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Shelf Life Stability of Enrobed Mutton Nuggets Admixed with Head and Cheek Meat

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Abstract: In the current study enrobing of mutton nuggets incorporated with 40% head and cheek meat was done using gram flour and refined wheat flour. The product was evaluated for its physico-chemical, sensory and storage quality. Physico-chemical parameters included pH, cooking yield and proximate composition. pH of enrobed mutton nuggets was 6.28 and non-significantly higher than control. Mean cooking yield values of control (T_0), gram flour enrobed (T_1) and refined wheat flour enrobed (T_2) mutton nuggets were 81.43%, 104.60% and 102.48% respectively. Proximate composition showed non-significant difference among the treatments with the protein and fat content lower than the control. Storage study of enrobed mutton nuggets was conducted under refrigeration in LDPE bags and the product was evaluated at regular intervals of 5 days during its 20 days storage. There was a progressive increase in pH of the product as well as control. TBA values also showed increasing trend from day 0 to 20th day of storage and mean values of TBA of enrobed mutton nuggets was significantly lower than control. During the storage there was constant increase in total plate count. However the product remained within the acceptability limit upto 10th day of its refrigerated storage.

Key words: Enrobing, nuggets, TBA, TPC.

INTRODUCTION

Processed meat and meat products are consumed all over the world and the number of meat eating consumers is increasing day by day. India ranks 5th in world in meat production which stands at over 6 million tones as against world's 272 million tons (Sharma, 2006). Meat is marketed in various forms and conveniences to suit the consumer's choice. Demand for meat and meat products has been growing strongly especially in developing countries of Asia where heavy industrialization and globalization has stimulated growth of per capita income and up-gradation of living standard which has widened the demand for meat products and it is amplified by population growth in developing countries. Thus there is scope in development of processed meat industry in order to cater the need of urban population, which consume 70 to 75 % meat products (Singh, 2004). Processing meat to value added products contributes to sustained demand for meat and efficient marketing of meat to earn reasonable returns from meat animals by the farmers (Kondiah, 2004). There is a vast scope of utilizing the by-products in the development of meat products. This will help to reduce the cost of the meat products and also efficient utilization of these by products. Two terms –"byproducts" and "offals"- are used to denote all materials of economic value produced from slaughter of food animals, which are not a part of the dressed carcass. They are classified into two major groups i.e. "edible byproducts" or "edible offals" and "inedible byproducts" or "inedible offals" depending upon their use for human food or otherwise. Compared to carcass meat, edible byproduct meat is generally tougher in texture due to high collagen content and poor in sanitary quality due to larger surface area requiring more handling and resulting in lower keeping quality. Cost wise, they are low priced meats. This is one reason for the majority of consumers of edible offals belonging to the socio- economically poor strata of the society. However edible offals do lend themselves for preparation into many delicious cuisines. Another major use is their incorporation in processed meats as substitute for lean with substantial reduction in manufacturing costs. They can be also used for preparation of value added products like protein isolates and many active principles of commercial importance. Efficient utilization of by-products has direct impact on the economy and environmental hygiene of the country. Non-utilization or under utilization of by-products not only leads to loss of potential revenues but also to the added and increasing cost of disposal of these products. In order to provide more affordable and high quality protein products, the strategy which is widely used is the partial replacement of the lean meat with low value meat i.e., offals, head and cheek meat and other edible by-products.

(Bhat *et al.*, 2011, Dalmas *et al.*, 2011). Head and cheek meat is difficult to market at remunerative prices because of its lower acceptance. Due to increase in slaughter rate, large quantities of head and cheek meat become available especially in festival seasons like Eid and also in marriage seasons. At these times head and cheek meat becomes difficult to market, hence it is sold at lower costs. Utilization of head and cheek meat enables production of low cost, protein rich products. The acceptance of such products can also be increased by enrobing. Enrobing is a process in which foods are coated with edible coatings in the form of batter, which increases their acceptance and enhances their quality. Enrobing brings several advantages to meat products such as value addition, versatility to consumers and improvement of nutritive value as well as eating and microbial qualities of the products (Richardson, 1989). Enrobing also contributes other advantages like preserving the nutritive value, reducing moisture and weight loss, and improving juiciness and tenderness. It has become means of offering consumers new items that are promotable features in supermarkets and even small improvements can be of high monetary value. Enrobing may also improve the appearance, color, crispness, flavor, juiciness, nutritive value and microbiological profile of the product (Cunningham, 1989). Enrobing, thus, provides processors with added value at low cost. The amount and composition of enrobing material influence color, appearance and overall acceptability. Besides fish and chicken, researchers have developed other enrobed meat products such as buffalo meat cutlets (Eyas, 2001), pork patties (Biswas, 2002), pork nuggets (Anjaneyulu *et al.*, 2002), buffalo meat patties (Chidanandaiah, 2003) and goat meat croquettes (Agnihotri & Rajkumar, 2003). The present work reviews the partial replacement of lean meat by head and cheek meat in production of mutton nuggets and value addition of such products by enrobing.

