Indian J Anim Health (2022), 61(2): 348- 356
DOI: https://doi.org/10.36062/ijah.2022.10222

Research Article

Use of carrageenan to improve the functional value of nuggets developed from Kadaknath

N. Nayak[1*], P. Chauhan[1] and S. Nanavati[2]

[1]Department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Mhow, Indore- 453 446, Madhya Pradesh, India; [2]Department of Livestock Production Management, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Mhow, Indore- 453 446, Madhya Pradesh, India

Abstract

An experiment was performed to enhance the functional value of meat nuggets developed from Kadaknath. Carrageenan at three levels T-1- 0.25%, T-2- 0.50% and T-3- 0.75%, were used to develop low-fat Kadaknath meat nuggets. Developed products were assessed for various physicochemical, textural and sensory attributes. Cooking yield and moisture content differed significantly (P<0.05) among the treatments. The fat content was reduced significantly (P<0.05) in developed carrageenan incorporated functional meat nuggets compared to the control. The moisture and fat retention were increased with increasing levels of carrageenan and differed significantly (P<0.05). Hardness, cohesiveness and gumminess values of functional Kadaknath nuggets differed significantly (P<0.05). Sensory attributes of carrageenan incorporated Kadaknath meat nuggets indicated comparable scores for T-2 compared to control. Overall acceptability revealed that the product was very well accepted at 0.5% incorporation of carrageenan and may be used in the development of functional Kadaknath nuggets without affecting the quality and sensory attributes.

Key words: Carrageenan, Functional value, Kadaknath, Low-fat, Nuggets

Highlights

- Value added cum functional Kadaknath meat nuggets
- Use of carrageenan as a fat replacer
- Development of low-fat Kadaknath nuggets
- 0.5% incorporation of carrageenan may suitably be used in the development of functional meat nuggets without affecting the quality and sensory attributes.

INTRODUCTION

Kadaknath is a native bird of India (Jhabua district of Madhya Pradesh) and is considered the only black meat breed in the country. Initially, it was reared mainly by the tribal communities of the country, but nowadays, it is continuously gaining popularity mainly due to its better adaptability, resistance against various diseases, rich in protein (Uikey, 2018), desirable texture, as well as flavour. Increased consciousness about balanced diet and health is forcing us to understand the effect of food ingredients on functional enhancement and consumer health. Therefore, demand for such food with health promoting and good nutritional value along with some additional healthy components has continuously increased. Over the last several decades, based on scientific facts and advisories released by medical and nutritional professionals, consumer groups have been aware of relationship between the consumption of meat products (low fat, cholesterol and fibre enriched) and the threat of degenerative and unremitting diseases

*Corresponding Author, E mail: nayaknarendra2@rediffmail.com

(cardiovascular, blood pressure, obesity and colon cancer) (Chauhan *et al*., 2021).

It is a well-known fact that excess fat is responsible for obesity (Chauhan *et al.*, 2021) as it provides 2.25 times higher energy per unit basis compared to carbohydrate and protein. As per the nutritional guideline, the proportion of dietary fat should range from 15 to 30 percent of the total calories required, and saturated fat should not exceed 10 percent of the total calories intake (WHO, 2003). Advanced research on meat-based functional foods is strategic technology to incorporate the healthy promoting component (Jimenez-Colmenero, 2007; Brian *et al.*, 2012). Diet serves as a driving force for health and quality of life. Functional food may be considered to be the most beneficial. As traditional meat products have a higher amount of fat, it provides a good opportunity to develop functional meat products with reduced fat. Therefore, replacements of fat should be done with suitable fat replacers which contribute the least calories to the product without affecting the sensorial attributes of the product.

Fat content plays an important role to improve the sensory attributes like flavour, juiciness and texture of developed meat products (El-Magoli, 1996). Therefore, direct replacement or simply reducing fat content in the development of comminuted meat products may develop rubbery and dry texture, which results in undesirable sensory attributes followed by browning reaction and lower shelf life (Keeton, 1994). Hence, the use of appropriate functional ingredients is needed to replace the fat, which may not deteriorate the quality as well as sensory attributes of the finished products.

