J.Meat Sci., 2015, 11(1) : 11 - 16

Research Paper

Development and Quality Assessment of Functional Chicken Star

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ABSTRACT

The objective of this study was to evaluate the effect of carrageenan at different levels as fat replacer to develop functional chicken star. The physico-chemical, proximate and sensory quality of chicken meat star was evaluated. Results indicated that the pH, cooking yield, emulsion stability and moisture content was significantly ($p<0.05$) higher in carrageenan added chicken star. The fat content and cholesterol contents were significantly ($p<0.05$) reduced in treated chicken star. However, protein and ash content differed non-significantly ($p>0.05$) in between treatments and control. The fat and moisture retention capacity of the functional chicken star were also improved significantly ($p<0.05$) with the incorporation of carrageenan. The mean scores for appearance and colour as well as flavor were non-significantly ($p>0.05$) higher in functional chicken star. Texture and juiciness were comparable in T-2 (emulsion with 5% vegetable oil + 0.6% hydrated carrageenan) functional chicken star and full fat chicken star. However, the mean value of overall acceptability score increased significantly ($p<0.05$) in developed product. On the basis of physicochemical properties it may be concluded that the carrageenan may be best suitable fat replacer to develop functional chicken star without affecting the sensory attributes.

Keywords : *Chicken star, Carrageenan, Fat replacer, Functional property*

Received : 12.12.2014 Accepted: 28.05.2015

INTRODUCTION

A chicken meat star is a chicken product made from either meat emulsion or chicken breasts cut to shape, breaded or battered, then deep-fried or baked. Fat is an essential component of meat for sensory perception of juiciness, flavor and texture. Fat in meat also supplies fatty acids that cannot be synthesized by humans. The perception of healthiness and sensory quality are important criteria that influence the decision of a consumer to purchase a particular food product (Allen *et al.* 1999). Today's consumers are health and nutrition conscious and tend to avoid food products with high fat content. Comminuted meat products contain approximately 20–30% fat; therefore it is essential for the meat industry to reduce the fat contents of their products (Candogan and Kolsarici 2003). Fat contributes to flavor, or the combined perception of mouth feel, taste and aroma/ odor of food products. The desirable sensory characteristics of juiciness and mouth feel of ground meat products are associated with higher fat levels. To maintain these characteristics when fat contents are reduced, binders are used. Binders can also be added in meat formulations to improve water and fat binding properties, as well as to improve cooking yields, slicing characteristics and flavor. Carrageenans are the polysaccharides extracted with hot water from certain genera of red seaweeds such as Chondrus, Gigartina, Eucheuma, Furcellaria, Phyllophora, etc. are finding wide spread application in low fat meat products. Carrageenan is being used with good results in ground beef patties as a binder and extender due to its ability to retain moisture.

Generally, the low-fat meat and chicken products have generated a variety of strategies for reducing fat, but the final goal has been to reduce fat with retaining traditional full-fat flavor, taste and texture. Keeping the literature survey of the variety meat products and aforesaid consideration the present study was aimed to develop and assess the quality of carrageenan added functional chicken star.

MATERIALS AND METHODS

The experiment was conducted in department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura. Live birds of 8 -9 weeks of age were procured from Instructional Poultry Farm, DUVASU. The birds were scientifically slaughtered and deboned. Various spices, condiments (onion, ginger, and garlic), oil, salt and carrageenan were purchased from local market of Mathura. All the chemicals and media used in the study were of analytical grade and obtained from standard firm.

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Preparation of chicken meat star: Manually deboned meat obtained from breast and leg pieces was cut into small cubes and minced first through 9 mm and then through 4 mm plate in meat mincer. The emulsion was prepared by adding and mixing of all ingredients (Refined wheat flour 3%, Condiments 3%, Spices 2%, Salt 1.5%, Vegetable oil 10% and or hydrated carrageenan, Ice flakes 8% and phosphate 0.5%) in a appropriate manner with the use of bowl chopper. The chicken star was prepared by filling the emulsion in stainless steel moulds to get proper shape. The molded chicken star was cooked in convection oven at 180^0C for 13 minutes and 4 minutes after turning it so as to reach the internal temperature of 80^0C. The developed chicken stars were packed separately in pre-sterilized (in UV light) LDPE bags. The products were prepared in four different groups (500 gm each) i.e. (1) C = Emulsion with 10% vegetable oil, (2) T-1 = Emulsion with 5% vegetable oil + 0.3% hydrated carrageenan, (3) T-2 = Emulsion with 5% vegetable oil + 0.6% hydrated carrageenan, (4) T- 3 = Emulsion with 5% vegetable oil + 0.9 % hydrated carrageenan) for the study.