MATERIALS AND METHODS

Raw materials were procured from local market. Head and cheek meat was obtained within 3-4 hours of slaughter of animals. Mutton nuggets were prepared by replacing lean meat by head and cheek meat @ 20%, 30% and 40% level which served as treatments T_1, T_2 and T_3 respectively. In addition a control mutton nugget (C) was prepared to which no head and cheek meat was added. The ingredients used in preparation of nuggets included oil @ 10%, salt @ 2%, water @ 10%, whole egg liquid @ 6%, condiments @ 6 % and spices @ 2% on weight basis. The product was evaluated for proximate composition, cooking yield, emulsion stability and sensory characteristics.

Flow chart for the preparation of mutton nuggets

Mutton
(Lean or Lean+head and cheek meat)
↓
Cut into pieces
↓
Minced
(Through 8mm plate)
↓
Addition of salt with ice flakes
↓
Chopping in bowl chopper (2-3 minutes)
↓
Addition of refined vegetable oil
↓
Chopping (2-3 minutes)
↓
Addition of whole egg, condiment, spice mix and other ingredients
↓
Chopping (1-2 minutes)
↓
Filling into stainless steel moulds
↓
Hot water cooking for 35 minutes at 90°C
↓
Cooling to ambient temperature, slicing, cutting and packaging

Enrobing of mutton nuggets incorporated with prestandardized level of head and cheek meat was done with 2 different batter mixtures prepared from gram flour (T_1) and refined wheat flour (T_2) following Rajnish *et al.* (2008). The product was deep fat fried in vegetable oil at 130 to 140^{o}C for 6 minutes. The product was evaluated for proximate composition, cooking yield and sensory evaluation. Enrobed mutton nuggets extended with prestandardized level of head and cheek meat were packed aerobically in LDPE pouches and stored at 4±1° C for 20 days. The product was evaluated at an interval of five days on 0th, 5th, 10th, 15th and 20th day of storage for pH, TBA value, sensory parameters and microbiological quality viz., Total plate count and Yeast and Mould count. The pH of mutton emulsion as well as nuggets was determined by the method of Trout *et al.,* (1992) by using combination electrode digital pH meter (ESICO-1012). Cooking yield (%) was determined by weight of cooked enrobed product / the weight of uncooked emulsion x 100. The percentage moisture, protein, ether extract and ash of the meat product samples were evaluated as

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per standard procedure of Association of Official Analytical Chemists (AOAC, 1995). The estimation of TBA value was done by following the method of Witte *et al.* (1970) with slight modifications. The TBA value was calculated as mg malonaldehyde per kg of sample by multiplying O.D. value with k factor 5.2. The samples of meat products were subjected to microbiological analysis for Total Plate Count and Yeast and Mould Count as per the method described by APHA (1992). The product was evaluated for sensory parameters viz., appearance, flavor, texture, juiciness, mouth coating and overall acceptability as per 8 point hedonic scale (Keeton, *et al.*, 1984). The data generated from various trials under each experiment was pooled and subjected to statistical analysis using the software of Statistical Package for Social Sciences (SPSS-Base 17.0). The statistically analyzed results were tabulated and interpreted.

RESULTS AND DISCUSSION

Physico-chemical parameters of enrobed mutton nuggets incorporated with 40% head and cheek meat

pH: As delineated in Table 1 pH of T_1 and T_2 was non-significantly ($P>0.05$) higher than T_0. This might be due to the different pH of batter mix and varying buffering capacity of enrobing material used (Chidanandaiah and Keshri, 2006). The pH values were in agreement with the findings of Chidanandaiah and Keshri, (2007) who also reported non-significant ($P>0.05$) increase in pH of gram flour enrobed buffalo meat patties. Similar findings were reported by Rajnish *et al.,* (2008) wherein enrobing of spent hen meat patties resulted in significant increase in pH.