Materials replicating the function and physicochemical properties of regular fats, which give rise to very few calories per gram basis and can be used for the development of low calories food, are termed as fat substitutes (Jacqueline, 2013; O'Sullivan, 2016).

It is a well-known fact that using fat substitutes in reformulating meat products will create some adverse qualities and characteristics in cooking and reheating. However, some of them, which mimic the sensory properties of fat, can potentially be used to prepare reduced-fat functional meat products. Globally a couple of scientists like Jimenez (2007) and O'Sullivan (2016) are working to search out the possibility of developing low-fat functional food products without affecting the quality as well as sensory attributes of the products, simultaneously that will also remain healthful to the consumer. Based on these facts and consumer health concerns on priority, an attempt was made to design the fibre enriched along with reduced fat functional meat nuggets developed from Kadaknath.

MATERIALS AND METHODS

Raw material: Approximately 5 months age of Kadaknath chicken (1.5 kg) was procured from the Department of Poultry Science of the College. The chicken was slaughtered, and the meat was deboned and stored at 18°C till further use.

Analytical grades of chemicals required for the study were procured from Hi Media laboratories (P) Ltd, Mumbai. Low density polyethylene (LDPE) bags of 250 gauge thickness and other ingredients used in the study were procured from a standard firm and neighbouring market as per availability and requirement of the project.

Preparation of product: After partial thawing, Kadaknath chicken meat was double minced in an Electrolux mincer. Pre-weighed quantity of minced chicken meat and other required ingredients were added as formulation for the preparation of emulsion (Table 1). The Kadaknath meat nuggets of each treatment were prepared separately as per the process mentioned in the flow chart.

Flow chart for the preparation of functional low-fat chicken nuggets

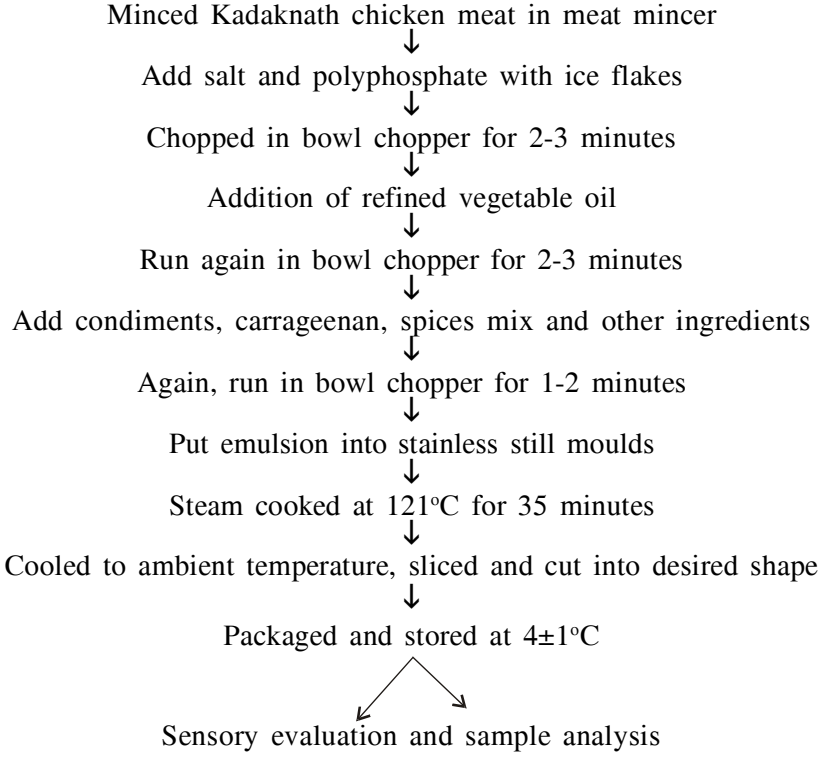

Table 1. Formulation of functional nuggets developed from Kadaknath

Ingredients	C	T-1	T-2	T-3
Meat (%)	69.0	69.0	69.0	69.0
Carrageenan (%)	00	0.25	0.50	0.75
Gram hull (%)	6.0	6.0	6.0	6.0
Refined flour (%)	4.0	4.0	4.0	4.0
Vegetable refined oil (%)	6.0	3.0	3.0	3.0
Condiments (%)	3.8	3.8	3.8	3.8
Ice-flakes (%)	7.0	9.75	9.50	9.25
Spices (%)	2.0	2.0	2.0	2.0
Salt (%)	1.8	1.8	1.8	1.8
STPP (%)	0.4	0.4	0.4	0.4