Physicochemical analysis of chicken star:

For determination of pH, the sample from each treatment was blended with distilled water (5 times the weight of the sample) to get uniform suspension and the pH was recorded by using a digital pH meter by immersing the electrode of pH meter into aliquot of the sample.

Cooking yield: Cooking yield was determined by measuring the ratio of cooked weight to raw weight and expressed as a percentage.

Emulsion stability: The emulsion stability was determined by the method of Baliga and Madaiah (1970) with minor modifications. Twenty five grams of meat emulsion was taken in polyethylene bag and heated in thermostatically controlled water bath at 80^0C for 20 min. Then the exudate was drained out and the cooked mass was weighed. The percentage of cooked mass was expressed as emulsion stability.

Proximate analysis: Moisture, protein, fat (ether extract) and total ash were determined as per AOAC (1995) method.

TBA: Thiobarbituric acid value was estimated as per the procedure given by Tarladgis *et al*. (1960).

Moisture-retention*:* Moisture retention was determined according to equation by El-Magoli *et al.* (1996). Calculation of moisture retention is as below:

Moisture retention (%) = (% cooking yield x moisture in cooked chicken star)/100

Fat retention*:* Fat retention was calculated based on a modified method of Murphy *et al*. (1975) as follows:

Fat retention (%) = (A/B) x 100

A = Fat content in cooked chicken star x weight of cooked chicken star

B = Fat content in uncooked chicken star x weight of uncooked chicken star

Cholesterol content: Total cholesterol was determined as per Zlatkis *et al.* (1953) with little modifications. Lipid extract was prepared by mixing 1 g of sample with 10 ml of freshly prepared 2:1 chloroform: methanol solution and homogenizing it in a blender. Homogenate was filtered using Whatman filter paper No. 42 and 5 ml of filtrate was added with equal quantity of distilled water, mixed and centrifuged at 3000 rpm for 7 minutes. Top layer (methanol) was removed by suction. Volume of bottom layer (chloroform) having cholesterol was recorded. The O.D. of standard and sample against blank was taken at 560 nm. Total cholesterol mg % was calculated as follows:

$$\text{Cholesterol (mg \%)} = \frac{\text{O.D. of sample}}{\text{O.D. of standard}} \times \frac{\text{Volume of chloroform (ml)}}{\text{Weight of sample taken (g)}} \times \text{Concentration of standard}$$

Microbiological analysis*:* Total plate count, lipolytic count and yeast and mold were determined using a colony counter according to guidelines of the American Public Health Association (APHA 1992).

Sensory evaluation: The sensory quality of samples was evaluated using 8 point hedonic scale where in 1 indicates dislike extremely and 8 indicate like extremely. At least seven sensory panelists drawn from staff and students of this university were utilized for sensory evaluation.

Statistical analysis: The data obtained from various trials under each experiment was subjected to statistical analysis (Snedecor and Cochran 1994) for analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) to compare the means by using SPSS16 software package. Each experiment was replicated thrice and the samples were analyzed in duplicate leading to total observation 6 (n=6). Sensory evaluation was performed by a panel of seven member judges three times, (n=21). The statistical significance was expressed at $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical analysis: There was a significant ($p<0.05$) difference of pH values between the control and carrageenan treated chicken star (Table 1). However, among the treatments a non-significant ($p>0.05$) increasing trend was observed. Similar results were obtained by Kumar and Sharma (2004) in low fat pork patties. Data presented in Table 1 revealed that cooking yield was significantly higher ($p<0.05$) at all levels of carrageenan than control. It could be due to the ability of carrageenan to form complexes with water and protein (Egbert *et al.* 1991) which improved water retention and cooking yield. Foegeding and Ramsey (1987) also observed a significant ($p<0.05$) increase in cooking yield of low fat frankfurters at 0.5-1 percent carrageenan. A non-significant ($p>0.05$) increasing trend was recorded in the emulsion stability with the increasing level of carrageenan. It might be due to presence of high ionic strength soluble protein present (He and Sabranek 1996).

