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Full Length Research Paper

Quality assessment of vacuum packaged chicken snacks stored at room temperature

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Chicken snacks were prepared by utilizing spent hen meat, sodium caseinate and rice flour, spice mix, condiments, common salt, phosphate and baking powder. The control was prepared in a similar manner except that, spent hen meat was substituted by equal quantity of rice flour. Chicken snack and control were packaged under vacuum in laminated (polyethylene/aluminium foil) pouches (size 25 × 20 cm), stored at 30 ± 2°C. The changes in physico-chemical characteristics, sensory attributes and microbiological profile of vacuum packaged chicken snacks, as well as control were analyzed during storage at room temperature (30 ± 2°C) for 30 days with regular intervals of six days. Both chicken snacks and control indicated non-significant effect of treatment on days of storage with respect to the contents of fat, protein, ash, pH, total plate count (TPC), yeast and mould counts (YMC). However, shear force value in treated products were significantly (P<0.05) different on day 0 and 6 from the rest of the storage days. The TBA values for control on day 0, 6, 12 were found significantly different from the rest of the storage days. Sensory attributes for both control and treated products were found to be less affected by the days of storage in the whole of the storage period. Overall comparison of physico-chemical, microbiological and sensory profiles of control and treated products found highly significant (P<0.01) difference except for some values of moisture, shear force and pH. The study revealed that both products can be stored under vacuum in very good condition up to 30 days at room temperature.

Key words: Chicken snack, spent hen meat, rice flour, sodium caseinate, vacuum.

INTRODUCTION

Snacks are convenient fast food and their consumption is increasing day by day due to rapid urbanization and sociological changes. It is a food of choice for school going children, adolescent girls and high mobility groups. The market of snack food industry including semi-processed/cooked and ready to eat foods was around Rs 82.9 billion in 2004 to 2005 and is rising rapidly with a growth rate of 20%. Most of the snacks available in the market are mainly based of cereals which are high in calorie and low in protein contents. So, the incorporation of meat in these snacks is a good alteration in its nutritional value particularly high value animal protein.

By incorporation of spent hen meat, we can enhance nutritive value, palatability and can help in utilizing this poultry industry by-product. The spent hens are old and culled chickens, which have completed their productive and reproductive phase of life (Mahapatra, 1992). The meat of such birds is tougher, less juicy due to high collagen contents (Abe et al., 1996) and high degree of cross linkages (Wenham et al., 1973; Bailey, 1984) as compared to broiler meat. These shortcomings of using spent hens meat in different products can be overcome with suitable food additives or extenders like flours, starch and milk proteins (Chung et al., 1989; Tarte et al., 1989). Non-meat proteins from a variety of plant sources can be utilized in different meat products in various ways (Gujral et al., 2002; Dzudie et al., 2002; Bhat and Pathak, 2009; Serdarouglu and Degirmencioglu, 2004).

The broiler production in our country is increasing in a faster pace. Similarly, the number of broiler spent hens in poultry industry is also increasing. These birds are heavier in weight and their meat is high in fat contents (10 to 15%) (Kondaiah, 1990). The meat of such birds is poor in quality similar to the spent hen's meat. Very few workers have attempted the still inconclusive study of

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Table 1. Formulations for chicken snack preparations.

Ingredients (w/w)	Chicken snack	Control snack
Broiler spent hen meat	50.0	0
Rice flour	41.0	91
Sodium caseinate	2.5	2.5
Common salt	2.0	2.0
Condiments	2.5	2.5
Spice mix	1.5	1.5
Baking powder	0.5	0.5

Phosphate: 0.3% of meat used (on weight basis), ice water: 100% of flour used (on weight basis).

Table 2. Composition of spice mixture.