C (Control)- Kadaknath meat nuggets without carrageenan, T-1- Kadaknath meat nuggets with 0.25% carrageenan, T-2- Kadaknath meat nuggets with 0.5% carrageenan and T-3- Kadaknath meat nuggets with 0.75% carrageenan

Analysis of product: The developed functional Kadaknath meat products were evaluated for various physicochemical analyses. A digital pH meter (WTW, Germany, model pH 330i) was used to determine the pH of the samples. Before measurement, the pH meter was calibrated using two standard buffer solutions. (pH 4.0 and 7.0). The average of two readings for each

sample was considered as the final pH reading. The parameters were evaluated, such as emulsion stability (Baliga and Madaiah, 1970) with minor modifications, cooking yield (Murphy *et al.*, 1975) and proximate composition (AOAC, 1995), whereas moisture protein ratio was calculated by dividing the moisture by protein content of the respective sample multiplied by 100. The moisture retention and fat retention were estimated according to the equation given by Murphy *et al.* (1975) and El-Magoli *et al.* (1996), respectively, and instrumental texture profile by the method of Bourne (1978). The sensory evacuation was performed as per the scale method (8 point descriptive) described by Keeton (1983), where 1 point denoted extremely poor and 8 denoted extremely desirable. A semi-trained judge's panel consisting of seven members was selected from post-graduate students and young staff of the College of Veterinary Science and Animal Husbandry, Mhow, Indore M.P., India. A training/briefing session for the selected panel was organized and then requested to evaluate the different treatments of Kadaknath chicken nuggets for various sensory attributes in the sensory room of the department.

Statistical analysis: The data generated from the present experiment on various parameters were statistically analyzed by using the 'SPSS-20.0' software package as per standard methods of Snedecor and Cochran (1995). Three trials in duplicate for each experiment was conducted (n=6). However, Sensory evaluation was carried out three times each by a trained judges panel of seven members, so the total observations were 21 (n=21).

RESULTS

Physico-chemical properties: The mean values for various physico-chemical properties of low-fat Kadaknath chicken nuggets with different levels of carrageenan are presented in Table 2. The pH value of control was 6.07, while for treatment group T-1, T-2 and T-3 were 6.11, 6.13 and 6.14, respectively. The pH value was increasing from control to treatments. The emulsion stability of control was 90.53%, while for treatment group T-1, T-2 and T-3 were 91.37, 91.91 and 91.62%, respectively. The cooking yield of the control was 92.06%, while for treatment, it varied from 92.48 to 93.24%. The mean moisture (%) content for C, T-1, T-2 and T-3 were found to be 59.36, 61.40, 61.71 and 61.44 respectively. The mean protein (%) content for C, T-1, T-2 and T-3 were found to be 26.22, 25.90, 26.26 and 25.94, respectively. The mean fat (%) content for C, T-1, T-2 and T-3 were found to be 6.22, 4.00, 4.07 and 4.19, respectively. The mean fibre (%) content for C, T-1, T-2 and T-3 were found to be 3.80, 3.85, 3.86 and 3.89, respectively. The mean ash (%) content for C, T-1, T-2 and T-3 were found to be 2.41, 3.39, 3.55 and 3.47, respectively. The mean moisture–protein ratio for C, T-1, T-2 and T-3 were found to be 2.26, 2.37, 2.35 and 2.37, respectively. The mean moisture retention (%) for C, T-1, T-2 and T-3 were found to be 54.99, 55.92, 57.33 and 57.42, respectively. The mean fat retention (%) for C, T-1, T-2 and T-3 were found to be 88.55, 91.07, 93.18 and 93.46, respectively. The analysis of variance indicated a significant ($P<0.05$) difference in cooking yield, moisture content, fat content (%), moisture retention (%) and fat retention (%) between treatments. Whereas for the pH value, emulsion stability, protein content (%), fibre content (%), ash content (%), and moisture-protein ratio indicated no significant ($P>0.05$) difference in protein content between treatments.

