

Folch, J.M., M.P. Lees and G.H.S. Stanley, 1957. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226: 497-509.

Garcia-Garcia, E. and A. Totosaus, 2008. Low-fat sodium-reduced sausages: Effect of the interaction between locust bean gum, potato starch and k-carrageenan by a mixture design approach. Meat Sci., 78: 406-413.

Hanel, H.K. and H. Dam, 1955. Determination of small amount of total cholesterol by Tschugaeff reaction with a note on the determination of lonosterol. Acta Chem. Scand., 9: 677-682.

Huffman, D.L., W.B. Mikel, W.R. Egbert, C. Chen and K.L. Smith, 1992. Development of lean pork sausage products. Cereal Foods World, 37: 439-442.

Keeton, J.T., 1983. Effect of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. J. Food Sci., 48: 879-881.

Keeton, J.T., 1994. Low-fat meat products--technological problems with processing. Meat Sci., 36: 261-276.

Koniecko, E.S., 1979. Handbook for Meat Chemists. Avery Pub. Group Inc., Wayne, New Jersey, USA., pp: 68-69.

Kumar, M. and B.D. Sharma, 2004. The storage stability and textural, physico-chemical and sensory quality of low-fat ground pork patties with carrageenan as fat replacer. Int. J. Food Sci. Technol., 39: 31-42.

Marinetti, G.V., 1962. Chromatographic separation, identification and analysis of phosphatides. J. Lipid Res., 3: 1-20.

Mela, D.J., 1990. The basis of dietary fat preferences. Trends Food Sci. Technol., 1: 71-73.

Mittal, G.S. and S. Barbut, 1994. Effect of fat reduction on frankfurteurs physical and sensory characteristics. Food Res. Int., 27: 425-431.

Panin, J., M. Polic and M. Dordevic, 1974. The use of carrageenan in the manufacture of semi-perishable canned meat products. Technologija Mesa, 15: 82-84.

Roughan, P.G. and R.D. Batt, 1968. Quantitative analysis of sulfolipid (sulfoquinoxosyl diglyceride) and galactolipids (Monogalactosyl and Digalactosyl diglycerides) in plant tissues. Anal. Biochem., 22: 74-88.

Seol, K.H., D.G. Lim, A. Jang, C. Jo and M. Lee, 2009. Antimicrobial effect of k-carrageenan-based edible film containing ovotransferrin in fresh chicken breast stored at 50°C. Meat Sci., 83: 479-483.

Snedecor, G.W. and W.G. Cochran, 1995. Statistical Methods. 8th Edn., Oxford and IBH Publishing Co., New Delhi.

USDA., 1973. Meat and Poultry Inspection Regulation. US Government Printing Office, Washington D.C..

Wallingford, L.W. and T.P. Labuza, 1983. Evaluation of the water binding properties of food hydrocolloids by physical/chemical methods and in a low meat emulsion. J. Food Sci., 48: 1-5.