Ingredients	Percent (%)
Coriander powder	15.0
Cumin seeds	15 .0
Red chilli powder	20.0
Black pepper	15.0
Cloves	5.0
Cardamom	5.0
Turmeric	10.0
Cinnamon	5.0
Aniseed	10.0

chicken snacks from spent hens, particularly from broiler spent hens meat. Thus, the study was conducted and chicken snacks prepared were envisaged to evaluate the effect of vacuum packaging to know the suitability of its storage at ambient temperature.

MATERIALS AND METHODS

Sources of chicken meat

Fifty weeks old broiler spent hens were procured from Central Avian Research Institute, Izatnagar. The birds were slaughtered and dressed in the abattoir of the Institute by humane method of slaughter. The body fat was removed and deboning of dressed chicken was done manually removing all tendons and separable connective tissues. The lean meat was packed in low density polyethylene bags and frozen at -20°C until use.

Condiments and rice flour

Onion, garlic and ginger in the ratio of 3:1:1 were ground in a mixture to the consistency of fine paste. Rice flour used in the study was procured from the standard flour mill of Izatnagar, Bareilly.

Spice mixture

The spice mix formula shown in Table 2 was formulated on the basis of the trials conducted among the scientists and students of the Livestock Products Technology Division of the Institute. The ingredients used in this formulation were purchased from the local market. After removal of extraneous matter, all spices were dried in an oven at 80°C for 3 h and then ground in a grinder to powder. The course particles were removed using a sieve of 100 mesh and fine powdered spices were mixed in required proportion to obtain spice mixture for chicken and control snacks preparation.

The spice mix was stored in plastic airtight container for subsequent use.

Sodium caseinate, common salt, baking powder and phosphate

Sodium caseinate was procured from Central Drug House (P) ltd., Mumbai, India. Common salt of the brand Tata and baking powder of the brand Rex were purchased from the local market. Sodium phosphate of food grade was procured from the local market.

Packaging materials

Two layered laminated pouches (aluminium foil/polyethylene) of food grade quality (size 25 x 20 cm) were procured from Sadar Bazaar, Delhi for packaging of chicken snack as well as control snack.

Preparation of chicken and control snacks

For the preparation of chicken snack and control, standardized formulation (Table 1) on the basis of several trials was used. Dressed and deboned meat was cut into small cubes and minced twice through the mincer (Electrolux, Sweden) after microwave thawing of the stored chicken meat. Minced chicken meat was blended with ice water (5% of calculated amount of water), common salt and sodium hexametaphosphate and chopped in a bowl chopper (Seydelmann, Germany) for 1 min. Condiment mixture was added to the emulsion and chopped again for 30 s followed by mixing of sodium caseinate and rechopped for 1 min. Spice mix powder, rice flour and the rest, 95% of the water was added to the mixture and chopped again for 1 min. Thus, the emulsion was prepared for chicken snacks. The emulsion was extruded through a manually operated stainless steel extruder into the shape of chips (size 20 x 2.5 x 0.3 cm) which were cooked in a microwave oven (Kelvinator, India) for about 8 to 10 min to prepare crisp snacks. Control snacks were prepared following the procedure mentioned earlier, except that no spoilt hen meat was used in its preparation.

Analytical techniques for physico-chemical characteristics

Moisture, fat, protein and ash of treated as well as control samples were analyzed as per the method described in AOAC (1995). The pH was determined following the method of Strange et al. (1977), whereas, thiobarbituric acid (TBA) value by the procedure of Witte et al. (1970). The procedure of Smith et al. (1991) was followed with suitable modifications for determining the shear force value of chicken and control snacks using Bratzler shear press.

Sensory evaluation

Chicken snacks as well as control snacks were subjected to sensory evaluation by a panel of seven judges comprising of scientists of the institute by using 8-point Hedonic scale (Keeton, 1983).

Table 3. Physico-chemical properties of chicken snacks as affected by the packaging under aerobic and vacuum packaging during storage at 30 ± 2°C (Mean*± SE).

