Original Research

Development and Quality Evaluation of Chicken Nuggets Incorporated with Finger Millet (*Eleusine coracana)*

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Abstract

Current study involves the development of chicken nugget by replacing binder refined wheat flour by finger millet flour which has anti-diabetic, anti-oxidant, hypocholesterolaemic and anti-microbial effects. Aerobically packed treatment nuggets, R (replacement of refined wheat flour at 100 percent level) and MR (replacement of refined wheat flour at 50 percent level) were compared with aerobically packed control nugget, M (refined wheat flour alone) for physico-chemical and sensory attributes on 0, 30, 60, 90 and 120 days of frozen (-18±2^{0}C) storage. No spoilage was seen till 120 days in control and treatment nuggets. Cooking loss and dimension shrinkage was higher for treatment R. TBARS, texture profile and sensory evaluation proved finger millet flour could be successfully incorporated in chicken nuggets as a binder for providing novelty to the product.

Key words: Finger Millet, Refined Wheat Flour, Thiobarbituric Acid Reacting Substances, Tyrosine

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Introduction

Meat is an essential and nutritious food which can fulfill most of the physiological and functional requirements of body mechanisms. Meat and poultry products are a food category with both positive and negative nutritional properties. Muscle foods are major sources for many bioactive compounds including iron, zinc, conjugated linoleic acid (mainly red meat) and B vitamins (Jimenez-Colmenero *et al.*, 2001). Among all the meats, chicken is preferred by majority of the people in India due to lower cost, greater

availability and no religious taboo. According to American Heart Association Dietary Guidelines daily protein intake can meet 15 % of the average total energy and the healthy diet must consist variety of foods from all the food categories such as fruits and vegetables, fat-free and low-fat dairy products, cereal and grain products, legumes and nuts, fish, poultry, and lean meat (Krauss *et al.*, 2000). Though meat and meat products provide the essential requirements of a balanced diet, it lacks dietary fibre and regular consumption meat being associated with various health disorders such as colon cancer, obesity and cardiovascular diseases. Many researches stated that intake of fibre can reduces the risk of such diseases. Hence, meat products can be enriched by incorporation of dietary fibre from different sources to enhance their nutritional composition and desirability as well (Verma *et al.*, 2010). The functional and technological properties of dietary fibers do not alter the product but increase the cooking yield due to their water and fat binding property (Talukder and Sharma, 2010). A chicken nugget is breaded or battered chicken product made by deep-frying or baking. The demand for restructured meat products, such as nuggets, has increased significantly in the last 20 years. This product offers many opportunities to the food industry (Perlo *et al.*, 2006). Refined wheat flour is commonly used as a binder in most of the processed meat products. Even though it has high binding value, it has negligible dietary fibre and hence is not preferred by health-conscious consumers.

India ranks first in millet production of which finger millet (*Eleusine coracana L.*) (85%) whereas, wheat, rice, maize, sorghum and bajra which constitutes as a staple food for a major sector of the population in Africa and India. It ranks sixth in cereal production after wheat, rice, maize, sorghum and bajra in India. Finger millet is a brick red-coloured seed coat and is generally used in the form of the whole meal for preparation of traditional foods, such as roti (pancake), dosa (fermented pancake), mudde (dumpling) and ambali (thin porridge) (Devi *et al.*, 2014). Epidemiological studies have demonstrated that regular consumption of whole grain cereals and their products can protect against the risk of cardiovascular diseases, type II diabetes, gastrointestinal cancers and a range of other disorders (McKeown, 2002). In the current scenario, the health-conscious consumers, in an urge to meet their requirements of dietary fibre, antioxidants, vitamins and minerals are advised to replace refined wheat flour from their food products with alternate flours like finger millet. Hence, the present study is envisaged with the objective to develop chicken nuggets incorporating finger millet (ragi) at different levels replacing refined wheat flour and to compare their physico-chemical and sensory characteristics of \ aerobically packed products -18±2^{0}C storage.