Cooking yield: The cooking yield of T_1 and T_2 was significantly ($P<0.05$) higher than T_0. Among the treatment groups, cooking yield of T_1 and T_2 was non-significantly ($P>0.05$) different from each other (Table 1). Lower cooking yield of T_0 was due to absence of enrobing material, which contributed to weight and resulted in higher cooking yield in treatments in comparison to control. The difference in cooking yield between treatments could be attributed to the different moisture absorption property of batter mix prepared from different flours (Hanson and Fletcher, 1963). Similar results were found by Chidanandaiah and Keshri, (2006) in 2% pectin and gram flour enrobed buffalo meat patties. Rajnish *et al.,* (2008) also reported increase in cooking yield in enrobed spent hen meat patties than control patties.

Moisture: As shown in Table 1 the moisture content T_1 and T_2 was significantly ($P<0.05$) higher than T_0. However, there was non-significant difference between T_1 and T_2. The higher moisture content in enrobed mutton nuggets could be due to moisture retention by starch present in gram flour and refined wheat flour (Miller *et al.,* 1973). The results were in agreement with the findings of Rajnish *et al.,* (2008) who reported higher moisture content in Bengal gram flour and corn flour enrobed spent hen meat patties than control (not enrobed) patties.

Protein: As shown in Table 1 protein content of T_1 and T_2 was significantly ($P<0.05$) lower than T_0. Lower protein content in enrobed nuggets could be attributed to relatively higher amount of starch present in the batter mix. T_2 had significantly ($P<0.05$) lower protein content than T_1 which might be due to higher protein and lower starch content in gram flour than refined wheat flour. The results of present study were in agreement with the findings of Rajnish *et al.,* (2008) who reported lower protein content in Bengal gram flour and corn flour enrobed spent hen meat patties than control. Chidanandaiah and Keshri, (2006) also reported lower protein content in buffalo patties enrobed with pectin and gram flour. Similar results were reported by Chidanandaiah and Keshri, (2007) in buffalo patties enrobed with Bengal gram flour and rice flour.

Fat: As shown in Table 1 fat content of T_1 and T_2 mutton nuggets was significantly ($P<0.05$) lower than control (T_0). The difference in fat content of T_1 and T_2 mutton nuggets was non-significant ($P>0.05$). Less fat content in enrobed mutton nuggets (T_1 and T_2) might have been due to action of coating ingredients, where protein get denatured and starch get gelatinised, both act together to form a coating on the product with oil and moisture barrier properties. Increase in moisture content of enrobed product also proportionally decreased fat content of the product. The findings were corroborated by Rajnish *et al.,* (2008) who reported lower fat content in Bengal gram flour and corn flour enrobed spent hen meat patties than control. Chidanandaiah and Keshri, (2006) also reported lower fat content in buffalo patties enrobed with pectin and gram flour. Similar results were found by Chidanandaiah and Keshri, (2007) buffalo patties enrobed with Bengal gram flour and rice flour.

Ash: As given in table 1 ash content revealed non-significant difference ($P>0.05$) among all treatments. This might be due to the similar mineral content in meat and batter mix. Addition of same amount of salt in mutton and batter mix may also be the reason for similar ash content among control and treatments.

Sensory quality of enrobed mutton nuggets incorporated with 40% head and cheek meat

Appearance: Mean appearance scores of T_1 and T_2 mutton nuggets were significantly ($P<0.05$) higher than control. Among the treatment groups (T_1 and T_2), non-significant ($P>0.05$) difference in the appearance scores was observed but the score of gram flour enrobed mutton nuggets was better than refined wheat four mutton nuggets. Higher appearance scores of T_1 and T_2 than T_0 (control) might be due to the golden brown color imparted by enrobing and frying. Deep fat frying of control nuggets produced slightly dark color which decreased the score. These observations were in agreement with the observations reported by Chidanandaiah and Keshri, (2006) in buffalo meat patties enrobed with Bengal gram flour and rice flour. Similar results were reported by Chidanandaiah and Keshri, (2007) in buffalo patties enrobed with pectin and gram flour.