Particulars	Days of storage					
	0	6	12	18	24	30
Moisture %						
Control	8.27±0.28	8.20±0.29	8.18±0.12	8.16± 0.16	8.13± 0.07	8.10± 0.13
Treated	8.80±0.14	8.73±0.21	8.70±0.29	8.68± 0.30	8.64± 0.27	8.61± 0.24
Fat %						
Control	0.65±0.08	0.63±0.06	0.62±0.07	0.60± 0.13	0.56± 0.04	0.52± 0.09
Treated	3.54±0.25	3.50±0.25	3.48±0.11	3.44± 0.12	3.41±0.26	3.39±0.09
Protein %						
Control	9.08±0.71	9.03±0.12	8.98±0.36	8.92±0.09	8.87±0.07	8.82±0.17
Treated	22.10±1.13	22.05±0.20	22.01±0.52	21.96±0.62	21.89±0.09	21.86±0.14
Ash (%)						
Control	1.50±0.14	1.48±0.26	1.45±0.26	1.42±0.08	1.41±0.22	1.39±0.10
Treated	2.60±0.18	2.58±0.23	2.54±0.25	2.51±0.10	2.48±0.11	2.47±0.22
Thiobarbituric acid value (mg malonaldehyde/kg)						
Control	0.25^{abc}±0.03	0.23^{bcd}±0.02	0.24^{cd}±0.01	0.21± 0.02	0.26±0.01	0.27±0.02
Treated	0.89^{ab}±0.02	0.87^{abc}±0.03	0.84^{abc}±0.03	0.87^{abc}±0.04	0.89^{ab}±0.02	0.90^{a}±0.02
Shear force value (kg/cm^2)						
Control	5.30±0.21	5.38±0.08	5.40±0.20	5.43± 0.16	5.48±0.08	5.51±0.06
Treated	4.40^{b} ±0.31	4.43^{b} ±0.09	5.46^{a} ±0.15	5.52^{a} ±0.24	5.58^{a}± 0.28	5.61^{a}±0.29
pH						
Control	6.22±0.14	6.47±0.22	6.57±0.19	6.59±0.14	6.40±0.15	6.35±0.15
Treated	5.50 ±0.20	6.13±0.27	6.38 ±0.13	6.53±0.18	6.36±0.21	6.30±0.20

*Means with different superscript in a row differ significantly (P<0.05).

Micro-biological quality assessment

The total plate count (TPC), Enterobacteriaceae count (EC), yeast and mould count (YMC) in chicken snack, as well as control were determined following the methods of APHA (1984). The experiment was repeated three times for each and every parameter.

Statistical analysis

Data collected in study were analyzed statistically, following the procedure of Snedecor and Cochran (1980) in the computer center of the Institute. Mean and standard errors were calculated for different parameters. The data were subjected to analysis of variance and paired comparison test. In significant effects, least significant differences were calculated at an appropriate level of significance.

RESULTS

The mean values and degree of significance for various parameters such as moisture, fat, protein, ash, thiobarbituric acid (TBA) value, shear force value and pH for the chicken snacks, as well as for control snack at regular interval of 0, 6, 12, 18, 24 and 30 is presented in Table 3. Same values for microbiological profile and different sensory attributes are depicted in Tables 4 and 5 respectively.

Physico-chemical characteristics of chicken and control snacks

The physico-chemical characteristics of chicken snacks and control for storage period of 30 days showed none significant differences (P>0.05) in the contents of moisture, fat, protein, ash and pH in both of the treatments. The contents of shear force value (kg/cm^2) and pH were found in increasing order with advancement of the days of storage while moisture, fat, protein and ash

Table 4. Changes in microbiological profile of chicken snacks packaged under vacuum in laminated pouches during storage at 30±2℃ (Mean± SE)*.

