Research Article

Assessment of Shelf Life of Japanese Quail meat Nuggets Using Finger Millet Flour (*Eleusine coracana*) During Refrigerated Storage

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Abstract

Japanese quail meat nuggets were prepared with addition of 6% Finger millet flour (*Eleusine coracana*) and were compared with control. Cooked Japanese quail meat nuggets were stored at refrigeration temperature (4±1°C) in low density polyethylene (LDPE) pouches and were assessed for various quality parameters such as physico-chemical, proximate, microbiological and sensory characteristics. During storage pH and Thiobarbituric acid value decreased significantly, similarly moisture, protein, fat content declined significantly whereas, ash content increased significantly throughout the storage. The microbiological parameters such as total plate count and yeast and mould count increased throughout the storage but were within the permissible limits however, psychrophilic count were not observed during the storage period of 20 days. The sensory scores for all sensory characteristics declined progressively with the advancement of storage period of 20 days. However, both control and 6% finger millet flour added Japanese quail meat nuggets were acceptable upto 20th day of refrigerated storage.

Keywords: Finger millet flour, Japanese quail meat nuggets, Low density polyethylene, Refrigerated storage

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Introduction

Indian agricultural economy constitutes poultry as its vital component. Poultry meat occupies a unique place in human diet by virtue of its specific nutritional characteristics. The present scale of poultry industry in the state is far below the potential. The poultry meat and eggs available in pockets in the market are not adequate to meet the increasing demand of the people. There is a heavy demand for meat (animal protein) in the local market as majority of the people are fond of meat and eggs. Promoting the quail farming in rural area will not only supplement the shortage of animal proteins but will also generate supplement income for improvement of their socio-economic status.

In the recent years, quail meat has gained much popularly among consumers, belonging to species *Coturnix coturnix japonica.* In India two species occurs namely black breasted quail found in jungle (*Coturnix coromandelica*) and other one brown color Japanese quail (*Coturnix coturnix japonica*) [1]. The quail contains the more protein, essential fatty acid and minerals such as sodium, potassium, iron. Quail meat contains least cholesterol value. Quail meat nuggets is one of the most popular ground meat products and is used as snack food. Only those nuggets with high nutritional value, low cholesterol, good textural properties, nice flavor and taste profile will become the favourite choice of consumers as flavor and texture, particularly juiciness and tenderness, have a clear relationship to meat palatability [2, 3].

Finger millet or Ragi (*Eleusine coracana*) is one of the most popular millets in India. It is the vital food grain of the rural population belonging to low income groups in the Eastern and central Africa and India. It is easily digested without producing much acid and allergic reaction, suitable for gastric patients [4]. It contains 72.0-79.5% total carbohydrates, 18.6% dietary fibre, 3.7% crude fibre, 7.0% protein, 1.3-1.8% crude fat and 2.0-2.7% total ash [4]. It is rich in potassium (408 mg%), calcium (344 mg%) and contains 283 mg% phosphorus, 3.9 mg% iron and many other trace elements and vitamins [5] and polyphenolic compounds thus possess high antioxidant capacity. Its utilization in meat is a novel area and can provide better functionality as compared to other cereals. Therefore, incorporation of finger millet flour into different food products will improve functionality and nutritional value of the food products. Looking to the interest of health conscious people for quail meat due to its low fat and cholesterol content and properties of finger millet flour (*Eleusine coracana*) the present study was planned to develop nutritional and acceptable quality of Japanese quail meat nuggets.

Materials and Methods

Raw materials

Six weeks old Japanese quail birds were purchased from Department of poultry science, Parbhani and slaughtered. The carcass was washed and cut into small sizes and subsequently packed in low density polyethylene pouches (LDPE) for frozen storage (18±1^{o}C) for subsequent use. Finger millet grains (*Eleusine coracana*) were procured from the local market of Parbhani city. They were cleaned to remove extraneous matter, washed and dried in hot air oven at 50^{o}C for one hour. Dried finger millet grains were ground into fine flour using mixer-grinder. All the chemicals used in the present study of analytical grade were procured from standard firms viz., Himedia, Qualigens and Loba Chemie. Fine quality spice ingredients were purchased from the local market of Parbhani city. Condiments viz. onion and garlic were used after removing the external coverings. These were cut into small pieces and fine condiment paste was made by blending in a ratio of 4:1 in a grinder with a suitable blade.