Instrumental texture profile: The mean values for textural properties of low-fat Kadaknath chicken nuggets incorporated with different levels of carrageenan are presented in Table 3. The mean hardness value (N/cm^2) for C, T-1, T-2 and T-3 were found to be 19.12, 19.32, 21.91 and 22.84, respectively. The mean value of adhesive force (Ns/g sec) content for C, T-1, T-2 and T-3 were found to -0.64, -0.62, -0.63 and -0.63, respectively. The mean cohesiveness value (%) for C, T-1, T-2 and T-3 were found to be 0.37, 0.37, 0.36 and 0.32, respectively.

Table 2. Physico-chemical properties (Mean±SE) of carrageenan incorporated low-fat nuggets developed from Kadaknath

Parameters	C	T-1	T-2	T-3
pH	6.07±0.01	6.11±0.03	6.13±0.02	6.14±0.14
Emulsion stability (%)	90.53±1.08	91.37±0.86	91.91±0.41	91.62±0.86
Cooking yield (%)	92.06±0.23^{a}	92.48±0.23^{ab}	92.79±0.16^{b}	93.24±0.18^{b}
Moisture (%)	59.36±0.48^{a}	61.40±0.41^{b}	61.71±0.37^{b}	61.44±0.28^{b}
Protein (%)	26.22± 0.32	25.90±0.03	26.26±0.67	25.94±0.44
Fat (%)	6.22±0.11^{b}	4.00±0.20^{a}	4.07±0.04^{a}	4.19±0.20^{a}
Fibre (%)	3.80±0.01	3.85±0.04	3.86±0.04	3.89±0.06
Ash (%)	3.41±0.03	3.42±0.07	3.47±0.14	3.54±0.04
Moisture – protein ratio	2.26±0.04	2.37±0.03	2.35±0.04	2.37±0.03
Moisture retention (%)	54.99±0.55^{a}	55.92±0.81^{ab}	57.33±0.74^{b}	57.42±0.52^{b}
Fat retention (%)	88.55±0.38^{a}	91.07±0.43^{b}	93.18±0.33^{c}	93.46±0.76^{c}

C (Control)- Kadaknath meat nuggets without carrageenan, T-1- Kadaknath meat nuggets with 0.25% carrageenan, T-2- Kadaknath meat nuggets with 0.5% carrageenan and T-3- Kadaknath meat nuggets with 0.75% carrageenan
Different superscripts row wise differ significantly (P<0.05) (n= 6)

Table 3. Instrumental textural profile (Mean±SE) of carrageenan incorporated low-fat nuggets developed from Kadaknath

Parameters	C	T-1	T-2	T-3
Hardness (N/cm^2)	19.12±0.26^{a}	19.33±0.74^{a}	21.91±0.72^{b}	22.84±0.91^{b}
Adhesive force (Ns/g sec)	-0.640±0.013	-0.620±0.012	-0.633±0.013	-.631±0.010
Cohesiveness (ratio)	0.378±0.007^{b}	0.370±0.003^{b}	0.360±0.002^{b}	0.323±0.009^{a}
Gumminess (N/cm^2)	7.72±0.04^{a}	7.70±0.02^{a}	8.51±0.07^{b}	9.18±0.02^{c}

C (Control)- Kadaknath meat nuggets without carrageenan, T-1- Kadaknath meat nuggets with 0.25% carrageenan, T-2- Kadaknath meat nuggets with 0.5% carrageenan and T-3- Kadaknath meat nuggets with 0.75% carrageenan
Different superscripts row wise differ significantly (P<0.05) (n= 6)

The mean gumminess (N/cm^2) for C, T-1, T-2 and T-3 were found to be 7.72, 7.70, 8.51 and 9.18, respectively. The analysis of variance indicated a significant (P<0.05) difference in the mean value of hardness, cohesiveness and gumminess values between treatments, however there was no significant (P>0.05) difference in the mean value of adhesive force between treatments.