Table 1: Effect of carrageenan on physico-chemical properties and sensory attributes of low fat chicken star

Constituents	Treatments			
	Control	T-1	T-2	T-3
		Physico-chemical properties		
Emulsion pH	$6.00^{b} \pm 0.03$	$6.03^{a} \pm 0.04$	$6.03^{a} \pm 0.02$	$6.05^{a} \pm 0.03$
Product pH	$6.12^{b} \pm 0.03$	$6.21^{a} \pm 0.03$	$6.24^{a} \pm 0.04$	$6.26^{a} \pm 0.03$
Cooking yield (%)	$82.15^{b} \pm 0.21$	$86.11^{a} \pm 0.34$	$86.23^{a} \pm 0.36$	$86.24^{a} \pm 0.30$
Emulsion stability (%)	$88.66^{b} \pm 0.34$	$91.37^{a} \pm 0.26$	$91.43^{a} \pm 0.23$	$91.53^{a} \pm 0.27$
Moisture (%)	$58.93^{b} \pm 0.40$	$63.66^{a} \pm 0.48$	$63.89^{a} \pm 0.40$	$63.91^{a} \pm 0.44$
Protein (%)	17.48 ± 0.20	17.45 ± 0.15	17.56 ± 0.20	17.58 ± 0.23
Fat (%)	$12.13^{a} \pm 0.16$	$7.83^{b} \pm 0.14$	$7.89^{b} \pm 0.12$	$7.99^{b} \pm 0.11$
Ash (%)	2.39 ± 0.13	2.54 ± 0.10	2.56 ± 0.16	2.59 ± 0.11
Moisture retention (%)	$52.12^{c} \pm 0.83$	$56.21^{b} \pm 0.13$	$58.33^{a} \pm 0.13$	$58.58^{a} \pm 0.13$
Fat retention (%)	$85.27^{c} \pm 0.62$	$88.12^{b} \pm 0.53$	$91.31^{a} \pm 0.71$	$91.62^{a}. \pm 0.62$
Cholesterol (mg/100 gm)	$174.12^{a} \pm 0.34$	$109^{b} \pm 0.34$	$111^{b} \pm 0.34$	$115^{b} \pm 0.34$
		Sensory attributes		
Appearance & color	6.88 ± 0.16	6.35 ± 0.18	6.87 ± 0.20	6.75 ± 0.13
Flavor	7.08 ± 0.14	6.92 ± 0.11	7.13 ± 0.12	6.95 ± 0.13
Texture	$6.89^{a} \pm 0.102$	$6.58^{b} \pm 0.19$	$6.99^{a} \pm 0.23$	$6.98^{a} \pm 0.16$
Juiciness	$6.83^{b} \pm 0.21$	$6.42^{b} \pm 0.23$	$6.94^{b} \pm 0.10$	$6.92^{a} \pm 0.20$
Overall acceptability	$6.86^{a} \pm 0.18$	$6.31^{b} \pm 0.13$	$7.12^{a} \pm 0.12$	$7.01^{a} \pm .17$

n=6 *Mean±SE with different superscripts (a, b, c…) in a column differ significantly ($p<0.05$), n=6 for each treatment; C= Emulsion with 10% vegetable oil;T-1 = Emulsion with 5% vegetable oil + 0.3% carrageenan; T-2 = Emulsion with 5% vegetable oil + 0.6% Hydrated carrageenan; T-4 = Emulsion with 5% vegetable oil + 0.9 % Hydrated carrageenan

Moisture content of cooked chicken star containing carrageenan at different levels (Table 1) exhibited significant ($p<0.05$) difference with control but there was no significant ($p>0.05$) difference in moisture contents among different levels of carrageenan addition. It might be due to obvious difference in formulation of low fat chicken star which contained additional water due to in-corporation of hydrated carrageenan and also because of the ability of carrageenan particles to retain more water (Huffman *et al.* 1992). Results shown in Table 1 clearly indicated that there was a non-significant ($p>0.05$) difference in protein and ash contents of low fat chicken star and control. This might be due to approximately similar amount of lean meat used in the preparation.