Flavour: As shown in table 2, the mean flavour score of T_1 and T_2 mutton nuggets were significantly (P<0.05) higher than of control. There was non-significant (P>0.05) difference in the flavour scores of treatment groups (T_1 and T_2). The flavour score T_1 (Gram flour enrobed) and T_2 (Refined wheat flour enrobed) mutton nuggets were significantly (P<0.05) higher than of control. There was non-significant (P>0.05) difference in the flavour scores of treatment groups (T_1 and T_2). Significantly higher flavour values in enrobed mutton nuggets (T_1 and T_2) might be due to enrobing which prevented loss of flavour components during deep fat frying. The results of present study on the flavour scores of gram flour enrobed and refined wheat flour enrobed mutton nuggets were in agreement with the findings of Chidanandaiah and Keshri, (2006) who reported increase in flavour scores in Bengal gram flour and rice flour enrobed buffalo patties. Chidanandaiah and Keshri, (2007) also reported similar observations in pectin and gram flour enrobed buffalo patties.

Juiciness: Mean Juiciness score of T_1 and T_2 mutton nuggets were significantly (P<0.05) higher than control (Table 2). No significant (P>0.05) difference was observed in the juiciness scores of treatment groups (T_1 and T_2) but the score of T_1 was slightly better than T_2. Juiciness score of T_1 (Gram flour enrobed) and T_2 (Refined wheat flour enrobed) mutton nuggets were significantly (P<0.05) higher than T_0 (control). No significant (P>0.05) difference was observed in the juiciness scores of treatment groups (T_1 and T_2). Enrobing acts as a sealant which prevents flow of juices from inside to outside during frying. This resulted in higher juiciness scores in enrobed products than control mutton nuggets. The results of present study on the juiciness scores of gram flour enrobed and refined wheat flour enrobed mutton nuggets were in agreement with the findings of Chidanandaiah and Keshri, (2006) who reported increase in juiciness scores in Bengal gram flour and rice flour enrobed buffalo patties. Chidanandaiah and Keshri, (2007) also reported similar observations in pectin and gram flour enrobed buffalo patties.

Texture: As shown in table 2, Mean texture score of T_1 and T_2 mutton nuggets were significantly (P<0.05) higher than control. The difference of texture score of T_1 and T_2 mutton nuggets was non-significant (P>0.05). Texture score of T_1 (Gram flour enrobed) and T_2 (Refined wheat flour enrobed) mutton nuggets were significantly (P<0.05) higher than control. The difference of texture score between T_1 and T_2 mutton nuggets was non-significant (P>0.05). The texture score is influenced by moisture content of the product and changes occurring during deep fat frying. High textural scores of T_1 and T_2 mutton nuggets might be related to the higher moisture content of the products. Saccharides have been reported to have control over form, texture and shelf life of enrobed foods (Suderman *et al.*, 1981). The results of present study on the texture scores of gram flour enrobed and refined wheat flour enrobed mutton nuggets were in agreement with the findings of Chidanandaiah and keshri, (2006) who reported increased texture scores in Bengal gram flour and rice flour enrobed buffalo patties; Chidanandaiah and Keshri, (2007) reported similar observations in enrobed buffalo patties.

Mouth coating: All the products had mouth coating value between practically none to none. Mean mouth coating scores for (T_0) control, (T_1) gram flour enrobed and (T_2) refined wheat flour enrobed mutton nuggets were non-significantly (P>0.05) different because the fat content was low in the products.

Overall acceptability: As shown in table 2, the overall palatability scores score of T_1 (Gram flour enrobed) and T_2 (Refined wheat flour enrobed) mutton nuggets were significantly (P<0.05) higher than T_0 (control). No significant (P>0.05) difference was observed in the overall palatability scores of treatment groups (T_1 and T_2). Overall palatability depends on other sensory attributes, so improvement in other sensory attributes accordingly improved overall palatability of the enrobed products. The results of present study on the overall acceptability scores of gram flour enrobed and refined wheat flour enrobed mutton nuggets were in agreement with the findings of Chidanandaiah and Keshri, (2006) who reported increase in overall acceptability scores in Bengal gram flour and rice flour enrobed buffalo patties. Chidanandaiah and Keshri, (2007) also reported similar observations in pectin and gram flour enrobed buffalo patties.