Sensory evaluation: The mean value for general appearance, flavour, texture, saltiness, juiciness, mouth coating and overall acceptability of low-fat Kadaknath chicken nuggets incorporated with different levels of carrageenan are presented in Table 4. The mean sensory score of parameters like general appearance for C, T-1, T-2 and T-3 were found to be 6.95, 6.76, 6.90 and 6.85, for flavour, 7.08, 7.04, 7.14 and 6.51, for texture, 6.88, 6.61, 6.85 and 6.67, for mouth coating 6.90, 6.66, 6.85 and 6.80, for saltiness 7.12, 7.04, 7.09 and 6.71, for juiciness 6.90, 7.04, 7.14 and 7.19, for overall acceptability 7.11, 6.85, 7.09 and 6.71, respectively. The analysis of

Table 4. Sensory attributes (Mean±SE) of carrageenan incorporated low fat nuggets developed from Kadaknath

Parameters	C	T-1	T-2	T-3
General appearance	6.96±0.12	6.76±0.20	6.90±0.16	6.85±0.15
Flavor	7.08±0.18^{b}	7.04±0.20^{b}	7.14±0.18^{b}	6.51±0.14^{a}
Texture	6.88±0.10^{b}	6.61±0.17^{b}	6.85±0.15^{ab}	6.67±0.11^{a}
Mouth coating	6.90±0.20	6.66±0.21	6.85±0.17	6.80±0.16
Saltiness	7.12±0.26	7.04±0.17	7.09±0.15	6.71±0.20
Juiciness	6.90±0.19	7.04±0.20	7.14±0.18	7.19±0.17
Overall acceptability	7.11±0.12^{b}	6.85±0.09^{a}	7.09±0.11^{b}	6.71±0.14^{a}

C (Control)- Kadaknath meat nuggets without carrageenan, T-1- Kadaknath meat nuggets with 0.25% carrageenan, T-2- Kadaknath meat nuggets with 0.5% carrageenan and T-3- Kadaknath meat nuggets with 0.75% carrageenan
Different superscripts row wise differ significantly (P<0.05) (n= 6)

variance indicated a significant (P<0.05) difference in the mean of parameters flavour, texture and overall acceptability scores between treatments. Whereas for the sensory parameters like general appearance, mouth coating and saltines. Juiciness indicated no significant (P>0.05) difference between treatment groups.

DISCUSSION

Physico-chemical properties: The physico-chemical properties indicated (Table 2) that pH was increased with increasing levels of carrageenan. However, the difference was non-significant (P>0.05). Nayak and Pathak (2016) also reported higher pH values in chevon patties incorporated with carrageenan. The emulsion stability was initially increased from control to T-2 and then decreased with the further increasing level of carrageenan. With the increasing levels of carrageenan, the protein compactness gel network allowed more binding of water with heat while cooking. Therefore, improvement in the water holding capacity was recorded (Ayadi *et al.*, 2009). These results are supported by the findings of Nayak *et al.* (2015). The cooking yield of Kadaknath chicken nuggets differed significantly (P<0.05) among the treatments. A non–significant (P>0.05) increment was at T-1, and then a significantly (P<0.05) higher value at T-2 and T-3 as compared to the control was recorded. Carrageenan might have the ability to make a complex with protein and water (Egbert *et al.*, 1991). Further, it results in more retention of water which ultimately increases the cooking yield. The addition of WBF, BPF and BSF in association with pre-emulsified oil increased the cooking yield of the final product (Jailson *et al.*, 2020). Higher value of cooking yield in guargum-incorporated Kadaknath chicken patties were also observed by Badole *et al.* (2021).

However, in between the treatments, the difference was non–significant (P>0.05). It may be probably due to the addition of water to compensate the formulation for the development of low fat Kadaknath chicken nuggets. There was a significant (P<0.05) difference in moisture content of reduced-fat frankfurter containing banana by-products and pre-emulsified sunflower oil (Jailson *et al.*, 2020).