Preparation of Japanese quail meat nuggets

Japanese quail meat nuggets were prepared according to [6] with slight modification. Quail meat was thawed effectively and made it boneless. The boneless meat ground twice in a meat mincer with 5 mm plate followed by 3 mm plates. After mincing, the minced raw meat with various levels of non-meat ingredients was mixed in bowl chopper to obtain homogenous mixture of emulsion. Emulsion was prepared by blending of minced and chopped meat with addition of salt, sodium tripolyphosphate along with non-meat ingredients viz., spices, condiments, ice flakes and finger millet flour. The emulsion was placed in stainless steel boxes and was cooked for 30 min. by intermittent changing the side of mould at 15 min. interval. The internal core temperature of 72±5^{0}C was recorded. The cooked mould was cooled at room temperature and cut into small size of nuggets. Quail meat nuggets after cooling to room temperature was packed in low density polyethylene (LDPE) pouches and subsequently analyzed as per the experimental requirement.

Measurement of Quality parameters

Physico-chemical characteristics: pH

The pH of Japanese quail meat nuggets was determined by the method of Trout *et al*. [7]. 10 g of cooked Japanese quail meat nuggets was made into fine suspension with addition of 50 ml distilled water to prepare pH suspension and measured using digital pH meter.

Thiobarbituric acid value

TBA value was determined as per the method described by Strange *et al*. [8] with slight modification. Five ml of aliquot of TCA extract (as above) was mixed with 5 ml of TBA reagent in a test tube. The test tubes containing sample were kept in a water bath at 100^{o}C for 30 min along with control (blank with 5 ml of 10% TCA and 5 ml TBA reagent). After cooling the tubes in running water for about 10 minutes, the optical density was measured at 530 nm using spectrophotometer.

Proximate analysis

The moisture, protein, fat and ash content of Japanese quail meat nuggets were determined by following the method of AOAC [9].

Microbiological quality

The microbiological quality of Japanese quail meat nuggets was assessed as per the method of American Public Health Association [10] for total plate count (TPC), psychrophilic (PPC) count and yeast and mould count during storage.

Sensory evaluation

The developed products were then subjected for sensory attributes viz., appearance, flavour, juiciness, texture and overall palatability using 8 point descriptive scale [11] where ‘8’ denoted extremely desirable and ‘1’ denoted extremely poor by a panel of 5 trained panellists from College of Veterinary and Animal Sciences, Parbhani.

Statistical analysis

The data generated during the study were analyzed by Analysis of Variance technique following standard procedure of Snedecor and Cochran [12].

Results and Discussion

The observations pertaining to storage changes in control and finger millet flour (*Eleusine coracana*) extended Japanese quail meat nuggets aerobically packed in LDPE pouches and stored at refrigeration temperature (4±1^{o}C) upto 20 days are presented in **Table 1-4**.

Physico-chemical parameters

pH

It is revealed from the Table 1 that pH of Japanese quail meat nuggets increased significantly throughout the storage period of 20 days. However, pH shows non-significant difference between 4th and 5th storage interval. Similarly, significant differences in pH of products within treatments are observed. The increase in pH might be due to accumulation of bacterial metabolites and deamination of proteins [13, 14]. The results are congruent with the findings of Sakunde [15] for chicken patties using various binders.

TBA

TBA value indicates the extent of lipid oxidation in meat products. TBA value of both control and finger millet flour treated Japanese quail meat nuggets increased significantly (P<0.05) throughout the storage period indicating an increase in the lipid oxidation. However, TBA value of treated product was lower than control at every stage. The increase in TBA value during storage was due to increase in the lipid oxidation and production of volatile metabolites [16]. However, relatively lower values in treated products than control might be due to presence of antioxidants in FMF [17]. Initial TBA values for control and FMF treated quail meat nuggets were 0.25 and 0.21 mg malonaldehyde/kg and increased upto 0.94 and 0.89 for control and FMF treated nugget, which were well within threshold limit of 1-2 malonaldehyde/kg of meat [18]. The results are corroborated with the findings of Das *et al*. [19] on chicken patties.

