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Development and evaluation of shelf life of kodo millet added chicken meat nuggets

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ABSTRACT

The present study was envisaged to develop kodo millet incorporated chicken meat nuggets and to explore the effect of kodo millet flour on the shelf life of chicken meat nuggets. The chicken meat nuggets were developed by using kodo millet flour (KMF) at three different levels (T1-6%, T2-8% and T3-10%) by replacing lean meat. Appearance/colour and flavour score, juiciness and overall palatability were found significantly higher ($P < 0.05$) for T1. On the basis of sensory scores, control and T1 were selected for further comparison and storage studies in refrigerated temperature for 28 days and assessed for microbial analysis at regular interval of 7 days. Thiobarbituric acid (TBA) and standard plate count (SPC) values increased significantly ($P < 0.05$) in both variants during storage. These values were found lower in treatment. Results of sensory evaluation studies during storage also revealed decrease in sensory scores in almost all occasions. T1 (treatment containing 6 % KMF) was rated higher for flavour, texture, juiciness and overall palatability throughout the storage period. It was concluded that functional chicken nuggets could be developed by replacing the chicken meat in standardized formulation at the level of 6 % kodo millet flour. The developed product maintains better physiochemical, microbiological and sensory qualities during refrigerated storage and was acceptable up to 14 days of storage.
Key words: Chicken meat nuggets, Kodo millet flour, Sensory attributes, Proximate composition, Storage stability.

INTRODUCTION

India ranks sixth in the world meat production with annual production of 8.60 million tonnes. India is currently the third-largest producer of eggs and fifth largest producer of broilers in the world. The poultry industry, one of the agricultural subsectors that come under the category of livestock, has seen an enhancement in both employment and production in recent years. Over the previous five years, the Indian poultry market saw an upward trend, expanding at a Compound Annual Growth Rate (CAGR) of 11.39 % (DAHD, 2019).

The processed meat industry is expanding quickly on a global scale as a result of lifestyle changes, rapid urbanisation, higher per capita income and an increase in the number of working couples. The eating habits of

majority of people around the world now includes ready-to-eat meat items. They are made from both meat and non-meat ingredients to provide substances with particular functional qualities. Unprocessed meat will perish in a matter of hours or days due to bacterial and fungal infections that cause decomposition (Truswell, 2002).

Essentially, nuggets are an international snack meal that is loved everywhere not just in the Indian subcontinent. These products are simple to prepare and are ready to eat, which makes them a popular option for consumers looking for a quick dinner. Meat, typically from chicken, chevon or their mix with vegetable protein and an appropriate binder, makes up the majority of a nugget. To address hunger, malnutrition and poverty, scientists working in the fields of production, processing, storage and nutrition face enormous challenges. Millets are regarded as ancient grains because they were cultivated at the dawn of human civilisation thousands of years ago. Evidence suggests that millets were first cultivated around 4000 years ago (Shahidi and Chandrasekara, 2013).

Kodo millet (*Paspalum scrobiculatum*) is also known as cow grass, rice grass, ditch millet, Native Paspalum and Indian Crown Grass. It is grown in West Africa, India, Pakistan, Philippines, Indonesia, Vietnam and Thailand. The most common places for its cultivation are in tropical and subtropical climates (Hulse, 1980; Saxena *et al*., 2018). It is a modest grain crop in India but it is quite important on the Deccan plateau. Typically Gujarat, Karnataka, Chhattisgarh, Eastern Madhya Pradesh and portions of Tamil Nadu are the states in India where it is grown. (Nithiyanantham *et al*., 2019). Kodo millet is renowned for having the strongest drought resistance of all minor millets and is supposed to yield well in a short period of time, between 80 to 135 days (Ravi, 2004, Saxena *et al*., 2018). Kodo millet has the highest free radical (DPPH) quenching activity followed by great millet (sorghum) and finger millet (Hegde and Chandra, 2005). There are many health advantages of kodo millet. Kodo millet has been shown in numerous studies to have higher levels of phenolics and antioxidants (Vali Pasha *et al*., 2018).

The incorporation of kodo millet in meat could improve the nutritive and functional value of these products. Studies on the incorporation of kodo millets in the development of chicken nuggets and their effect on the extension of shelf life are scarce. In view of the prevailing circumstances and looking to the merits of the lesser known minor millet, kodo, the present study has been conducted to develop the meat nuggets with suitable fortification.