Data presented in Table 2 indicated that protein content differed non significantly (P>0.05) between all treatments of carrageenan added low-fat Kadaknath chicken nuggets. A similar proportion of meat was incorporated in the formulation for the development of the products. A non-significant (P>0.05) difference in carrageenan incorporated chevon patties was also observed by Nayak and Pathak (2016). A drastic reduction in the fat content was observed with a significant difference (P<0.05) in carrageenan incorporated Kadaknath chicken

nuggets compared to the control. This might be due to noticeable variation in the formulation of low-fat Kadaknath chicken nuggets, as they developed using 3% vegetable fat compared to 6% as in control. However, between the treatments, no significant (P>0.05) difference was observed. Kumar and Sharma (2004) in pork patties; Nayak and Pathak (2018) in sago flour incorporated low-fat chevon patties also reported a similar trend during the study.

Fibre and ash content of devolved low-fat Kadaknath chicken nuggets did not differ significantly (P>0.05). However, mean values of fibre and ash content were higher in treatments compared to the control. Moisture - protein ratio was found to be non-significant (P>0.05) among the treatments as well as in comparison to the control. This might be due to proportional ratio of water and protein contents in the low-fat Kadaknath chicken nuggets. Moisture retention was significantly (P<0.05) lower in the control as compared to low-fat carrageenan-incorporated Kadaknath chicken nuggets. The marginal improvement with increasing levels of carrageenan was also noticed among the treatments. Nayak and Pathak (2016) also reported higher moisture retention in carrageenan incorporated chevon patties. With the increasing level of carrageenan, fat retention was also increased significantly (P<0.05) from control to T-2. However, with further increasing level of carrageenan in the development of low-fat Kadaknath nuggets, a non-significant (P>0.05) difference was noticed. Results of the study conducted for the development of low-fat chevon patties incorporated with sago flour also indicated higher fat retention in treatment compared to control (Nayak and Pathak, 2017).

Instrumental texture profile: The instrumental textural profile of carrageenan incorporated functional Kadaknath meat nuggets are presented in Table 3. A progressive increment in the hardness value of carrageenan incorporated low-fat Kadaknath chicken nuggets with increasing levels of carrageenan. However, at the level of T-1 compared to the control, the difference was non-significant (P>0.05). Improvement in hardness value was recorded by Oh *et al.* (2019) in hydroxypropyl methylcellulose oleo gel incorporated meat patties. Significant (P<0.05) differences in the hardness value were also recorded in low-fat chevon patties using poppy seed (Nayak and Pathak, 2017); in guargum added Kadaknath chicken patties (Badole *et al.*, 2021). Mean values of adhesive force indicated a non-significant (P>0.05) difference between the treatments of fibre enriched low-fat Kadaknath chicken nuggets. However, the value was lower compared to the control. A gradual decline in cohesiveness was observed with increasing levels of carrageenan in low-fat Kadaknath chicken nuggets, and a significant (P<0.05) difference was recorded at T-3 compared to the control. Nayak and Pathak (2017) reported a marginal difference in adhesiveness value and lower cohesiveness value in poppy seed incorporated low-fat chevon patties. The gumminess value was increased significantly (P<0.05) with an increasing levels of carrageenan fibre enriched low-fat Kadaknath chicken nuggets. On the contrary, no difference in the gumminess of the low-salt sausages with or without Basil seed gum powder was observed (Lee and Chin, 2019)

Sensory evaluation: Sensory attributes of carrageenan incorporated low-fat nuggets developed from Kadaknath are presented in Table 4. Flavour score at T-1 and T-2 were comparable to control, although score was significantly (P<0.05) lower for T-3. This may be because the carrageenan produces some unpleasant flavour at higher concentration. These results agreed with the findings of Nayak *et al.* (2015) in carrageenan incorporated meat nuggets. The texture score decreased non-significantly (P>0.05) from control to T-2, and the difference was significant (P<0.05) at T-3. Sensory panellists rated T-2, similar to control for texture attributes. It could be due to the maximum fat mimicking property of