Materials and Methods

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Chicken Used for Product

Broiler chicken of the same age group was procured from the local markets in Vythiri, Wayanad district and were brought to the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Pookode. The birds were provided *ad libitum* water and proper rest. They were slaughtered, dressed under hygienic conditions and the carcasses were washed and chilled overnight (4 ± 1^0C). After overnight chilling carcasses were deboned and meat was harvested for the preparation of chicken nuggets.

Preparation of Chicken Nuggets

Control and treatment chicken nuggets were prepared using ingredients as shown in Table 1. Meat was minced once through 6 mm diameter grinder plate in a meat mincer (Sirman, Italy).

Table 1: Formulation for the preparation of control and treatment nuggets

Ingredients	Control, M (g)	Treatment, R (g)	Treatment, MR (g)
Chicken	1000	1000	1000
Binder	200 (refined wheat flour)	200 (finger millet)	200 (finger millet and refined wheat flour in 1:1 ratio)
Refined sunflower oil	100	100	100
Small onion	15	15	15
Ginger	15	15	15
Garlic	10	10	10
Mace	4	4	4
Salt	19	19	19
Pepper	14	14	14
Red chilli powder	5	5	5
Ice water	60	60	60

Minced meat was chopped with salt, ice, refined sunflower oil, spices and condiments for 8 min in a bowl chopper (Talsa -TC12E, Spain). The batter was collected after chopping and separated into three equal batches and each batch was mixed with binders at the level of 20 percent of the final batter weight with refined wheat (M- Control), finger millet (R) and both flours in equal proportion (MR). The batters were filled in rectangular moulds smeared with oil and steam cooked for 45 minutes. The cooked meat blocks were cooled to ambient temperature, cut into uniform square shapes to obtain nuggets and were aerobically packed in high density polyethylene (HDPE) pouches. The pouches were sealed using continuous sealer (Sevana sepack – CS3H, Kochi) and were stored in a freezer (-18 ± 2^0C) for further evaluation. Analyses was conducted on days 0, 30, 60, 90 and 120 or until spoilage, whichever was earlier. The spoilage of samples was assessed by physical examination like odour, colour and slime formation on the samples. The samples were analysed for physico-chemical qualities like pH (AOAC, 1990), cooking loss (Boccard *et al*., 1981), dimension shrinkage, thio barbituric acid reacting substances (TBARS) (Witte e*t al*., 1970), tyrosine

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value (Pearson, 1968), Hunter L, a, b colour values, texture profile analysis (Bourne, 1978) and organoleptic qualities (Badr, 2004).

Statistical Analysis

The data collected was analysed statistically according to the procedures of Snedecor and Cochran (1994) using SPSS version 21.

Results and Discussion

Dimension Shrinkage and Cooking Loss

R had significantly ($p<0.001$) higher dimension shrinkage when compared to M and MR. There was significant ($p<0.001$) difference between samples with regard to cooking loss with the highest loss for R (3.22 ± 0.007%) and the lowest loss for M (1.67±0.022 %) and MR (1.85± 0.035%) as shown in Table 2, showing that incorporation of finger millet resulted in increased cooking loss. In contrast, Santhi and Kalaikannan (2014) noticed lower values of cooking loss when oat flour was incorporated into chicken nuggets.

Table 2: Dimension shrinkage and cooking loss in nuggets

Treatment	Dimension Shrinkage (cm^2)	Cooking Loss (%)
M	9.34 ± 0.035^{b}	1.67 ± 0.022^{c}
MR	5.33 ± 0.022^{c}	1.85 ± 0.035^{b}
R	11.30 ± 0.024^{a}	3.22 ± 0.007^{a}
F-value	12293.642^{**}	640.422^{**}
p-value	<0.001	<0.001

*** significant at 1 % level; Means with same lower case of alphabets as superscripts are not significantly different between treatments*

pH

On the initial day of storage R showed significantly ($p<0.001$) higher pH value compared to M and MR as shown in the Fig. 1. This might be due to the high pH values of finger millet flour. Polizer *et al*. (2015) in a study observed that pea fibre incorporated chicken nuggets showed an increased pH when compared to control nuggets and concluded that it might be due to the high pH of pea fibre. pH significantly ($p<0.001$) increased in all samples across the storage period till 120th day which was also observed in finger millet incorporated chicken patties on storage (Naveena *et al*., 2005).