Particulars	Days of storage					
	0	6	12	18	24	30
Total plate count (cfu/g)						
Control	NDS	$14.7x10^{1a}$±0.09	$28x10^{1b}$±1.53	$60x10^{1c}$±1.73	$9.8x10^{2d}$±0.14	$31x10^{2e}$± 2.08
Treated	NDS	$22x10^{1a}$±1.15	$34x10^{1b}$±3.18	$58x10^{1c}$±2.08	$13x10^{2d}$±1.73	$42x10^{2e}$±1.53
Enterobacteriaceae count (cfu/g)						
Control	NDS	NDS	NDS	NDS	$10.9x10^{1a}$±0.15	$32.4x10^{1b}$±0.87
Treated	NDS	NDS	NDS	NDS	$14.6x10^{1a}$±1.03	$47.5x10^{1b}$±1.61
Yeast and Mould count (cfu/g)						
Control	NDS	NDS	NDS	NDS	$12.7x10^{1a}$±3.60	$25.3x10^{1b}$±17.57
Treated	NDS	NDS	NDS	NDS	$15.0x10^{1a}$±14.42	$29.7x10^{1b}$±22.11

*Means with different superscript row-wise differ significantly (P<0.05); NDS- Not detected significantly.

Table 5. Sensory attributes of chicken snacks as affected by aerobic and vacuum packaging during storage at 30±2℃ (Mean*± SE).

Particulars	Days of storage					
	0	6	12	18	24	30
Colour and appearance						
Control	6.47±0.07	6.45± 0.07	6.42± 0.07	6.34± 0.08	6.30± 0.08	6.30± 0.08
Treated	7.29^{a}±0.07	7.26^{ab}±0.07	7.21^{ab}±0.07	7.20^{ab}±0.07	7.16^{ab}±0.07	7.09^{ab}±0.06
Flavour						
Control	6.20^{ab}±0.06	6.15^{ab}±0.07	6.21^{ab}± 0.07	6.16^{ab}±0.07	6.10^{ab}±0.07	6.23^{b} ±0.06
Treated	7.17^{a}±0.06	7.09^{a}±0.06	7.02^{abc}±0.06	7.00^{abcd}±0.07	6.95^{abcd}±0.07	7.15^{bcd}±0.06
Texture						
Control	6.03^{bc}±0.05	6.00^{a}±0.05	5.97^{ab} ±0.05	5.92^{abc} ±0.05	5.88^{ab} ±0.05	5.87^{bcd}±0.05
Treated	7.34±0.08	7.31±0.08	7.29±0.08	7.25±0.07	7.21±0.07	7.19±0.07
Crispness						
Control	6.00^{ab}±0.06	5.98^{a}±0.06	5.95^{ab} ±0.06	5.97^{ab} ±0.06	5.92^{b} ±0.06	5.88^{b} ±0.06
Treated	7.03^{a}±0.08	7.00^{a}±0.07	6.96^{ab}±0.07	6.92^{ab}±0.07	6.90^{ab}±0.07	6.84^{ab}±0.07
Aftertaste						
Control	6.33^{a}±0.07	6.31^{abc}±0.07	6.28^{abc}±0.07	6.30^{abc}±0.07	6.28^{abc}±0.07	6.22^{c}±0.06
Treated	7.13^{a}±0.05	7.10^{ab}±0.05	7.06^{abc}±0.05	7.02^{abc}±0.05	7.00^{abc}±0.05	6.94^{bc}±0.05
Meat flavour intensity						
Treated	6.27±0.06	6.25±0.06	6.23±0.06	6.20±0.06	6.18±0.06	6.20±0.05
Overall acceptability						
Control	6.13±0.07	6.11±0.06	6.10±0.06	6.07±0.06	6.05±0.06	6.00±0.06
Treated	7.06^{a}±0.15	7.17^{ab}±0.06	7.15^{abc}±0.06	7.10^{abc}±0.06	7.09^{abc}±0.06	7.03^{abc}±0.06

*Means with different superscript in a row differ significantly (P<0.05).

showed decreasing trend in the whole of the storage period of 30 days. TBA value of chicken snacks initially decreased up to the 12th and 18th day in control snacks and thereafter increased. TBA (mg malonaldehyde/kg) values of chicken snacks were none significantly different in the entire storage period while control snacks of 0, 6 and 12th day was significantly (P<0.05) different from the product of the 18th, 24th and 30th days. The values of shear force on day 0 and 6 were significantly (P<0.05) different from the rest of the storage values in chicken

snacks while a non significant difference was observed on control snacks during the whole of the storage period.