MATERIALS AND METHODS

The present study was conducted in the department of Livestock Products Technology, College of Veterinary Science and Animal Husbandry, Dau Shri Vasudev Chandrakar Kamdhenu Vishwavidyalaya (DSVCKV) Anjora, Durg, Chhattisgarh. Fresh boneless broiler meat was procured from the local market in Anjora, Durg from broilers about 6 weeks old. Using polythene pouches, the fresh meat was received in sanitary condition and brought directly to the lab. The tendons, separable connective tissue, visible fat and skin were trimmed off. The dressed chicken meat was packaged in LDPE bag and stored overnight at 4±1°C. Kodo millet grain was procured from the Risali, Durg, super market. Cleaned grains were dried for 20 minutes at 70 °C in a hot air oven. Using a mixer-grinder, dried kodo millet grains were grinded to fine flour.

To standardise the recipe for making chicken meat nuggets, preliminary tests were carried out using the various quantities of broiler meat and whole kodo millet flour shown in Table 1. The method of preparation of chicken meat nuggets was adopted from Nag *et al*. (1997) with slight modifications.

Table 1: Formulation of chicken meat nugget

Ingredient %	Control	T1	T2	T3
Broiler meat	69.2	63.2	61.2	59.2
Kodo millet flour	-	6.0	8.0	10.0
Refined oil	10.0	10.0	10.0	10.0
Water	10.0	10.0	10.0	10.0
Condiments	4.0	4.0	4.0	4.0
Salt	1.5	1.5	1.5	1.5
Sodium tri poly phosphate	0.3	0.3	0.3	0.3
Refined wheat flour	3.0	3.0	3.0	3.0
Spices mix	2.0	2.0	2.0	2.0

Market-purchased broiler meat was used to make the chicken meat nuggets, which were then made by adding kodo millet flour (a binder) and other components. The treated chicken meat nuggets and the control (without kodo millet flour) were aerobically packaged in LDPE bags and evaluated for their storage stability and microbial qualities at refrigeration temperature (4±1°C) over a period of 28 days at 7 days interval.

Analytical Procedures– Cooking yield percentage

Each replicate's raw and cooked chicken meat nugget weight was recorded both before and after cooking, and the yield was reported as a percentage.

Cooking yield= {(raw sample weight-cooked sample weight) / raw sample weight} x 100

pH

The pH of chicken meat nuggets were determined as per the method given by Trout *et al.* (1992) using digital pH meter (Systonics, Naroda, Ahmedabad) equipped with a combined glass electrode.

Proximate composition

Moisture was determined by standard procedures of AOAC (2005). 20g minced sample was placed in aluminium dish. The samples were dried at 100±3°C for 24 h in hot air oven without the lid of the dish. After drying the lid was placed over it again and cooled in desiccator. The moisture content was calculated and expressed in percentage.

The protein content of chicken meat nuggets in the study was estimated as per method described by AOAC (2005) using combined digestion and distillation unit (Relitech, 16.540.02, Pragati Laboratory Equipment, Ambala Cantt.).

Fat content in chicken meat nuggets was estimated by ether extraction following AOAC (2005) method using Relitech Soxhlet apparatus (model-16.580.0l, Pragati Laboratory Equipment, Ambala Cantt.).

The ash content and fibre content in the chicken meat nuggets was estimated as per AOAC (2005) method.

Microbiological Analysis

The microbiological quality of chicken meat nuggets was assessed on the basis of standard plate count (SPC) as per the procedure of APHA (1992).

Thiobarbituric Acid (TBA) value

The distillation method of Tarladgis *et al.* (1960) was followed to estimate TBA value.

Sensory Evaluation

The sensory quality of samples was evaluated using 8-point Hedonic Scale (Keeton *et al.*, 1983) by a sensory panel comprising 7 experienced members.

Statistical Analysis

All the statistical analysis was done using SPSS statistical software. The one way ANOVA was carried out to estimate effect of different factors on chicken meat nuggets. The significance of effects was analyzed by using the Duncan's Multiple Range Test. The independent sample t-test was done to compare control group with treatment group at different storage period. The experiment was conducted in a completely randomized design (CRD) with 6 replicates per treatment.

RESULTS AND DISCUSSION

Mean sensory score for the control and chicken meat nuggets incorporated with different levels of kodo millet flour are given in Table 2.

The appearance/colour scores of T1 recorded highest appearance/colour scores compared to control and other levels of respective flour formulation. A significant difference ($P < 0.05$) was found between various levels of kodo millet flour incorporated with chicken meat nuggets. Reddy *et al.*, (2009) and Dushyanthan *et al.*, (2008) found highest appearance/colour scores compared to control and other levels of respective flour formulations.

The analysis of variance indicated significant ($P < 0.05$) difference in mean flavour scores between treatments. The flavour scores of T1 were recorded highest compared to control and other treatments. Subsequent increase in kodo millet flour from 6 to 10 % resulted significant ($P < 0.05$) decline in the score. Decrease in the flavour score of the product might be either due to the development of bitterness as a sequel of Maillard browning reactions. Similar observation was also reported by Kumar *et al.*, (2015), Sakunde (2004) and Naveena *et al.*, (2006) who found the decreased flavour score upon higher level of finger millet incorporation.