Storage Study

Physico-chemical properties

pH: As depicted in Table 3 pH has shown increasing trend in T_1, T_2 and T_0. With the advancement of storage period significant (P<0.05) increase in the mean pH values of control and both treatment groups was observed. Increase in pH of products during storage could be due to production of amines from protein breakdown by micro-organisms. Different authors (Sunki *et al.*, 1978 and Nath, 1992) also reported significant increase in pH of meat and meat products during storage at 5 to 7 ^{0}C. Similar increase in pH was also reported by Nag *et al.*, (1998) in chicken nuggets, Kumar and Sharma (2004) in chicken patties, Chidanandaiah *et al.*, (2009) in buffalo meat patties, Sureshkumar *et al.*, (2010) in buffalo meat sausages, Kumar and Tanwar, (2010) in chicken nuggets.

TBA: The mean TBA values of control and enrobed mutton nuggets increased significantly (P<0.05) during storage period (Table 3). Overall mean TBA values of T_1 and T_2ts were significantly (P<0.05) lower than T_0. However there was nonsignificant between T_1 and T_2 . This might be due to the effect of enrobing (coating) which acted as good oxygen barriers (Conca and Yang, 1993) and might have retarded lipid oxidation in foods (Kester and Fennema, 1986). Similar results were reported by Conca and Yang, (1993), Kester and Fennema, (1986), Krochta *et al.,* (1994) and Earle and McKee (1985) and Chidanandaiah *et al.,* (2009) in various coated meat products. The increase in TBARS values on storage might be attributed to oxygen permeability of packaging material (Brewer *et al.,* 1992) that led to lipid oxidation. Kumar and Tanwar, (2010), Sudheer *et al.,* (2010) and Bhat *et al.,* (2010) who also found a similar increase in TBARS values upon storage of different meat products. The TBA value of the products was under permissible limits. The threshold value of TBA is 1-2 mg/Kg for rancidity in meats (watts, 1962). Witte *et al.,* (1970) also reported the threshold value of TBA at 1-2 mg of malonaldehyde per kg of meat.

Microbiological quality
T_0 (Control), T_1 (Gram flour enrobed) and T_2 (Refined wheat flour enrobed) mutton nuggets were evaluated for total plate count and yeast and mould count and results obtained are shown in table 3.

Total plate count: Overall mean Total plate count of T_1 and T_2 mutton nuggets was significantly (P<0.05) lower than T_0. No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets. This might be due to the effect of enrobing which affected the microbiological profile of the product. The results of present study on the juiciness scores of gram flour enrobed and refined wheat flour enrobed mutton nuggets were in agreement with the findings of El-Ebzary *et al.,* (1981), Chidanandaiah *et al.,* (2009). Similar findings were also reported by Bhat *et al.,* (2011) in enrobed spent hen meatballs. During storage an overall increase in total plate count was observed in control and enrobed mutton nuggets. The mean total plate count values of control and enrobed mutton nuggets increased significantly (P<0.05) during storage period A significant (P<0.05) increase in total plate counts of mutton nuggets stored under refrigeration was in agreement with findings of Nath *et al.,* (1995), Kumar and Tanwar, (2010) and Bhat *et al.,* (2010) who also reported the similar results in chicken patties, chicken nuggets and chevon Harissa respectively.

Yeast and Mould count: Yeast and mould count of T_1 and T_2 mutton nuggets was significantly (P<0.05) lower than T_0 mutton nuggets on 15^{th} and 20^{th} day of storage. This might be due to effect of enrobing. Overall yeast and mould count of products during entire storage period was non-significantly (P>0.05) different. During storage counts were not detected up to 15 days of storage in T_0 (Control) as well as T_1 and T_2 (enrobed mutton nuggets). Mean yeast and mould count of control and enrobed mutton nuggets increased significantly (P<0.05) from 15^{th} to 20^{th} day of storage (Table 3). Yeast and Mould count were not detected during early period of storage study which could be due to thorough cooking, good hygiene and absence of post processing contamination. Eyas *et al.,* (2001) did not detect yeast and mould count in enrobed cutlets due to post processing contamination. Similar results were found by Humaira (2011) Yeast and mould value of T_0, T_1 and T_2 mutton nuggets on 20^{th} day of storage was 1.43, 1.15 and 1.10 respectively. When yeast and mould counts exceed log 4, spoilage occurs.

Sensory evaluation
Mean values of different sensory parameters of control (T_0) as well as enrobed (T_1 and T_2) control and enrobed mutton nuggets are shown in table 4.