On comparative assessment of chicken snacks and control snacks, we found highly significant difference ($P<0.01$) in the contents of fat, proteins, ash and TBA value during the whole of the storage period and in moisture contents and shear force value on day 6 and in pH on both day 0 and 6. However, a significant difference ($P<0.05$) in the contents of moisture was observed in the rest of the storage time and shear force value on day 0, in pH on day 12, among the treated and control snacks. There were non-significant differences also observed in shear force value between the 12th to 30th day, in pH on the last three studied days.

Microbiological profile

In general, TPC, EC and YMC profiles of chicken snacks and control snacks at different intervals during storage were in increasing trend. The TPC (cfu/g) of the products, irrespective of its product type indicated an increasing trend during storage after the 6th day of storage and increased significantly ($P<0.05$) after every 6 days until the 30^{th} day of storage. EC (cfu/g) of the products in both the treatments was not detected significantly until the 18^{th} day, after that it indicated an increasing trend. EC in the products during storage differed significantly ($P<0.05$) to each other from the 24th to 30th day. YMC (cfu/g) in chicken snacks was also not significantly detected until the 18th day; after that it showed increasing trend during the entire period of storage. Like EC, YMC of both the products increased significantly ($P<0.05$) after the 24^{th} day. Higher count for TPC, EC and YMC were noticed in chicken snacks, as compared to control snacks which might be due to presence of meat and higher moisture content. Comparative study of chicken and control snacks revealed significant differences during the entire period of the microbiological profile.

Sensory attributes

In general, all the sensory attributes that is colour and appearance, flavour, texture, crispness, aftertaste, meat flavour intensity and overall acceptability indicated decreasing trend during the entire storage period at ambient temperature in both chicken and control snacks. However, this statement is reversed on day 12 and 30 for flavour score of control snack, day 30 for flavour and meat flavour intensity of chicken snacks and on 0 day of chicken snack for overall acceptability. The scores for colour and appearance of the product did not change significantly during the whole of the storage period for both treatments.

This statement is also true for flavour scores of control snacks, but flavour scores of chicken snack on day 0 and 6 were significantly ($P<0.05$) different from other scores during storage. Texture scores of both products were non-significantly different during whole storage except the scores of day 6 as compared to 0 and 30th day scores for control.

The scores for crispness on day 6 for control were significantly ($P<0.05$) different from the scores of control on days 24 and 30, while the rest of the scores for crispness in all days were non-significantly different. The scores for aftertaste, meat flavour intensity and overall acceptability were none significantly different during the whole of the storage, except the aftertaste scores on day 0 which was significantly ($P<0.05$) different from day 30 in both of the treatment. Comparative study between control and treated snacks revealed overall highly significant difference, irrespective of the days of storage with some exceptions in the scores of flavour and overall acceptability. Flavour score of day 0 and overall scores for whole storage period except 0 day were found non-significantly different. Though, meat flavour intensity scores was not observed in control snacks, so the comparative study was not conducted for meat flavour intensity score.