Table 1 Storage related changes in physico-chemical characteristics of Japanese quail meat nuggets during refrigerated storage (4 ± 1^{0}C)

Type of product	Storage period (days)						Treatment mean
	0	4	8	12	16	20	
pH							
Control	5.99±0.11	6.08±0.05	6.16±0.04	6.24±0.07	6.33±0.06	6.45±0.07	6.21^{a}
6% FMF	5.94±0.04	6.02.±0.6	6.09±0.06	6.15±0.04	6.24±0.04	6.36±0.06	6.13^{b}
Storage period mean	5.96^{a}	6.05^{b}	6.13^{c}	6.20^{d}	6.28^{d}	6.41^{e}	
TBA (mg malonaldehyde /kg)							
Control	0.25±0.01	0.31±0.01	0.43±0.01	0.55±0.01	0.74±0.00	0.94±0.00	0.53^{a}
6% FMF	0.21±0.09	0.28±0.06	0.39±0.05	0.50±0.02	0.69±0.01	0.89±0.00	0.49^{b}
Storage period mean	0.23^{a}	0.29^{b}	0.41^{c}	0.52^{d}	0.71^{e}	0.91^{f}	

Means with common superscripts did not differ significantly (p<0.05)
6% FMF – Quail meat nuggets incorporated with 6% finger millet flour

Proximate Composition

Observations with related to changes in proximate composition of Japanese quail meat nuggets are presented in Table 2. The moisture, protein and fat content of Japanese quail meat nuggets decreased significantly (P<0.05) with progress of storage period of 20 days. Moisture content of FMF incorporated Japanese quail meat nuggets was higher than control indicating the hydration ability of protein based binders during the entire storage period and due to low shrinkage. The lowering of the moisture content might be due to loss of drip fluid during storage and also due to evaporation of moisture from meat in chiller [20]. The findings are in close agreement with Wadpalliwar [6] for chicken nuggets incorporated with FMF. The protein and fat content of control Japanese quail meat nuggets was significantly (P<0.05) higher than 6% FMF Japanese quail meat nuggets. Significant decrease in protein content of FMF based quail meat nuggets than control might be due to carbohydrate based nature of finger millet flour [14]. Due

to proteolysis of protein during storage the protein content get reduced during storage. The decline in protein content was non-significant upto 8th day but thereafter decline significantly. Moreover, protein content of two successive storage days did not show significant difference in the decrease of protein. The fat content of control Japanese quail meat nuggets was higher. This might be due to replacement of Japanese quail meat by FMF which contains less amount of fat and high fibre content. The fat content though differ significantly ($P<0.05$) during refrigeration storage, the difference were non significant up to 8th day of storage. Afterwards, it declined significantly throughout the entire storage period. The present findings of protein and fat are in conformation with Sakunde [14] and Dhond [21] for chicken patties and quail meat balls throughout refrigerated storage of 20 days and 24 days respectively.

The ash content of FMF treated Japanese quail meat nuggets is higher than control Japanese quail meat nuggets. Ash content of Japanese quail meat nuggets increased significantly ($P<0.05$) throughout the storage period. The higher amount of ash content in treated quail meat nuggets may be due to higher mineral contents in finger millet flour. At every storage interval the ash content was significantly increased except 2nd and 3rd storage interval where it was non significantly increased. The present findings are congruent with Reddy [22] for development of spent chicken meat nuggets with different extenders. Increase in ash content of cooked chicken seekh kababs was also reported by Bhat *et al*. [23].

