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RESEARCH ARTICLE

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Quality Characteristics of Chicken Meat Balls Incorporated with Pearl Millet (*Pennisetum glaucum*)

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ABSTRACT

Background: Pearl millet is rich in dietary fibre and micro-nutrients such as vitamins and minerals apart from the carbohydrates, protein and fat. This study was conducted to fortify low fat chicken meat balls with pearl millet (*Pennisetum glaucum*) as a dietary fibre source and to assess the physico-chemical, sensory and textural properties.

Methods: Emulsion based low fat chicken meat balls were prepared with the addition of Pearl millet flour (PMF) at levels of 4%, 7% and 10%, over and above the amount of meat along with a control and analysed for physico-chemical, textural and sensory properties.

Result: In the physico-chemical properties, Emulsion pH, product pH and emulsion stability were not affected by the addition of PMF. Product yield was significantly ($P \leq 0.01$) lowered at 4% level of PMF, but increased at higher levels of PMF inclusion. In texture analyses, hardness and cohesiveness were not affected by inclusion of PMF up to 7%. In sensory evaluation, though the scores for texture, tenderness and overall acceptability of 4% treatment were comparable with that of control and significantly ($P \leq 0.01$) decreased with increase in the level of PMF, the scores for 7% treatment were above 'Very acceptable' level. It is concluded emulsion based functional low fat chicken meat balls could be fortified with pearl millet flour up to a level of 7% without affecting the quality characteristics.

Key words: Chicken meat balls, Inclusion level, Pearl millet, Sensory scores, Textural analysis.

INTRODUCTION

The traditional Indian diet always had a prominent place for a variety of millets. Over a period, due to the economic reasons and lifestyle changes, the millet foods gradually vanished from the Indian cuisine. However, in the last few years, millets are gaining popularity among the people due to their nutritive value and the consumption of millet foods had increased considerably. The multiple health benefits of the millets attracted the consumers and at present millet based foods occupy a substantial part of the mainstream food items. Millets are small-seeded with different varieties such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), kodo millet (*Paspalum setaceum*), proso millet (*Penicum miliaceum*), foxtail millet (*Setaria italic*), little millet (*Panicum sumatrense*) and barnyard millet (*Echinochloa utilis*). They are known as coarse cereals beside maize (*Zea mays*), sorghum (*Sorghum bicolor*), oats (*Avena sativa*) and barley (*Hordeum vulgare*) (Bouis, 1996; Kaur *et al*., 2014). The magnitude of nutritional benefits of various millets have been studied (Ravindran, 1991; Ugare, 2008; Shobana *et al*., 2009; Palaniappan *et al*., 2017; Hassan, 2021) and reviewed (Saleh *et al*., 2013; Devi *et al*., 2014; Gull *et al*., 2014; Sharma and Niranjan, 2018; Hassan *et al*., 2021).

During the 1960s and 1970s, in parallel with a steady population growth, production of staple foods and safeguarding the human nutrition and health with sufficient energy was the priority (Pinstrup-Andersen, 2000). But subsequently, it was recognized that deficiencies of essential vitamins and minerals to be added to the list of scourges frequently associated with protein-energy malnutrition and deserving of special medical attention (Underwood, 2000).

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At par with the micronutrients, dietary fibre is an essential part of our regular diet which imparts various health benefits such as decreasing cholesterol levels, improving glucose tolerance and the insulin response, reducing hyperlipidaemia and hypertension and contributing to gastrointestinal health which had been evidenced from various epidemiological, clinical and biochemical studies (Ray *et al*., 1983; Brown *et al*., 1999; Wolk *et al*., 1999; Wirström *et al*., 2013). The dietary fibre intake recommended by the nutritionists is 35 g per person per day (Pilch, 1987). However, in industrialized countries it is estimated to be less than 25 g per person per day (Vuksan *et al*., 2008). Increasing the amount of dietary fibre without drastically changing the eating habits would be extremely hard and to achieve this difficult task, developing an array of foods enriched with dietary fibre is a probable solution.