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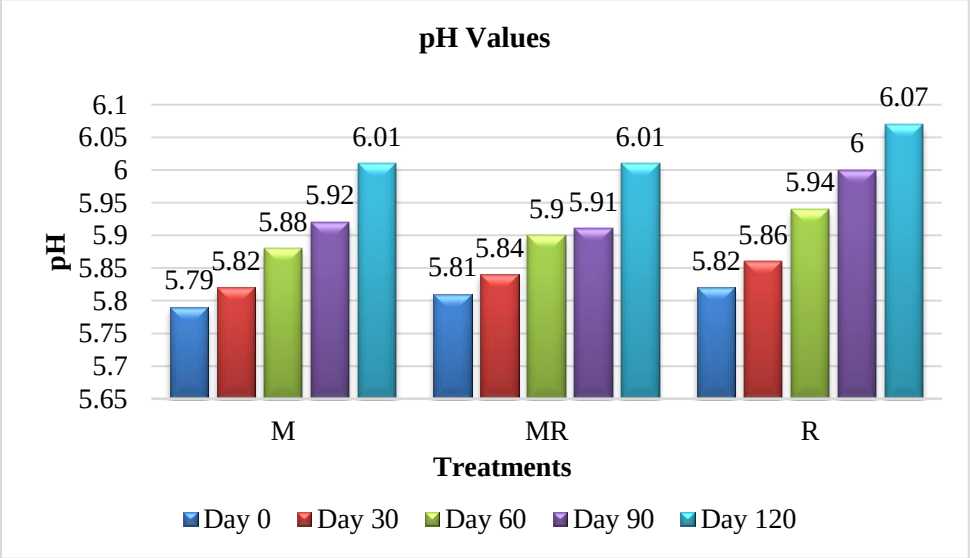

Fig. 1: pH values of control and treatment nuggets at different storage days

TBARS Numbers

The formation of secondary lipid oxidation products, such as malonaldehyde can be reported in terms of TBARS numbers. In the current study it was observed that all the treatments had significantly higher TBARS numbers on the initial day of storage and later it decreased significantly. The treatment with finger millet showed significantly ($p<0.001$) decreased TBARS numbers compared to control on all the storage days, which can be due to the antioxidant properties of the finger millet. The decrease in TBARS numbers is depicted in Fig. 2. In contrast with this result, Ozer *et al*. (2010) found that TBARS values steadily increased in chicken patties during 6 months of frozen storage (–20°C), and rate was faster after 2 months of storage.

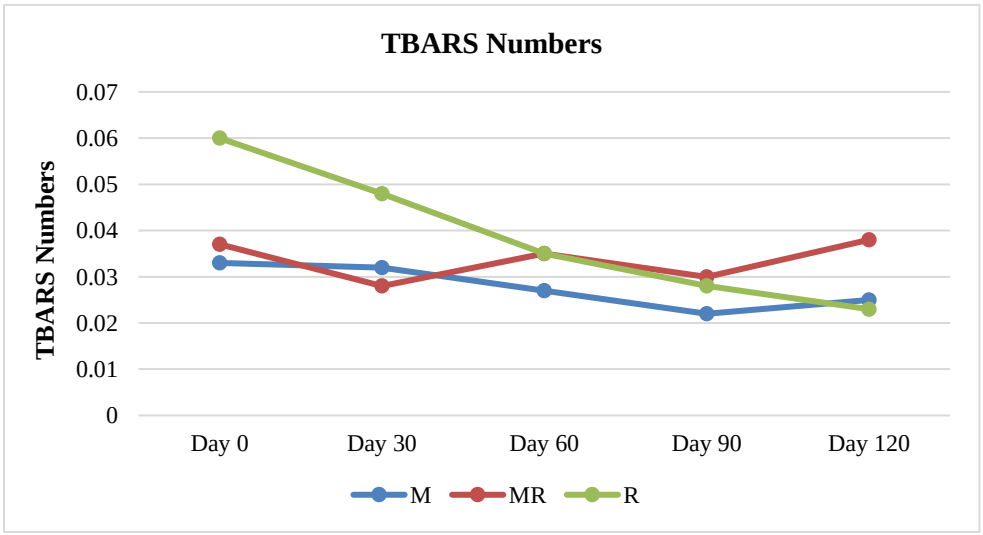

Fig. 2: TBARS numbers of control and treatment nuggets at different storage period