Appearance: Overall appearance scores of T_1 and T_2 mutton nuggets were higher than T_0 and difference was significant (P<0.05). No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets. During storage an overall decrease in appearance scores was observed in T_0, T_1 and T_2 mutton nuggets. The decrease in appearance scores might be due to pigment and lipid oxidation resulting in non-enzymatic browning. A decrease in appearance and colour scores of meat products with increase in storage period was also reported by Bhat *et al.,* (2011) in enrobed spent hen meatballs, Biswas *et al.,* (2011), Nag *et al.,* (1998) in chicken nuggets, Kumar and Sharma, (2004) in chicken patties and Bhat *et al.,* (2010) in chevon Harrisa. It could also be due to relative moisture loss from the surface of coating.

Flavor: Overall mean flavor scores of T_1 and T_2 mutton nuggets were significantly (P<0.05) higher than T_0. No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets**.** This might be due to enrobing which prevented leaching of flavor components during deep fat frying. During storage an overall decrease in flavor scores was observed in T_0, T_1 and T_2 mutton nuggets. The progressive decrease in flavor could be attributed to increase in thiobarbituric acid reacting substances (TBARS) value of meat product (Tarladgis *et al.,* 1960) stored under aerobic conditions. The reduction of flavor score has been attributed to the increased lipid oxidation, liberation of fatty acids and increased microbial load (Sahoo and Anjaneyulu, 1997). The results of present study were in agreement with the findings reported by Bhat *et al.,* (2011) in enrobed chicken meatballs. Biswas *et al.,* (2011) in duck patties and Nag *et al.,* (1998) in chicken nuggets also reported a decrease in flavor scores.

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Texture: Overall mean texture scores of T_1 and T_2 mutton nuggets were higher than T_0 and difference was significant (P<0.05). No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets. This might be due to higher moisture content of enrobed products than control mutton nuggets. During storage an overall decrease in texture scores was observed in T_0, T_1 and T_2 mutton nuggets. These results are in agreement with findings of Biswas *et al.*, (2004), who stated that coated patties released moisture more slowly than uncoated patties which resulted in decreased texture score. Lower textural scores could also be due to breakdown of fat, protein and fat substitutes. Loss of moisture during storage caused the mutton nuggets to retain lesser texture scores (Wu *et al.*, 2000) and changes in properties of fats (Colemenero *et al.*, 1996). Similar results were presented by Bhat *et al.*, (2011) in enrobed spent hen meatballs, Biswas *et al.*, (2011) in duck patties and Bhat *et al.*, (2010) in chevon Harrisa during refrigerated storage respectively. Vedamurthy, (1998) also observed decrease in textural score during refrigerated storage of low fat chevon sausage.

Juiciness: Overall mean juiciness scores of T_1 and T_2 mutton nuggets were higher than T_0 and difference was significant (P<0.05). No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets. This might be due to higher moisture content of enrobed products than control mutton nuggets. During storage an overall decrease in juiciness scores was observed in T_0, T_1 and T_2 mutton nuggets. It could be due to some loss of moisture from the products during storage as low density polythene bags were permeable to water vapour (Biswas *et al.*, 2011; Eyas, 2001). The results were in accordance with findings of Bhat *et al.*, (2011) in enrobed spent hen meatballs, Nag *et al.*, (1998) in chicken nuggets. However, the juiciness scores of coated mutton nuggets were higher than uncoated meat balls as a result of higher moisture content.

Mouth coating: During the storage period, a decrease in mean mouth coating scores of the T_0, T_1 and T_2 mutton nuggets was observed. It could be due to changes in nuggets because of lipid oxidation and degradation of protein during storage period. Similar findings were also reported by Egbert *et al.*, (1992) and Bullock *et al.*, (1994) in low fat ground beef patties.

Overall acceptability: Overall mean acceptability scores of T_1 and T_2 mutton nuggets were higher than T_0 and difference was significant (P<0.05). No significant (P>0.05) difference was observed in T_1 and T_2 mutton nuggets. These results are in agreement with findings of Biswas *et al.*, (2004) who observed increased overall acceptability scores in enrobed pork patties compared to control patties. During storage an overall decrease in overall acceptability scores was observed in control and enrobed mutton nuggets. The decrease in scores during study might be reflective of the decline in scores of appearance, flavour, juiciness and texture attributes. Similar results were found by Bhat *et al.*, (2011) in enrobed meat balls. Biswas *et al.*, (2011) reported decrease in overall acceptability in duck patties during refrigerated storage.