DISCUSSION

Physico-chemical characteristics of chicken and control snacks

A non-significant difference in contents of moisture, fat, protein and ash was noticed in the products but quantitative trend decreased in order during the entire period of storage. This trend was very well in the range of the findings of Kalra et al. (1987) but the qualitative trend for moisture in his study was in increasing order rather than in decreasing. Values for TBA were also similar to the findings of Park et al. (1993) for beef snacks. The trend of gradual increase in pH with the advancement of the storage time is very well agreed according to the findings of Huang et al. (1996), Prabhakara and Janardhana (2000), Kumar and Sharma (2006), and Bhat and Pathak (2009) for different meat products**.** The increasing trend of shear force value during the entire storage period in both of the products, might be due to gradual decline in moisture content with the advancement of the storage period.

Microbiological profile

TPC (cfu/g) was not detected significantly on day 0, as the total colony count was less than 30, so we did not consider it as significant. Thereafter, it showed increasing trend from day 6 to 30 of storage. Enterobacteriaceae count, yeast and mould count were also not detected significantly, until day 18 of the storage and then showed

increasing trend. The counts for all three parameters were greater than the values obtained by Hobbs and Greene (1976) for beef snacks stored at 37°C for 5 months which might be due to post processing contaminations. However, the values obtained in this study were very well in the standards microbiological limits for meat products. Higher TPC, enterobacteriaceae count, yeast and mould count were noticed in treated products, as compared to control during the entire storage period. It could be due to the incorporation of meat which is a good medium for the growth of micro-organisms.

Sensory attributes

In general, sensory attributes showed insignificant decreasing trend during the whole of the storage period irrespective of the product type. Kalra et al. (1987) also observed slight decrease in the scores for colour and texture of snacks packaged in low density polyethylene (LDPE) bags of 100 and 150 gauge thickness, as well as in friction top tins during storage at room temperature up to 6 months. Decline in colour and appearance scores during storage could be due to dilution of meat pigments.

These findings are also supported by Zyl and Zayas (1996), Kumar and Sharma (2006), and Bhat and Pathak (2009). The decrease in flavour and meat flavour scores with the advancement of the storage period might be due to dilution in meaty flavour. Similar reports were published by Padda et al. (1989), Kumar and Sharma (2005, 2006), and Bhat and Pathak (2009) for various meat products. The decline in overall acceptability scores, could be reflective of changes in scores of flavour, colour, texture and other sensory attributes. Similar findings were reported by Nag et al. (1998) and other workers.

Conclusion

Chicken snacks prepared by utilizing 50% broiler spent hen meat, sodium caseinate and rice starch, as well as control snacks kept well for 30 days at ambient temperature (30±2°C) under vacuum in laminated pouches. During entire storage, chicken as well as control snacks did not show much change in their physico-chemical characteristics, microbiological profile and sensory attributes. Although, they all were in decreasing trend but their values were very well under the acceptable limit. So we can say that, vacuum packaging for such type of self sustained meat snacks may be a good alternative of packaging. Though, the study was only for 30 days storage, we cannot definitely comment on the shelf life of the product.

REFERENCES

Abe HA, Kimura T, Yamuchi K (1996). Effect of collagen on the toughness of meat from spent laying hens. J. Jpn. Soc. Food Sci. Technol., 43(7): 831-834.

APHA (1984). In: Compendium of methods for the microbiological examination of foods. Speck, M.L (Ed), American. Public Health Association, Washington, DC.

AOAC (1995). Official methods of analysis. 16th Edn. Association of Official Analytical Chemists, Washington, DC.

Bailey AJ (1984). The chemistry of intra molecular collagen. The Royal Society of Chemistry, Burlington House. Recent Adv. Chem. Meat., pp. 22-47.

Bhat ZF, Pathak V (2009). Effect of mung bean (*Vigna radiate*) on quality characteristics of oven roasted chicken seekh kababs. Fleischwirtschaft Int., 6: 58-60.

Chung S, Bechtel P, Villota R (1989). Production of meat based intermediate moisture snack foods by twin-screw extrusion. 49th Annual Meeting, Institute of Food Technologists, Chicago, IL. June 25-29.