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There was significant ($p<0.001$) difference between samples for tyrosine value on all storage days and the results are shown in Fig. 3. The samples showed a significant ($p<0.001$) difference across storage periods, with the values increasing from day 0 to day 120 in M and decreasing for R and MR. In MR, there was a significant ($p<0.001$) decrease on day 30 followed by an increase on day 120, values of which were similar to those of day 0. The insignificant variation of tyrosine value might be due to reduced protein degradation during frozen storage but Ahamed *et al*. (2007) analysed enrobed frozen buffalo meat cutlets and found no significant difference in tyrosine value during storage, whereas Ponsingh *et al*. (2010) incorporated potato flour as binder in buffalo meat sausage and found a significant increase in the tyrosine value with increase in storage days.

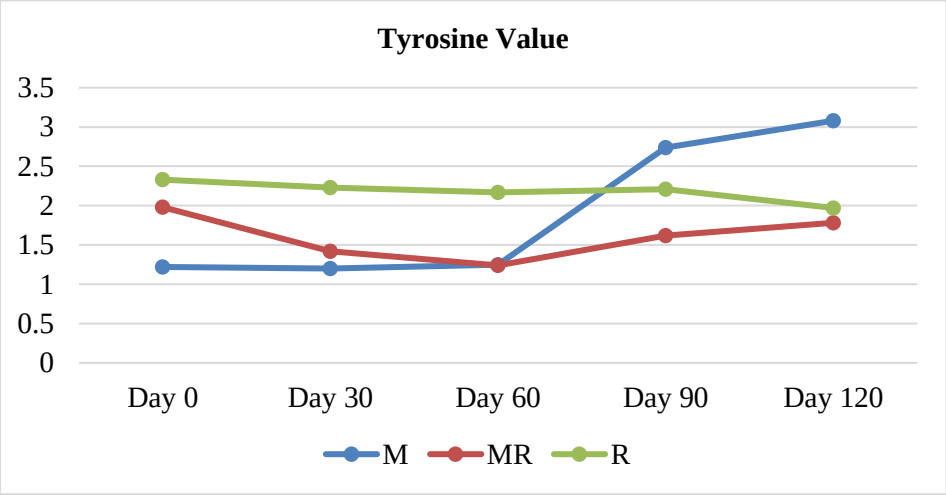

Fig. 3: Tyrosine values of control and treatment nuggets at different storage intervals

Texture Profile Analysis

Texture parameters like hardness, cohesiveness, springiness and adhesiveness were assessed. The higher hardness value in finger millet incorporated chicken nuggets is because of less moisture content, more cooking loss and good binding property of finger millet which could be confirmed by the results of instrumental texture profile analysis. Finger millet incorporated chicken nuggets, R and MR had significantly ($p<0.001$) higher values for hardness and cohesiveness as shown in Fig. 4 & 5, respectively. The hardness values increased in all the samples on storage. Springiness values reduced across the storage days in both the treatments as depicted in Fig. 6, and might be due to the effect of freezing. Adhesiveness values (Fig. 7) were higher for M, with refined wheat flour alone as binder which might be due to its sticky nature. Finger millet incorporated nuggets showed significantly lesser adhesiveness values on all storage days. The hardness values increased in all treatments along the storage period. Kumar *et al*. (2013) reported

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increased firmness, chewiness and elasticity values in chicken nuggets formulated with soybean skin flour (3 to 5%) stored under refrigeration conditions.