A significant ($p<0.05$) reduction was noticed in fat content as well as cholesterol content of carrageenan added chicken star (Table 1) over control. It might be due to obvious difference in the formulation of low fat chicken star since the products were developed with 5% of added fat with varying level of carrageenan. Pietrasik and Duda (1999) also reported the decrease in fat content of sausages containing carrageenan. However, among the treatments with the increasing level of carrageenan a non-significant ($p>0.05$) increasing fat content was increase in amount of carrageenan because of fat binding ability of carrageenan. Our findings are in accordance with the results obtained by Kumar and Sharma (2004).

Moisture and fat retention: The results of moisture and fat retention of chicken star formulated with carrageenan were more or less similar with the trend of cooking yield (Table 1). The moisture and fat retention was proportionally increased with the increment of carrageenan in chicken star formulation. This might be due to inherent quality of carrageenan to retain moisture and fat in the products. The higher moisture and fat retention capacity were also reported by Wan Rosli *et al*. (2011) in corn silk incorporated beef patties.

Sensory evaluation: The results presented in Table 1 indicated that a non-significant ($p>0.05$) difference in the colour and appearance score of carrageenan treated chicken star was observed in the study. The mean flavor score of chicken star at 0.3 percent and 0.6 percent level of carrageenan were comparable to control although it decreased significantly ($p<0.05$) at 0.9 percent of carrageenan, it might be due to pronounced off flavor at higher level of carrageenan. Pannin (1974) also reported bitter off flavor in the meat products incorporated with higher concentration of carrageenan. The texture of chicken star was significantly ($p<0.05$) decrease at 0.9 percent of carrageenan level, whereas, 0.60 percent level had scores similar to control. It could be due to maximum fat mimicking property of carrageenan at particular level (Wallingford and Labuza 1983). Juiciness of chicken star did not vary significantly. However, chicken star with 0.9 percent carrageenan had highest score. It might be due to higher retention of moisture and fat. Carrageenan has been reported to improve juiciness in low fat beef patties (Egbert *et al.* 1991). The overall mean value of acceptability score was superior at 0.6 percent level and it differ significantly ($p<0.05$) with other treatment.

pH, TBA and microbial qualities: The pH value was significantly ($p<0.05$) higher for control compared to treatment during the storage. However with advancement of storage period pH values were also increased significantly ($p<0.05$) in both control as well as carrageenan added low fat chicken star. The Lower pH value in low fat pork patties during storage was also reported by Kumar and Sharma (2004). TBA value of control chicken star was recorded significantly ($p<0.05$) higher on each day of storage. However, with the progress of storage the TBA value increased significantly ($p<0.05$) in either of the chicken star. Lower TBA values in low fat developed products might be due to lower fat content in the formulation.

The total plate count and lipolytic counts increased significantly ($p<0.05$) in both treatments and control with the advancement of storage (Table 2). However, counts were remains lower in carrageenan incorporated chicken star

Table 2: Changes in pH, TBA and microbial quality of functional chicken star during storage (4°C)

Products	Storage days			
	0	5	10	15
		pH		
Control	$6.00^{aA} \pm 0.02$	$6.08^{aA} \pm 0.03$	$6.18^{aB} \pm 0.03$	$6.25^{aC} \pm 0.04$
Treatment	$6.03^{aA} \pm 0.02$	$6.07^{aA} \pm 0.03$	$6.15^{aB} \pm 0.02$	$6.21^{aC} \pm 0.03$
		TBA (mg malonaldehyde/kg)		
Control	$0.303^{aA} \pm 0.22$	$0.409^{aB} \pm 0.27$	$0.598^{aC} \pm 0.24$	$0.741^{aD} \pm 0.22$
Treatment	$0.276^{aA} \pm 0.16$	$0.356^{bB} \pm 0.21$	$0.432^{bC} \pm 0.19$	$0.681^{bD} \pm 0.19$
		Total plate count (log_{10} cfu/g)		
Control	$3.11^{aA} \pm 0.14$	$3.71^{aB} \pm 0.18$	$4.22^{aC} \pm 0.14$	$4.89^{aD} \pm 0.12$
Treatment	$2.98^{aA} \pm 0.12$	$3.12^{aB} \pm 0.14$	$3.87^{aC} \pm 0.17$	$4.62^{aD} \pm 0.17$
		Lipolytic count (log_{10} cfu/g)		
Control	$2.21^{aA} \pm 0.19$	$2.83^{aB} \pm 0.16$	$3.06^{aC} \pm 0.10$	$3.71^{aD} \pm 0.18$
Treatment	$1.93^{aA} \pm 0.24$	$2.07^{bB}0.14$	$2.57^{bC} \pm 0.18$	$3.11^{bD} \pm 0.13$
		Yeast & Mold count (log_{10} cfu/g)		
Control	ND	ND	$1.60^{aB} \pm 0.14$	$2.51^{aA} \pm 0.19$
Treatment	ND	ND	$1.45^{aB} \pm 0.20$	$2.40^{aA} \pm 0.21$