Pearl millet is rich in dietary fibre and micro-nutrients such as vitamins and minerals apart from the carbohydrates, protein and fat (Ravindran, 1991; Shobana *et al*., 2009; Devi, 2014; Guo, 2012; Hassan, 2021). Pearl millet (*Pennisetum glaucum*) is most widely grown type of millet and an important food and forage crop in Africa and Asia (Uppal *et al*., 2015). Pearl Millet accounts for more than 50% of the cereal consumption in Rajasthan, Gujarat and in Maharashtra contributing about 20 to 40% of the total energy and protein intake with higher contribution of micronutrients (Fe and Zn) varying from 30% to 50% (Rao *et al*., 2006). With its potential nutrient contents, pearl millet contributes immense health benefits as a food component (Nambiar *et al*., 2011; Malik, 2015; Patni and Agrawal, 2017; Dias-Martins *et al*., 2018; Hassan *et al*., 2020; Hassan, 2021).

Chicken meat is widely consumed by the non-vegetarian population due its low cost, less fat and easy availability. In addition, consumption of chicken meat does not involve any religious taboo. Hence chicken meat foods are preferred by all kinds of people irrespective of age, community, religion and place. Since meat is devoid of dietary fibre, people have hesitation in eating more amount of meat with a mis-conception that it may lead to ailments such as colon cancer. However, a balanced diet is not a complete one without meat proteins. Hence for consumer ease and well-being it would be appropriate to develop ready-to-eat and ready-to-cook meat products incorporating dietary fibre sources. Since pearl millet is a common and popular food with high dietary fibre and micro-nutrients it would be a highly preferred ingredient to formulate newer functional meat products. Various types of meat products had been developed over years with pearl millet (Para and Ganguly, 2015; Santhi and Kalaikannan, 2015; Nandhini *et al*., 2018; Santhi *et al*., 2020) and other millet varieties (Devatkal *et al*., 2011; Sanwo, 2012; Malav *et al*., 2013; Ramadan *et al*., 2013; Chatli *et al.,* 2015; Abinayaselvi *et al*., 2018; Shinde *et al.,* 2019; Gamit *et al.,* 2020).

This study was carried out to include pearl millet flour in the chicken meat ball formulation with an aim to improve the functional properties of the product with enhanced dietary fibre and micronutrients in addition to the other nutrients. The inclusion level of pearl millet flour in chicken meat balls was optimized by assessing the quality characteristics of the product.

MATERIALS AND METHODS

Raw materials

Broiler chicken meat

Dressed broiler carcasses were purchased from the retail outlets of Namakkal town, packed in fresh polyethylene bags and transported in thermo cool box to the Department of Meat Science and Technology, Veterinary College and Research Institute. The carcasses were hygienically deboned and trimmed of all visible adipose and connective tissues at the department laboratory. The deboned meat was minced through an 8-mm plate using a meat mincer (Junior MEW 510, MADO, Germany) packaged in low-density polyethylene (LDPE) and stored in the laboratory freezer at -18±2°C for subsequent use in the experiments.

Pearl millet flour (PMF)

Food grade local variety pearl millet (*Pennisetum glaucum*) was purchased from the market, powdered into flour and used in the study.

Green condiments

Freshly procured ginger, garlic and onion were peeled off, cut in to pieces, made in to a paste in a mixer and used as condiments in the meat ball formulation.

Other ingredients

Commercially available food grade ingredients available in the local market namely refined sunflower oil, refined wheat flour (RWF), dried spices, salt, ginger, garlic and onion were used in the present the study.

Chemicals and media used for analyses

Standard chemicals and media procured from authorized dealers were used in the present study for various analyses.

Preparation of chicken meat balls

Preparation of meat emulsion

The frozen minced meat was tempered to 4°C by keeping in refrigerator overnight and used for the preparation of emulsion. The emulsion was prepared in a bowl chopper (TC11 Bowl Cutter Scharfen, Germany) by adding minced meat and the other ingredients of the formulation (Table 1) in a sequential order at a specified time interval. During chopping, the temperature of the emulsion was maintained at 10-12°C by the addition of slush ice. PMF was added at levels of 0% (C), 4% (PMF4), 7% (PMF7) and 10% (PMF10) over and above the control formulation and processed.