The analysis of variance indicated significant (P < 0.05) difference in mean texture scores between treatments. The texture scores of control were recorded highest texture scores compared to levels of treatments.

The juiciness and overall palatability scores of T1 were recorded higher scores compared to control and other levels of respective flour formulation. A significant difference (P < 0.05) was found between various levels of kodo millet flour incorporated with chicken meat nuggets. The increase in juiciness at 6 % level could be due to the increase the water-holding capacity of products due to the presence of millet starch (Nirmala *et al*., 2000, Vijayakumar *et al*., 2010; Talukder and Sharma, 2013).

T1 was found to have markedly higher (p<0.001) value from T2 and T3 in colour, flavour, juiciness and overall palatability scores of the products.

Based on the sensory scores, chicken meat nuggets with 6 % KMF (T1)was selected as optimum for further assessment for physico-chemical, proximate and storage studies.

The observation with respect to the pH and cooking yield, moisture, protein, fat, fibre and ash of chicken meat nuggets influenced by incorporation of kodo millet flour are recorded in Table 3.

The pH of the chicken nuggets was increased significantly (P < 0.05) with incorporation of kodo millet flour. Similar results were reported by Chatli *et al*., (2015) who found pH of treated chicken nuggets increased significantly (P < 0.05) than control for finger millet flour added in emu meat nuggets. Huang *et al*., (1996), Prabhakara and Janardhana (2000), Bhat and Pathak (2009) and Para and Gangguly (2015) observed control chicken nuggets without flour was significantly lower in pH levels than treated chicken nuggets with flour.

The cooking yield of chicken nuggets revealed non-significant (p > 0.05) variations. However the mean values of cooking yield of products containing kodo millet flour were numerically higher than the control. Para and Ganguly (2015), Pinero *et al*., (2008), Talukder and Sharma (2009) who found the cooking yield of the bajra flour (BF) incorporated nuggets was significantly (P < 0.05) higher than the control nuggets.

The moisture of chicken nuggets revealed non-significant (p > 0.05) variations. However the mean values of moisture of products containing kodo millet flour were numerically lower than the control. Similarly Naveena *et al*., (2006) found non significant difference for cooked chicken patties with different level of ragi flour and Chatli *et al*., (2015) also reported the moisture content in emulsion and nuggets was significantly higher (P < 0.05) in control than the treatments.

The protein level decreased significantly (P < 0.05) with the incorporation of kodo millet flour. Slightly decrease in the protein content of chicken nuggets might be due to the incorporation of kodo millet flour which contains less protein (8.35 %) and high carbohydrate (65.65 %). Dawkins *et al*., (1999), Kerr *et al*., (2005), Talukder and Sharma (2009), Santhi and Kalaikannan (2014), and Chatli *et al*., (2015) reported significant decrease in crude protein levels in millet incorporated chicken nuggets as compared to control.

The fat level increased significantly (P < 0.05) with the addition of kodo millet flour. Similar results were reported by Reddy *et al*., (2018), Santhi and Kalaikannan (2014) and Chatli *et al*., (2015) who found treated chicken nuggets had significantly (P < 0.05) higher fat than control for flax seed flour added in chicken meat nuggets.

The crude fibre content in treated nuggets increased significantly (P < 0.05). This might be due to higher fibre content of kodo millet flour (9.05 %). Similarly Reddy *et al*., (2018), Santhi and Kalaikannan (2014), Chatli *et al*., (2015) and Madane *et al.,* (2019) reported that fibre content in treated chicken nuggets significantly (P < 0.05) higher than the control when flax seed flour added in chicken meat nuggets.

The total ash content in treated chicken nuggets increased significantly (P < 0.05). Similarly Reddy *et al*., (2018) reported treated chicken meat nuggets increased significantly (P < 0.05) in ash content with addition of

Table 2: Sensory profile of different treatment groups

	Control	T1(6% KMF)	T2 (8% KMF)	T3(10% KMF)	P-value
Appearance/colour	7.08±0.20^{b}	7.83±0.10^{c}	6.16±0.25^{a}	6.00±0.12^{a}	0.000
Flavour	7.50±0.18^{b}	7.83±0.10^{b}	6.08±0.15^{a}	5.83±0.10^{a}	0.000
Texture	7.83±0.10^{b}	7.41±0.20^{b}	5.83±0.10^{a}	5.41±0.20^{a}	0.000
Juiciness	6.91±0.83^{c}	7.16±0.16^{c}	6.00±0.12^{b}	5.00±0.12^{a}	0.000
Overall palatability	7.16±0.16^{b}	7.75±0.17^{c}	6.16±0.10^{a}	5.83±0.10^{a}	0.000

*Mean ± SE with different superscripts row-wise and column wise (a,b,c) differ significantly (p < 0.05) within a parameter.

flax seed flour. Madane *et al*., (2019), Chatli *et al*., (2015) and Santhi and Kalaikannan (2014) observed significant increase in total ash levels in treatment chicken nuggets.