Table 2 Storage related changes in proximate composition of Japanese quail meat nuggets during refrigerated storage ($4 \pm 1^{o}C$)

Type of product	Storage period (days)						Treatment mean
	0	4	8	12	16	20	
Moisture (%)							
Control	59.91±0.67	58.94±0.80	57.97±0.80	57.72±0.72	56.72±0.72	56.27±0.61	57.92^{b}
6% FMF	61.37±0.49	60.82±0.34	60.31±0.34	59.55±0.31	58.65±0.31	57.14±0.61	58.90^{a}
Storage period mean	60.64^{a}	59.88^{b}	59.14^{c}	58.63^{d}	57.68^{e}	56.70^{f}	
Protein (%)							
Control	21.15±0.23	20.99±0.25	20.80±0.24	20.31±0.02	19.75±0.01	19.32±0.02	20.38^{a}
6% FMF	20.86±0.55	20.83±0.53	20.39±0.37	19.65±0.08	19.37±0.05	18.95±0.06	20.00^{b}
Storage period mean	21.00^{a}	20.91^{a}	20.59^{ab}	19.98^{bc}	19.56^{cd}	19.13^{d}	
Fat (%)							
Control	11.52±0.01	11.44±0.01	11.35±0.02	10.97±0.05	10.65±0.05	10.35±0.04	11.04^{a}
6% FMF	11.38±0.01	11.32±0.01	11.25±0.05	10.87±0.06	10.56±0.08	10.27±0.07	10.94^{b}
Storage period mean	11.45^{a}	11.38^{a}	11.30^{a}	10.92^{b}	10.60^{c}	10.31^{d}	
Ash (%)							
Control	2.50±0.03	2.52±0.06	2.55±0.01	2.64±0.01	2.71±0.04	2.77±0.05	2.61^{b}
6% FMF	2.53±0.05	2.60±0.03	2.63±0.02	2.70±0.01	2.72±0.05	2.79±0.01	2.66^{a}
Storage period mean	2.51^{a}	2.56^{b}	2.59^{b}	2.67^{c}	2.71^{d}	2.78^{e}	

Means with common superscripts did not differ significantly ($p<0.05$)
6% FMF – Quail meat nuggets incorporated with 6% finger millet flour

Microbiological quality

Storage related changes pertaining to microbial quality of control meat nuggets and FMF added Japanese quail meat nuggets are presented in Table 3.

The Total plate count and yeast and mould count irrespective of treatments of Japanese quail meat nuggets increased ($p<0.05$) significantly throughout the refrigerated storage period of 20 days. FMF added Japanese quail meat nuggets shows relatively lower microbial counts than the control group throughout the storage which is indicative of presence of polyphenols in FMF that possess antimicrobial activity [4]. An increase in the bacterial counts was also observed by Tejasvi *et al*. [24] in chicken nuggets. The TPC count for control as well as treated product are well within the spoilage level 6.70 log cfu/g as reported [25]. These findings are congruent with Kumar and Tanwar [26] who reported significant increase in TPC in chicken nuggets respectively. The yeast and mould count of control nuggets shows growth of 3.22 $\log_{10}$ cfu/g and for 6% FMF Japanese quail meat nuggets 3.17 $\log_{10}$ cfu/g at the end of storage period. Present findings are in consonance with Anandh *et al*. [27] who reported increase in yeast and mould counts with storage days in refrigerated buffalo rolls and also [28] for chicken nuggets.

The Psychrophilic organisms were not observed in both control and 6% FMF added Japanese quail meat nuggets throughout the refrigerated storage of 20 days. It could be due to destruction of bacteria during high temperature cooking, sanitary measures undertaking during and after preparation of nuggets. Kumar *et al.* [29] also reported absence of psychrophiles in both control and chicken patties treated with sorghum, barley and pressed rice flour upto

21 days. Reddy [22] also observed absence of growth of psychrophiles in chicken nuggets irrespective of type of flour used at refrigerated (4 ± 1ºC) storage for a period of 20 days. Luckose *et al.* [28] noted absence of psychrotrophs in low salt restructured chicken nugget till 15th day of refrigerated storage. Absence of psychrophiles in the initial stages of cold storage might be due to cooking of the product at high temperature followed by storage at low temperature resulting in retardation of microbial growth due to temperature shock.

Sensory quality

Average scores for sensory attributes of Japanese quail meat nuggets during refrigerated storage (4±1°C) are presented in Table 4.