Forming, cooking and packaging of meat balls

Meat balls of 10 g weight each were formed manually and placed on stainless steel trays. Water was preheated to 50°C in a cooking vessel and the meat balls were put in to the water and cooked to reach an internal core temperature of 82°C. After cooking, the meat balls were allowed to cool at room temperature, weighed and used for analysis.

Analytical procedures

Physico-chemical (emulsion pH, product pH, emulsion stability, product yield) and sensory evaluations were conducted for all the trials to optimize the level of inclusion of pearl millet flour in the chicken meat balls.

Physico-chemical evaluation

pH

The pH of chicken meat was determined by adopting the method of AOAC (1995).

Emulsion stability (ES)

A method of Baliga and Madaiah (1971) as modified by Kondaiah *et al.,* (1985) was followed for the estimation of ES. The ES calculated by the formula

$$ES(\%) = \frac{\text{Weight after heating}}{\text{Raw emulsion weight}} \times 100$$

Product yield

Weights of meat balls before and after cooking were recorded. The product yield was calculated as below

Product yield (%) =

$$\frac{\text{Weight of chicken meat balls after cooking}}{\text{Raw emulsion weight}} \times 100$$

Texture profile analyses (TPA)

Texture profile analysis was performed using a texture analyzer (Stable Micro System, Model TA.XT 2i/25, UK). Each sample was compressed twice to 80% of the original height (Feng *et al*., 2003) using a compression probe (P25). A crosshead speed of 10 mm/s was used. For testing, the frozen samples were heated in a microwave oven for about 3 minutes in the defrost mode, equilibrated to room temperature for 20 mins and subjected to texture analyses. The values were recorded based on the software available in the instrument. Six samples from each treatment were measured and the mean values of the six readings for each texture profile analysis were used for the analyses.

Sensory evaluation

Semi trained sensory panel consisting of students and teaching faculty of the college evaluated the products. Samples were evaluated for appearance, flavour, juiciness, texture, tenderness and overall acceptability using an 8- point hedonic scale (Keeton, 1983) as given in the score sheet.

Statistical analysis

The data generated in the present study were subjected to statistical analysis (Snedecor and Cochran, 1994) for analysis of variance, critical difference and Duncan's multiple range test was done for comparing the means to find the effect of treatment using the statistical software SPSS for windows.

RESULTS AND DISCUSSION

Physico-chemical characteristics

Emulsion pH (EpH), product pH (PpH) and emulsion stability (ES) were not affected by the addition of PMF (Table 2). Product yield (PY) was significantly ($P \leq 0.01$) lowered when refined wheat flour was completely replaced by PMF at 4% level, but increased at higher levels of PMF inclusion. This might be due to the fact that insoluble fibre favours water-binding property and fat absorption capacity (Backers and Noli, 1997; Thebaudin *et al*., 1997) thus helping to reduce cooking loss and to improve ES (Colmenero *et al*., 2005). Addition of boiled pearl millet up to 30% as a filler in chicken cutlet lowered the product pH and improved the cooking yield (Nandhini *et al*., 2018). Chicken nuggets with 10% pearl millet flour (Para and Ganguly, 2015), chicken meat balls with 7.00% pearl millet flour and 10.00% wheat flour (Santhi *et al*., 2020) and chicken patties with up to 7.5% of finger millet (*Eleusine coracana*) flour did not affect the product pH but improved the product yield. In a similar study, Santhi and Kalaikannan (2015) observed that the addition

Table 1: Formulation for chicken meat balls with inclusion of pearl millet flour.

Ingredients (g)	Treatments			
	C	PMF4	PMF7	PMF10
Lean meat	1000	1000	1000	1000
Vegetable oil	50	50	50	50
Refined wheat flour	40	-	-	-
Pearl millet flour	-	40	70	100
Salt	20	20	20.60	21.20
Ginger	25	25	25.75	26.50
Garlic	25	25	25.75	26.50
Onion	25	25	25.75	26.50
Spice mix	20	20	20.60	21.20
Added water	100	100	160	220

C- Control; PMF4- 4% Pearl millet flour; PMF7- 7% Pearl millet flour; PMF10- 10% Pearl millet flour.