n=6 *Mean±SE with different superscripts - upper case (A, B, C…) in a row and lower case (a, b, c…) in column differ significantly ($p<0.05$), n=6 for each treatment; Control= Emulsion with 10% vegetable oil; Treatment= Emulsion with 5% Vegetable oil + 0.6% carrageenan throughout the storage. This could be attributed to lower lipolytic counts in the corresponding product and lower lipolytic counts in carrageenan added chicken star might be due to low fat content in the formulation. Kumar and Sharma (2004) also observed significant ($p<0.05$) growth in total plate counts with the storage time. A significant ($p<0.05$) increase in lipolytic count of chicken patties under refrigeration was also reported by Nayak and Tanwar (2004). Initially yeast and moulds was not detected during storage. It might be due to absence of favourable condition for yeast and mould (like humid climate) while preparing the product. However, with the progression of storage they became evident on 10th day and increased significantly ($p<0.05$) on 15th day of storage.

Sensory quality: There was a significant ($p<0.05$) decrease in score of colour and appearance as well as texture of chicken star with the storage time. However, a non-significant ($p>0.05$) higher score of colour and texture were noticed for treated chicken star throughout the storage (Table 3). The decrease in colour and appearance during storage might be due to light fading of pigment in presence of oxygen and also due to deterioration in the fat which causes colour instability.

Data presented in Table 3 indicated that juiciness and texture scores of treatment and control, decreased initially non-significantly ($p>0.05$) but with the progress of storage time, scores were decreased significantly ($p<0.05$). However, the scores were higher for treated chicken star throughout the study and difference become significant on 15th day of storage. This could be due to moisture and fat retention capacity of carrageenan. Similar findings were reported by Candogan and Kolsarici (2003) in low fat frankfurters.

Table 3: Changes in sensory attributes of functional chicken star during storage (4^{o}C)

Products	Storage days			
	0	5	10	15
		Appearance and colour		
Control	ND	ND	1.60^{aB}±0.14	2.51^{aA}±0.19
Treatment	ND	ND	1.45^{aB}±0.20	2.40^{aA}±0.21
Control	6.87^{A}±0.19	6.61^{A}±0.22	6.01^{B}±0.16	5.29^{C}±0.13
Treatment	6.91^{A}±0.32	6.58^{AB}±0.16	6.29^{B}±0.21	5.39^{C}±0.20
		Flavour		
Control	6.35^{A}±0.12	6.15^{A}±0.18	5.85^{B}±0.14	5.07^{C}±0.14
Treatment	6.49^{A}±0.13	6.27^{A}±0.15	5.95^{B}±0.16	5.27^{C}±0.16
		Juiciness		
Control	6.86^{A}±0.15	6.63^{AB}±0.18	6.23^{B}±0.16	5.13^{aC}±0.17
Treatment	6.96^{A}±0.18	6.66^{AB}±0.10	6.38^{B}±0.14	5.66^{bC}±0.17
		Texture		
Control	6.86^{A}±0.18	6.68^{A}±0.16	5.89^{B}±0.14	5.12^{aC}±0.19
Treatment	6.95^{A}±0.14	6.76^{AB}±0.33	6.38^{B}±0.18	5.48^{bC}±0.18
		Overall acceptability		
Control	6.91^{A}±0.16	6.68^{B}±0.14	6.09^{aB}±0.14	5.48^{aC}±0.13
Treatment	7.20^{A}±0.15	6.89^{AB}±0.12	6.49^{bB}±0.14	5.88^{bC}±0.21

n=21 *Mean±SE with different superscripts - upper case (A, B, C…) in a row and lower case (a, b, c…) in a column differ significantly ($p<0.05$), n=21 for each treatment ; Control= Emulsion with 10% vegetable oil; Treatment= Emulsion with 5% Vegetable oil + 0.6% carrageenan

The panelist rated higher acceptability score for low fat carrageenan added chicken star. However, the difference was significant ($p<0.05$) from 10th day of storage. A significant ($p<0.05$) reduction in overall acceptability score was recorded with the progression of storage time. This was probably due to an increase in lipid oxidation and degradation of protein as well as fat substitutes in the developed products. Blockas *et al.* (1997) also reported higher overall acceptability scores for carrageenan containing products.