Table 3 Storage related changes in microbiological quality of Japanese quail meat nuggets during refrigerated storage (4 ± 1°C)

Type of product	Storage period (days)						Treatment mean
	0	4	8	12	16	20	
Total plate count (log cfu/gm)							
Control	4.01±0.05	4.35±0.05	4.74±0.05	5.02±0.08	5.38±0.05	5.71±0.04	4.86[a]
6% FMF	3.91±0.08	4.24±0.08	4.63±0.05	4.86±0.05	5.23±0.02	5.54±0.05	4.76[b]
Storage period mean	3.96[a]	4.29[b]	4.68[c]	4.94[d]	5.30[e]	5.62[f]	
Psychrophilic count (log cfu/gm)							
Control	ND	ND	ND	ND	ND	ND	ND
6% FMF	ND	ND	ND	ND	ND	ND	ND
Storage period mean	ND	ND	ND	ND	ND	ND	
Yeast and mould count (log cfu/gm)							
Control	1.89±0.05	1.95±0.05	2.04±0.05	2.38±0.05	2.95±0.06	3.22±0.08	2.40[a]
6% FMF	1.78±0.04	1.85±0.04	1.96±0.05	2.31±0.08	2.89±0.05	3.17±0.03	2.32[b]
Storage period mean	1.83[a]	1.90[b]	2.00[c]	2.34[d]	2.92[de]	3.19[e]	

Means with common superscripts did not differ significantly ($p<0.05$)
6% FMF – Quail meat nuggets incorporated with 6% finger millet flour

Table 4 Storage related changes in sensory characteristics of Japanese quail meat nuggets during refrigerated storage (4 ± 1°C)

Type of product	Storage period (days)						Treatment mean
	0	4	8	12	16	20	
Appearance							
Control	7.26±0.01	7.12±0.01	7.06±0.01	6.90±0.01	6.71±0.03	6.60±0.05	6.94[b]
6% FMF	7.50±0.02	7.39±0.01	7.20±0.01	7.0±0.11	6.80±0.05	6.64±0.01	7.08[a]
Storage period mean	7.38[a]	7.25[a]	7.13[ab]	6.95[bc]	6.755[cd]	6.620[d]	
Flavour							
Control	6.93±0.05	6.90±0.09	6.88±0.03	6.61±0.05	6.59±0.05	6.42±0.05	6.72[b]
6% FMF	7.24±0.01	7.20±0.01	7.17±0.05	6.95±0.05	6.86±0.05	6.73±0.08	7.02[a]
Storage period mean	7.08[a]	7.05[a]	7.02[a]	6.78[b]	6.72[c]	6.57[d]	
Juiciness							
Control	6.85±0.03	6.80±0.08	6.75±0.05	6.70±0.08	6.57±0.05	6.44±0.01	6.68[b]
6% FMF	7.40±0.01	7.32±0.01	7.10±0.05	6.97±0.01	6.76±0.08	6.53±0.05	6.84[a]
Storage period mean	7.12[a]	7.06[b]	6.92[b]	6.83[c]	6.66[c]	6.48[d]	
Texture							
Control	7.09±0.04	6.85±0.02	6.55±0.03	6.03±0.03	5.80±0.03	5.54±0.03	6.31[b]
6% FMF	7.30±0.04	7.05±0.06	6.62±0.06	6.08±0.05	5.94±0.05	5.64±0.04	6.43[a]
Storage period mean	7.19[a]	6.95[a]	6.58[b]	6.05[c]	5.87[c]	5.59[d]	
Overall palatability							
Control	7.15±0.01	7.05±0.08	6.87±0.08	6.75±0.05	6.60±0.08	6.32±0.01	6.79[a]
6% FMF	7.26±0.08	7.21±0.01	6.94±0.01	6.74±0.01	6.53±0.01	6.39±0.01	6.84[a]
Storage period mean	7.20[a]	7.13[a]	6.90[b]	6.74[c]	6.56[d]	6.35[e]	

Means with common superscripts did not differ significantly ($p<0.05$)
6% FMF – Quail meat nuggets incorporated with 6% finger millet flour