Table 3: Physico-chemical and proximate parameters (Mean±SE) of chicken meat nuggets

Parameter	Control	Treatment (6 % KMF)	P-value
pH	6.93±0.05	7.11±0.03	0.01
Cooking yield (%)	94.63±0.71	94.66±0.49	0.97
Moisture (%)	60.50±0.44	59.33±0.70	0.19
Protein (%)	19.10±0.56	14.39±0.58	0.00
Fat (%)	5.54±0.17	9.55±0.21	0.00
Crude Fibre (%)	1.72±0.07	3.78±0.37	0.00
Total Ash (%)	2.00±0.11	3.36±0.12	0.00

*Mean ± SE column wise differ significantly (p < 0.05) within a parameter.

The changes observed in physico-chemical properties and oxidative stability of the chicken nuggets, prepared with or without incorporation of selected levels of kodo millet flour during assessment at a regular interval of 7 days under refrigerated storage (4±1°C) are represented in Table 4.

The changes observed in oxidative and microbial quality of chicken nuggets prepared with or without incorporation of kodo millet flour during assessment at refrigerated temperature (4±1**°C**) is presented in Table 5.

Control – chicken nuggets without kodo millet flour

T1 – chicken nuggets prepared with 6% kodo millet flour

Standard plate count (SPC)

In the present study, SPC value of control as well as treatment increased significantly (p < 0.05) throughout the storage period; however, it remained below the spoilage level (5.33 log10 cfu/g) as per FSSAI spoilage level. This could be due to presence of polyphenols in kodo millet flour that possess antimicrobial activity. Similar observations were also recorded by Kumar *et al.,* (2011) Chatli *et al*., (2015) and Madane *et al*., (2019) who found that showed the standard plate count (SPC) increased significantly with the advancement of storage period at 21 day.

The TBA value of the control as well as treatment increased significantly (P < 0.05) throughout the storage period; however, TBA value of treatment was significantly (P < 0.05) lower than the control at every stage due to potential to control lipid oxidation in KMF. The increase in TBA value during storage was due to increase in the lipid oxidation and production of volatile metabolites. Similarly, Chatli *et al*., (2015), Bhat and Kumar (2014), Zargar *et al.* (2014), Madane *et al.*, (2019) and El-Sohaimy *et al*., (2022) who reported TBARS values of the control and treatment increased significantly (p < 0.05) during the storage period.

CONCLUSSION

Sensory evaluation revealed better acceptance of nuggets containing 6 % kodo millet flour compared to control and other treated nuggets. Chicken nuggets containing kodo millet flour at 6 % level had higher pH, cooking yield and chemical composition (moisture, fat, crude fibre and total ash) compared to control except a decline in the protein content in the kodo millet added nuggets. Standard plate count and oxidative changes of refrigerator (4±1°C) storaged nuggets showed that both the 6% kodo millet treated and untreated nuggets had a shelf life of 14 days.

COMPETING INTERESTS

The authors have no known competing interests either financial or personal between themselves and others that might bias the work.

Table 5: Oxidative and microbiological quality of chicken nuggets during different stages of refrigerated storage (4 + 1oC)

Type of Product	Storage period (days)					P-value
	0	7	14	21	28	
	Standard plate count (log_{10} cfu/g)					
Control	1.87±0.01^{a}	2.44±0.00^{b}	3.02±0.00^{c}	3.67±0.01^{d}	4.50±0.00^{e}	0.000
T1	1.57±0.03^{a}	2.02±0.01^{b}	2.65±0.01^{c}	3.13±0.00^{d}	4.03±0.00^{e}	0.000
P-value	0.000	0.000	0.000	0.000	0.000	
	TBA value (mg malonaldehyde/kg)					
Control	0.41±0.00^{a}	0.59±0.01^{b}	0.76±0.00^{c}	0.93±0.00^{d}	1.44±0.01^{e}	0.000
T1	0.39±0.00^{a}	0.48±0.01^{b}	0.61±0.00^{c}	0.75±0.01^{d}	0.92±0.00^{e}	0.000
P-value	0.237	0.000	0.000	0.000	0.000	

*Mean ± S.E. with different superscripts column-wise differ significantly (p < 0.05) within a parameter.

ETHICS STATEMENT

Not applicable

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