carrageenan at a particular level. Rather *et al.* (2017) reported comparable texture scores in guargum incorporated low-fat meat emulsion. The score for saltiness was lower as compared to the control. Gradual non-significant (P>0.05) increment in the score of juiciness was recorded with the increasing level of carrageenan. This might be due to the higher moisture content in the high fibre low-fat Kadaknath chicken nuggets. Added water and/or phosphate resulted in higher (P<0.05) juiciness, tenderness and overall palatability scores. Overall acceptability showed a significant (P<0.05) variation between the different treatments of carrageenan incorporated low-fat Kadaknath chicken nuggets. The score was significantly (P<0.05) lower at the level of T-1 as well as T-3, and the acceptability score for T-2 was at par with the control. Results of Nayak *et al.* (2015) on chicken nuggets and Modi *et al.* (2009) on low-fat meat kofta also stated that carrageenan might be used without affecting the sensory attribute of the products.

The most acceptable low-fat fibre-enriched functional Kadaknath meat nuggets were prepared by incorporation of 6% gram hull and 0.5% carrageenan by reducing 50% of added fat and cooked at 121°C for 35 minutes. There were no adverse effects on physicochemical and texture properties as well as sensory attributes of low-fat Kadaknath nuggets developed with 0.5% of carrageenan. The sensory panel rated either higher or comparable scores for this functional product. Hence, it is concluded that carrageenan may be considered as an excellent fat replacer and can suitably be used to replace added fat in the development of low-fat Kadaknath chicken nuggets.

Conflict of interest: Authors have no conflict of interest in this study.

Author's contribution: NN: Conceptualization, resource, methodology, validation, drafting and editing; PC: Conceptualization, resource, drafting and editing; SN: Analysis, drafting and editing.

ACKNOWLEDGEMENT

The authors are grateful to the Madhya Pradesh Council of Science and Technology (MPCST), Bhopal and NDVSU University officials, and college administration for providing necessary funds and facilities to conduct the research.

REFERENCES

AOAC, 1995. Official Methods of Analysis. Association of Official Analytical Chemists, 16th edn, Will Behington, DC, pp 1-23

Ayadi MA, Kechaou A, Makni I and Attia H, 2009. Influence of carrageenan addition on turkey meat sausages properties. J Food Engi, 93(3): 278-283, doi: 10.1016/j.jfoodeng.2009.01.033

Badole S, Nayak NK and Aich R, 2021. Development and quality assessment of low fat Kadaknath chicken parties. J Entomol Zool Stud, 9(1): 2119-2123

Baliga BR and Madaiah N, 1970. Quality of sausage emulsion prepared from mutton. J Food Sci, 35(4): 383-385, doi: 10.1111/j.1365-2621.1970.tb00937.x

Bourne MC, 1978. Texture profile analysis. Food Tech, 32: 62-66

Brian DT, Maurice G, O'Sullivan R, Hamill M and Kerry JP, 2012. Effect of varying salt and fat levels on the sensory quality of beef patties. Meat Sci, 91: 460-465, doi: 10.1016/j.meatsci.2012.02.032

Chauhan P, Kumar RR, Mendiratta SK, Talukder S, Gangwar M *et al.*, 2021. *In-vitro* functional efficacy of extracts from *Phyllanthus emblica*, *Eucalyptus globulus*, *Tinospora cordifolia* as pancreatic lipase inhibitor and source of anti-oxidant in goat meat nuggets. Food Chem, 348: 129087, doi: 10.1016/j.foodchem.2021.129087

Egbert WR, Huffman DL, Chen C and Dylewski DP, 1991. Development of low fat ground beef. Food Tech, 45(6): 64-73

El-Magoli SB, Laroria S and Hansen PMT, 1996. Flavour and texture characteristics of low-fat ground beef patties formulated with whey protein

concentrate. Meat Sci, 42(2): 179-193, doi: 10.1016/0309-1740(95)00032-1

Jacqueline BM, 2013. Lipid basics: fats and oils in foods and health. In Culinary Nutrition, pp 231-277, doi: 10.1016/B978-0-12-391882-6.00006-6