CONCLUSION

Incorporation of 40% head and cheek meat in mutton nuggets significantly increased the emulsion stability and cooking yield while maintaining the physico- chemical and sensory properties. Enrobing of mutton nuggets with gram flour and refined wheat flour as a value addition tool resulted in increased cooking yield, increased sensory scores and reduced microbiological load and increased storage quality. Enrobed mutton nuggets remained fairly acceptable up to 20 days of refrigerated storage in LDPE bags. Thus it is concluded that 40% head and cheek meat can be incorporated in mutton nuggets which can further be enrobed with gram flour and refined wheat flour and stored for 20 days under aerobic refrigerated storage.

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Table 1: Physico-chemical parameters of enrobed mutton nuggets incorporated with 40% head and cheek meat

The values in a column with different superscript (a,b) differ significantly (p<0.05)

Treatments	pH	Cooking yield (%)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
T_0	6.24 ± 0.45^b	81.43 ± 0.99^b	51.64 ± 0.66^b	25.42 ± 0.76^b	16.92 ± 0.77^b	3.60 ± 0.54^a
T_1	6.28 ± 0.75^a	104.60 ± 0.76^a	57.47± 0.74^a	20.87 ± 0.53^a	13.27 ± 0.51^a	3.37 ± 0.43^a
T_2	6.28 ± 0.44^a	102.48 ± 0.54^a	56.88 ± 0.66^a	18.07 ± 0.64^a	13.63 ± 0.43^a	3.44 ± 0.71^a

Table 2: Sensory quality of enrobed mutton nuggets incorporated with 40% head and cheek meat

Sensory attributes	T_0	T_1	T_2
Appearance	6.63 ± 0.64^b	7.33 ± 0.87^a	7.26 ± 0.44^a
Flavor	6.52 ± 0.55^b	7.44 ± 0.43^a	7.41 ± 0.54^a
Juiciness	6.56 ± 0.34^b	7.37 ± 0.69^a	7.30 ± 0.43^a
Texture	6.78 ± 0.44^b	7.33 ± 0.45^a	7.29 ± 0.50^a
Mouth coating	7.59 ± 0.31^b	7.85 ± 0.65^a	7.81 ± 0.55^a
Overall acceptability	6.52 ± 0.76^b	7.41 ± 0.43^a	7.37 ± 0.34^a

The values in a row with different superscript (a,b) differ significantly (p<0.05)

Table 3: Effect of refrigerated storage and enrobing on the physico-chemical and microbiological quality of mutton nuggets incorporated with 40% head and cheek meat

Treatments	pH	TBA (mg malonaldehyde/Kg)	TPC (log_{10} CFU/gm)	Yeast and mould count (log_{10} CFU/Kg)
T_0	6.20 ± 0.77^b	0.59 ± 0.66^a	2.70 ± 0.61^a	0.46 ± 0.76^a
T_1	6.27 ± 0.87^a	0.48 ± 0.75^b	2.38 ± 0.55^b	0.34 ± 0.65^b
T_2	6.27 ± 0.54^a	0.49 ± 0.88^b	2.39 ± 0.63^b	0.36 ± 0.32^b

The values in a column with different superscript (a,b) differ significantly (p<0.05)

Table 4: Effect of refrigerated storage and enrobing on Sensory quality of mutton nuggets incorporated with 40% head and cheek meat

Sensory Attributes	T_0	T_1	T_2
Appearance	6.33 ± 0.76^b	6.90 ± 0.54^a	6.82 ± 0.72^a
Flavor	6.17 ± 0.65^b	7.01 ± 0.76^a	6.99 ± 0.56^a
Texture	6.18 ± 0.54^b	6.91 ± 0.66^a	6.83 ± 0.21^a
Juiciness	6.25 ± 0.42^b	6.92 ± 0.45^a	6.82 ± 0.33^a
Mouth coating	7.16 ± 0.50^b	7.48 ± 0.62^a	7.44 ± 0.52^a
Overall acceptability	6.18 ± 0.77^b	6.97 ± 0.73^a	6.92 ± 0.12^a

The values in a row with different superscript (a,b) differ significantly (p<0.05)