Dzudie T, Joel Scher J, Hardy J (2002). Common bean flour as an extender in beef sausages. J.Food Eng., 52 (2): 143-147.

Gujral HS, Kaur A, Singh N, Sodhi SN (2002). Effect of liquid whole egg, fat and textured soy protein on the textural and cooking properties of raw and baked patties from goat meat. J. Food Eng., 53: 377-385.

Hobbs WE, Greene VW (1976). Cereal and cereal products. In: Compendium of methods for the microbiological examination of foods. Speck, M.L (Ed), American. Public Health Association, Washington, DC. pp. 559 (cf Park et al., 1993).

Huang JC, Zayas JF, Bowers J (1996). Functional properties of Sorghum flour as an extender in ground beef patties. IFT Annual Meeting: Book of abstracts, ISSN 1082-1236, pp. 63-64.

Kalra CL, Kaur S, Sharma TC, Kulkarni SC, Berry SK (1987). Studies on the preparation, packaging and storage of potato snacks from cold stored potatoes. Indian Food Packer, 45: 30-39.

Keeton JT (1983). Organoleptic quality assessment methods for foods of animal origin. J. Food Sci., 48: 878.

Kondaiah N (1990). Poultry meat and its place in market. Poult. Guide, 27: 41-45.

Kumar RR, Sharma BD (2005). Evaluation of the efficacy of pressed rice flour as extender in chicken patties. Indian J. Poult. Sci., 40(2): 165-168.

Kumar RR, Sharma BD (2006). Efficacy of barley flour as extender in chicken patties from spent hen meat. J. Appl. Anim. Res., (30): 53-55.

Mahapatra CM (1992). Poultry Products Technology-Prospects and Problems. Poult. Guide, 29: 69-70.

Nag S, Sharma BD, Kumar S (1998). Quality attributes and shelf life of chicken nuggets extended with rice flour. Indian J. Poult. Sci., 33(2): 182-186.

Padda GS, Sharma N, Bisht GS (1989). Effect of some vegetative extenders on organoleptic and physico-chemical properties of goat meat balls. Indian J. Meat Sci. Technol., 2: 116-122.

Park J, Rhee KS, Kim BK, Rhee KC (1993). High protein texturized products of defatted soy flour, corn starch and beef: Shelf life, physical and sensory properties. J. Food Sci., 58: 21-27.

Prabhakara RK, Janardhana RB (2000). Effect of binders and precooking meat on quality of chicken loaves. J. Food Sci. Technol., 37 (5): 551-553.

Serdarouglu M, Degirmencioglu O (2004). Effect of fat level (5, 10 and 20%) and corn flour (0,2 and 4%) on some properties of Turkish type meat balls (koefte). Meat Sci., 68(2): 291-296.

Smith GL, Stadler JW, Keeton JT, Papadopoulos LS (1991). Evaluation of partially defatted chopped beef in fermented beef snack sausage. J. Food Sci., 56: 348-351.

Snedecor GW, Cochran WG (1980). In: Statistical Methods. 7th Edn. Oxford and IBH Publishing Co., Calcutta.

Strange ED, Benedit RC, Smith JL, Swift CE (1977). Evaluation of rapid test for monitoring alterations in meat quality during storage. J. Food Protect., 40: 843-847.

Tarte R, Molin RA, Koymazadeh M (1989). Development of beef/corn extruded snack model product. Proc. 50th Annual Meeting, Institute of Food Technologists, Chicago, IL. June 25-29.

Wenham LN, Fairbain K, McLeod W (1973). Eating quality of mutton

compared with lamb and its relationship to freezing practices. J. Anim. Sci., 36: 1081.
Witte VC, Krauze S, Bailey ME (1970). A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. J. Food Sci., 35: 582-585.
Zyl HV, Zayas JF (1996). Effect of three levels of sorghum flour on the quality characteristics of frankfurters. IFT Annual Meeting: Book of abstracts, ISSN 1082-1236, p. 64.