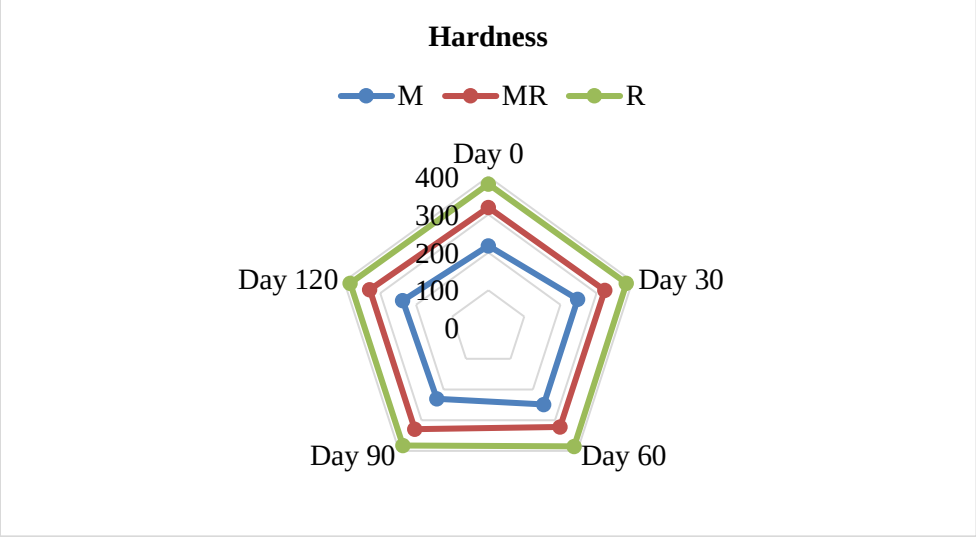

Fig. 4: Hardness values of control and treatment nuggets at different storage intervals

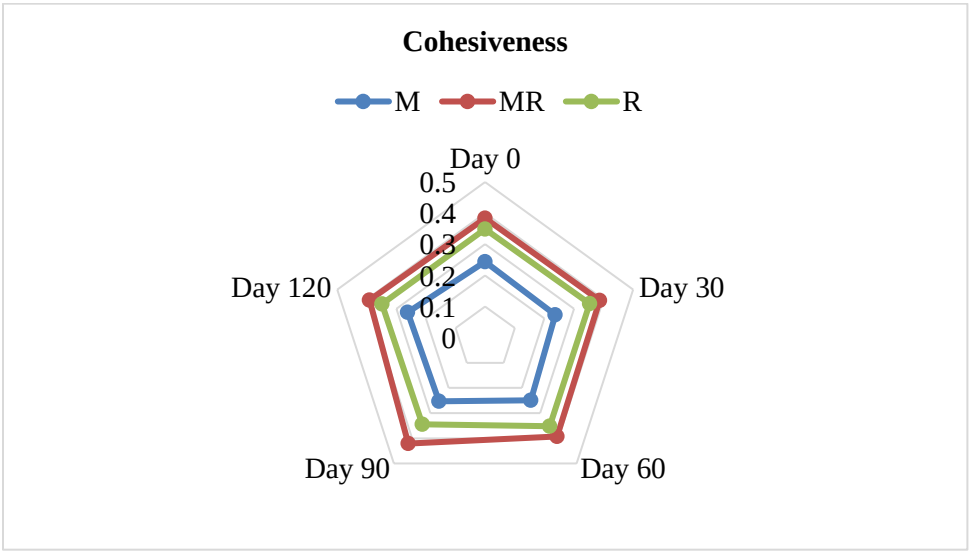

Fig. 5: Cohesiveness values of control and treatment nuggets at different storage intervals