Jailson P, Sarfaraz AB, Sathuvan M, Wangang Z and Guang-Hong Z, 2020. Quality of fat-reduced frankfurter formulated with unripe banana by-products and pre-emulsified sunflower oil. Int J Food Propert, 23(1): 420-433, doi: 10.1080/10942912.2020.1733014

Jimenez F, 2007. Healthier lipid formulation approaches in meat based functional foods: technological options for replacement of meat fats by non-meat fats. Trends Food Sci Tech, 18(11): 567-578, doi: 10.1016/j.tifs.2007.05.006

Keeton JT, 1983. Effect of fat and sodium chloride phosphate levels on the chemical and sensory properties of pork patties. J Food Sci Tech, 48(3): 878-881, doi: 10.1111/j.1365-2621.1983.tb14921.x

Keeton JT, 1994. Low fat meat products-technological problems with processing. Meat Sci, 36(1-2): 261-276, doi: 10.1016/0309-1740(94)90045-0

Kumar M and Sharma BD, 2004. The storage stability and textural, physio-chemical and sensory quality of low fat ground pork patties with carrageenan as fat replacer. Int J Food Sci Tech, 39(1): 31-42, doi: 10.1111/j.1365-2621.2004.00743.x

Lee CH and Chin K, 2019. Physicochemical and textural properties of low-fat pork sausages with basil seed gum as affected by different salt levels. Meat Muscle Biol, 2(2): 64, doi:10.22175/rmc2018.055

Modi VK, Yashoda KP and Naveen SK, 2009. Effect of carrageenan and oat flour on quality characteristics of meat kofta. Int J food proper, 12(1): 228-242, doi: 10.1080/10942910802252155

Murphy EW, Criner PE and Grey BC, 1975. Comparison of methods for calculating retention of nutrients in cooked foods. J Agric Food Chem, 23(6): 1153-1157, doi: 10.1021/jf60202a021

Nayak NK and Pathak V, 2016. Development and quality assessment of carrageenan incorporated low fat chevon patties. J Food Sci Technol, 53(9): 3477-3484, doi: 10.1007/s13197-016-2322-9

Nayak NK and Pathak V, 2017. Development of low fat chevon patties using poppy seed as fat replacer. Ind J Small Rumi, 23(2): 236-239, doi: 10.5958/0973-9718.2017.00038.1

Nayak NK and Pathak V, 2018. Development of low-fat chevon patties using sago flour as fat replacer. Indian J Small Rumin, 24(2): 329-333, doi: 10.5958/0973-9718.2018.00069.7

Nayak NK, Pathak V, Singh VP, Goswami M and Bharti SK, 2015. Quality of carrageenan incorporated low fat chicken nuggets during refrigerated storage at 4°C. Lives Res Int, 3(1): 7-13

O'Sullivan MG, 2016. Low-fat Foods: Types and Manufacture. Encyclopedia of food and Health, pp 571-575

Oh I, Lee J, Lee HG and Lee S, 2019. Feasibility of hydroxypropyl methylcellulose oleogel as an animal fat replacer for meat patties. Food Res Int, 122: 566-572, doi: 10.1016/j.foodres.2019. 01.012

Rather SA, Masoodi FA, Akhter R, Rather JA and Amin F, 2017. Effects of guar gum as a fat substitute in low fat meat emulsions. J Food Proces Preser, 41(6): e13249, doi: 10.1111/jfpp.13249

Snedecor GW and Cochran WG, 1995. Statistical methods, 8th edn., The Iowa state college press, INC. American Iowa, (USA), pp 237-238

Uikey S, 2018. Development and quality assessment of high fibre-low fat nuggets of Kadaknath chicken. MVSc thesis submitted to NDVSU, Jabalpur

WHO, 2003. Diet, nutrition and the prevention of chronic disease, report of a joint WHO/FAO Expert consultation. WHO Technical Report Series: World Health Organization, Geneva

Received- 03.08.2022, Accepted- 13.11.2022, Published- 28.11.2022(Online), 01.12.2022 (Print)
Section Editor: Dr. I. Samanta, Associate Editor