CONCLUSION

The present study showed successful utilization of carrageenan in the development of functional chicken star. The product incorporated with '0.6% carrageenan as fat replacer had comparatively superior physicochemical properties and sensory attributes. From the study it is concluded that carrageenan may be used to develop low fat functional chicken star without affecting sensory attributes of the products.

REFERENCES

Allen P, Dreeling N, Desmond E, Hughes E, Mullen AM, Troy D (1999) New technologies in the manufacture of low fat meat products. End of project report. The National Food Centre, Dublin

AOAC (1995) Official Methods of Analysis. 16th edn. Association of Official Analytical Chemist, Washington, DC

APHA (1992) Compendium of methods for the microbiological examination of foods. In: Vandergrant C, Splittstoesser DF (eds) American Public Health Association, Washington, DC, pp 919-927

Baliga BR, Madaiah N (1971) Preparation of mutton sausages. J Food Sci 36:607-610

Bloukas JG, Paneras ED, Papadima S (1997) Effect of carrageenan on processing and quality characteristics of low-fat frankfurters. J Muscle Foods 8(1):68-78

Candogan KS, Kolsarici N (2003) Storage stability of low-fat beef frankfurters formulated with carrageenan or carrageenan with pectin. Meat Sci 64:207–214

De Freitas Z, Saberanele JG, Olson DG, Carr JM (1997) Freeze/thaw stability of cooked pork sausage as affected by salt, phosphate, pH and carrageenan. J Food Sci 62(3):551-552

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

El-Magoli S, Laroia S, Hansen P (1996) Flavor and texture characteristics of low fat ground beef patties formulated with whey protein concentrate. Meat Sci 42(2): 179-193

Foegeding EA, Ramsey SR (1987) Rheological and water-holding properties of gelled meat batters containing iota carrageenan, kappa carrageenan or xanthan gum. J Food Sci 52(3):549-553

He Y, Sebranek JG (1996) Frankfurters with lean finely textured tissue as affected by ingredients. J Food Sci 61:1275-1280

Huffman DL, Mikel WB, Egbert WR, Chen C, Smith KL (1992) Development of lean pork sausage products. Cereal Food World 37(6): 439-442

Kumar M, Sharma BD (2004) The storage stability and textural, physic-chemical and sensory quality of low fat ground pork patties with carrageenan as fat replacer. Int J Food Sci Tech 39:31-42

Murphy EW, Criner PE, Grey BC (1975) Comparison of methods for calculating retentions of nutrients in cooked foods. J Agric Food Chem 23: 1153-1157

Nayak NK, Tanwar VK (2004) Effect of tofu addition on physicochemical and storage properties of cooked chicken meat patties. Indian J Poult Sci 39(2):142-146

Pannin J, Polic, M, Dordevic M (1974) The use of carrageenan in the manufacture of semi-perishable canned meat products. Technologija Mesa 15(3):82-84

Pietrasik Z, Duda Z (1999) Use of selected hydrocolloids in manufacture of boiled comminuted sausage. Gospodarka-Miesna 51(6):24, 26-31

Snedecor GW, Cochran WG (1994) Statistical methods, 8th edn. The Iowa State University Press Ames, Iowa, USA

Suman SP, Sharma BD (2003) Effect of grind size and fat levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties. Meat Sci 65:973-976

Tarladgis BG, Watts BM, Younathan MT, Dugan LJ (1960) A distillation method for the quantitative determination of malonaldehyde in rancid foods. J Am Oil Chem Soc 37: 44-48

Wan Rosli WI, Nurhanan AR, Solihah MA, Mohsin SSJ (2011) Cornsilk Improves nutrient content and physical characteristics of beef patties. Sains Malaysiana 40(2): 155–161

Wallingford LW, Labuz TP (1983) Evaluation of water binding properties of food hydrocolloids by physical/chemical methods and in a low meat emulsion. J Food Sci 48(1):1-5

Zlatkis A, Zak B, Boyle AJ (1953) A new method for the direct determination of serum cholesterol. J Lab Clin Med 41:486-492