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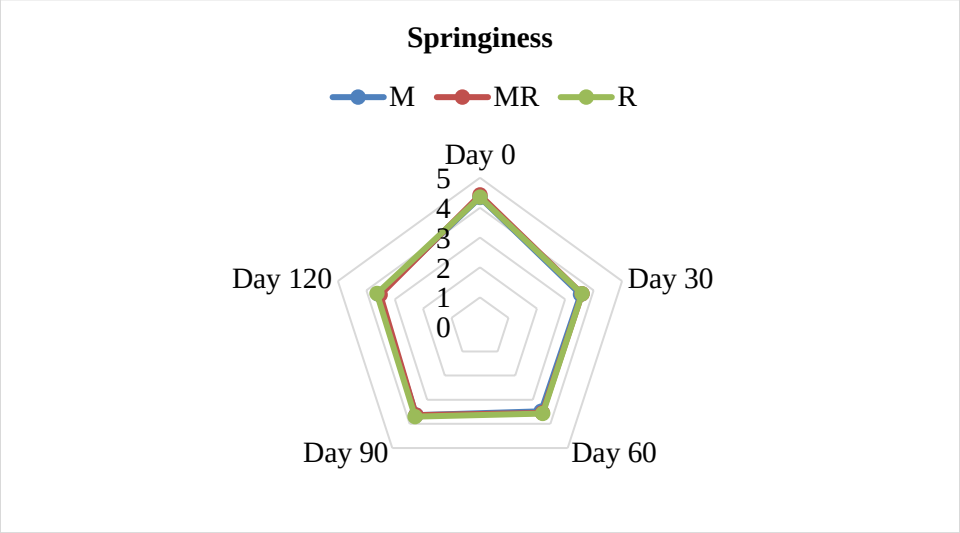

Fig. 6: Springiness values of control and treatment nuggets at different storage intervals

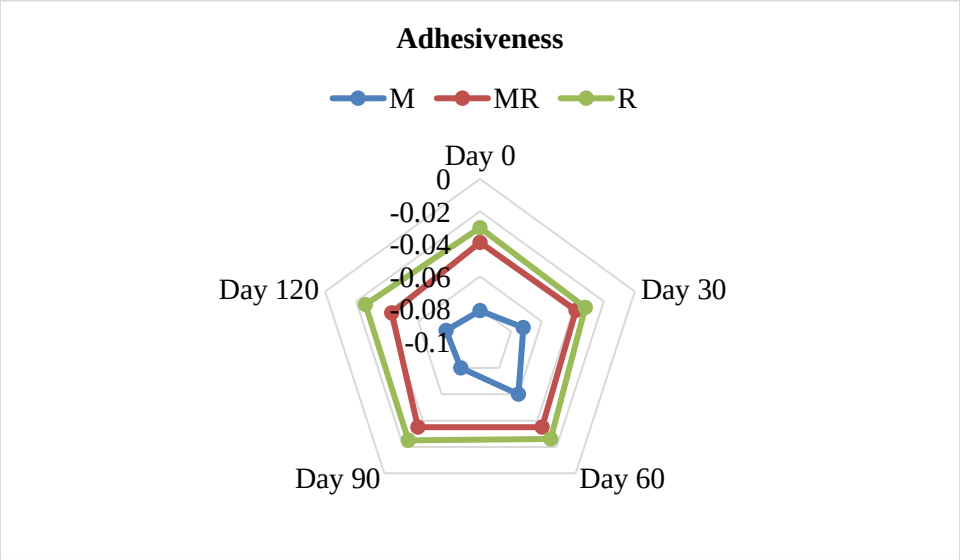

Fig. 7: Adhesiveness values of control and treatment nuggets at different storage intervals

Hunter L, a, b Values

Hunter L, a, b values reflects the lightness, redness and yellowness values of the product. The comparisons of hunter colour values are shown in Tables 3, 4 and 5. Treatments M and MR had higher lightness values and R, the lowest and might be due to the dark colour of finger millet flour. L values did not differ significantly across storage in M and MR, but reduced in M from day 30. 'a' values were significantly ($p<0.001$) higher for M than MR and R, and it increased significantly ($p<0.001$) across storage for M and did not show any significant difference in MR and R similarly Naveena *et al.* (2005) observed no change in Hunter L* values of chicken patties incorporated with ragi flour during storage. In contrast, Sameer

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(2013) reported a reduction of redness value in chicken kebab incorporated with green tea extract on storage. 'b' value was significantly ($p<0.001$) higher for M than MR and R. There was no significant change in 'b' values of samples during storage.