The perusal of sensory results from Table 4 revealed that appearance for Japanese quail meat nuggets during storage are significantly better in treatment product than control throughout storage of 20 days. A decrease in appearance scores during storage might be due to oxidation of myoglobin and increased loss of moisture and fat. The appearance scores differed significantly ($P<0.05$) during refrigerated storage period. The appearance scores upto 8^{th} day declined non-significantly and thereafter the scores declined significantly and sharply upto 20^{th} day of storage. Among the treatments, the 6% FMF incorporated quail meat nuggets had significantly ($P<0.05$) higher scores than control quail meat nuggets. The present findings are in consonance with [30] who reported significant declining trend for colour and appearance for emu meat nuggets. Similar trend was also observed [6] for appearance scores of chicken nuggets.

The flavour scores declined non-significantly upto 8^{th} day, thereafter the flavour scores declined significantly ($P<0.05$) towards the end of storage. Among the treatments, flavour scores were recorded significantly higher for 6% FMF added Japanese quail meat nuggets than control, which is indicative of flavour enhancing property of FMF. The decline in flavor score might be due to increased lipid oxidation resulting in malonaldehyde formation ,liberation of free fatty acids and increased microbial growth [31]. Similar findings are corroborated with Dhond [21] and who reported flavour scores was stable upto 16^{th} day and declined thereafter with increase in storage period in quail meat balls. Kamble [32] also reported flavour scores was stable upto 8^{th} day and declined thereafter with increase in storage period in chicken meat balls.

The juiciness score for Japanese quail meat nuggets incorporated 6% FMF differs significantly ($P>0.05$) as compare to control during storage at refrigeration temperature (4±1ºC). Among the treatment, the lowest scores for juiciness were recorded for Japanese quail meat nuggets (control) as compared to 6% FMF incorporated Japanese quail meat nuggets, which might be due to water binding property of FMF. The reduction in juiciness scores might be due to loss of moisture from the product during storage as low density polyethylene packages were permeable to water vapour [33]. Present findings are in close agreement [14] for chicken patties who stated reduction in moisture score affects the juiciness score. The decrease in juiciness score with increase in storage period was also reported [30] for emu meat nuggets formulated with finger millet flour.

The texture scores were influenced significantly throughout the storage period. The difference was non-significant upto 4^{th} day of storage, thereafter scores were declined significantly with the progress of storage period. Moreover, 6% FMF added Japanese quail meat nuggets exhibited higher scores than control (without FMF). A decrease in textural scores might be due to release of moisture [34] and depletion of fat during storage [35]. The present findings are in agreement with those of Wadpalliwar [6] and Chatli *et al*. [30] for chicken nuggets and emu meat nuggets with the increase in storage periods respectively.

Similarly, declining trend was also observed for overall palatability of Japanese quail meat nuggets during storage. The palatability score was non-significant upto 4^{th} day of storage but afterwards, decreased significantly ($P<0.05$) during entire storage period. Moreover, the scores for overall palatability were not differed significantly among the treatments, indicating overall quality was better in both the treatments. Present findings are similar with the findings of Naveena *et al*. [36] who reported significant decrease in overall acceptability for chicken patties and also noted non-significant difference among control and FMF added patties. Significant decrease in overall palatability after 5^{th} day of storage was also reported by Rindhe [37] for cooked chicken sausages.

The present findings reveals decrease in sensory scores for both control and treated product. However, the 6% FMF added quail meat nuggets scored significantly ($p<0.05$) higher score than control for sensory attributes but both 6% FMF added quail meat nuggets as well as control quail meat nuggets were acceptable upto 20 days at refrigeration storage (4±1ºC).

Conclusion

From the study, it is concluded that addition of finger millet flour increases the ash content of the product. In terms of spoilage, finger millet flour added Japanese quail meat nuggets shows relatively lower microbial count. Japanese quail meat nuggets (control) and 6% finger millet flour incorporated Japanese quail meat nuggets were acceptable for a period of 20 days when packed aerobically in LDPE (low density poly ethylene) and stored at refrigeration temperature (4±1^{o}C).

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