Table 3: Hunter 'L' values of control and treatment nuggets on different storage days

Treatment	Day 0	Day 30	Day 60	Day 90	Day 120	F-value	p-value
M	48.32 ± 0.57^{aA}	48.13 ± 0.388^{aA}	47.91 ± 0.466^{aAB}	47.05 ± 0.263^{aB}	47.16 ± 0.244^{cB}	5.246^{**}	0.005
MR	45.4 ± 0.777^{b}	45.61 ± 0.576^{b}	46.09 ± 0.461^{b}	45.73 ± 0.337^{b}	46.27 ± 0.441^{b}	1.022^{ns}	0.42
R	36.89 ± 0.367^{c}	36.85 ± 0.28^{c}	36.29 ± 0.161^{c}	36.5 ± 0.13^{c}	36.43 ± 0.098^{a}	1.410^{ns}	0.267
F-value	125.716^{**}	170.895^{**}	313.465^{**}	286.790^{**}	394.051^{**}		
p-value	<0.001	<0.001	<0.001	<0.001	<0.001		

***significant at 1 % level, ns- not significant; Means with same lower case of alphabets as superscripts are not significantly different between treatments; Means with same upper case of alphabets as superscripts are not significantly different between storage periods*

Table 4: Hunter 'a' values of control and treatment nuggets on different storage days

Treatment	Day 0	Day 30	Day 60	Day 90	Day 120	F-value	p value
M	7.49 ± 0.143^{aB}	7.6 ± 0.104^{aB}	7.74 ± 0.116^{aB}	8.12 ± 0.027^{aA}	8.3 ± 0.069^{aA}	15.235^{**}	<0.001
MR	6.24 ± 0.03^{cB}	6.29 ± 0.055^{bB}	6.48 ± 0.043^{bA}	6.57 ± 0.066^{bA}	6.45 ± 0.09^{cAB}	4.987^{*}	0.006
R	6.32 ± 0.074^{bAB}	6.24 ± 0.066^{cB}	6.22 ± 0.061^{cB}	6.5 ± 0.104^{cAB}	6.59 ± 0.044^{bA}	4.452^{*}	0.01
F-value	72.897^{**}	127.178^{**}	117.232^{**}	121.410^{**}	102.794^{**}		
p-value	<0.001	<0.001	<0.001	<0.001	<0.001		

***significant at 1 % level, *significant at 5% level, ns- not significant; Means with same lower case of alphabets as superscripts are not significantly different between treatments; Means with same upper case of alphabets as superscripts are not significantly different between storage periods*

Table 5: Hunter 'b' values of control and treatment nuggets on different storage days

Treatment	Day 0	Day 30	Day 60	Day 90	Day 120	F-value	p value
M	16.79 ± 0.058^{a}	16.61 ± 0.093^{a}	16.72 ± 0.048^{a}	16.69 ± 0.076^{a}	16.82 ± 0.072^{a}	1.365^{ns}	0.281
MR	12.65 ± 0.14^{b}	12.68 ± 0.125^{b}	12.66 ± 0.119^{b}	12.7 ± 0.141^{b}	12.66 ± 0.164^{b}	0.059^{ns}	0.993
R	12.35 ± 0.262^{c}	12.54 ± 0.192^{c}	12.45 ± 0.163^{c}	12.56 ± 0.181^{c}	12.51 ± 0.157^{c}	1.953^{ns}	0.141
F-value	231.240^{**}	263.223^{**}	325.908^{**}	268.948^{**}	281.661^{**}		
p-value	<0.001	<0.001	<0.001	<0.001	<0.001		

***significant at 1 % level, ns- not significant; Means with same lower case of alphabets as superscripts are not significantly different between treatments; Means with same upper case of alphabets as superscripts are not significantly different between storage periods*

Cost of Production and Sensory Evaluation

The cost of production of M, nugget with refined wheat flour alone as binder was the lowest, Rs. 251 per kg. Cost of production of R, nugget with finger millet alone as binder was, Rs.256 per kg. All the sensory attribute scores for M as well as for treatments R and MR were in the range of 'acceptable to more acceptable'. No significant difference was observed in any of the sensory attribute of any sample on storage up to day 120.

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Conclusion

Finger millet flour can be successfully incorporated into chicken nuggets replacing refined wheat flour partially or completely to provide novelty, attractive colour and good sensory appeal and can be aerobically packed and stored under freezer conditions for 120 days.

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