Table 2: Effect of inclusion of pearl millet flour on the physico-chemical quality of chicken meat balls (Mean±SE[#]).

Quality attributes	Treatments				Significance of treatment effect[##]
	C	PMF4	PMF7	PMF10	
Emulsion pH	6.10±0.02	6.12±0.02	6.14±0.022	6.15±0.02	NS
Product pH	6.28±0.03	6.30±0.02	6.31±0.03	6.31±0.04	NS
Emulsion stability (%)	93.92±1.52	90.29±1.01	93.26±0.67	92.72±1.50	NS
Product Yield (%)	90.26^{ab}±0.38	86.26^{c}±0.87	88.65^{bc}±0.87	92.36^{a}±1.25	**

C- Control; PMF4- 4% Pearl millet flour; PMF7- 7% Pearl millet flour; PMF10- 10% Pearl millet flour.

[a-c]Means in a same row with different letters are significantly different.

[#]Standard error of the mean.

[##]Significance of treatment effect: **$P \leq 0.01$, NS- Not Significant.

of a different variety of pearl millet up to 10% in low fat chicken meat balls significantly improved the cooking yield. Researches pertaining to the utilization of pearl millet in meat products are scanty and other millet varieties had been used in different studies. Devatkal *et al*. (2011) also observed improved ES and cooking yield of chicken nuggets prepared with sorghum flour, a coarse millet and they suggested an inclusion level of up to 5% which did not affect the sensory properties significantly. Similarly, 20% addition of oat flour to low-fat chicken nuggets improved the cooking yield (Santhi and Kalaikannan, 2014). The PpH was not affected by the inclusion of sorghum flour as observed in the present study. Sanwo (2012) reported that the cooking loss in beef sausage prepared with millet flour increased with the increased levels of millet flour up to 20%. Malav *et al*. (2013) incorporated sorghum flour at 9% level in restructured chicken meat blocks and found no significant change in pH and acceptable sensory scores. Such variations in the results of previous studies might be due to the different types and forms of the millets, variations in the formulations and preparation methods of the products. In the present study, though 10% PMF showed improved cooking yield than that of control, it was only moderately acceptable in sensory evaluation since the sensory panel members were able to perceive a high intense flavour of PM.

Textural characteristics

In the texture profile analyses, hardness and cohesiveness were not affected by inclusion of PMF up to 7%, but increased with 10% level (Table 3). Hardness of 10% treatment was significantly higher (P≤0.01) than the other treatments. However, cohesiveness of 4%, 7% and 10% treatments did not differ significantly. Springiness was not affected by the addition of PMF. Adhesiveness of 4% treatment was comparable with control and significantly lower (P≤0.01) for other treatments. The gumminess and resilience were significantly similar for control and 4% treatments; the values for 7% treatment were significantly higher (P≤0.01) than the control and similar to 4% treatment, wherein 10% treatment had significantly highest value than all the other treatments. Addition of PMF to the chicken meat balls invariably increased the chewiness significantly (P≤0.01) over the control, where 10% treatment had significantly highest value compared to the other three treatments. In a similar study with a different variety of pearl millet included up to 10% in low fat chicken meat balls, it was observed that the textural properties such as hardness, gumminess and chewiness increased over the control samples (Santhi and Kalaikannan, 2015). Incorporation of sorghum flour, oat flour and barley flour as binders in chicken meat sausages up to 9% (Reddy *et al.,* 2017a) and inclusion of oat flour up to 9% in mutton nuggets (Reddy *et al*., 2017b) significantly increased the hardness. Santhi and Kalaikannan (2014) observed an increase in the hardness of chicken nuggets incorporated with oats at 10% and 20% levels.

Sensory characteristics

Inclusion of PMF in chicken meat balls did not affect the appearance and colour score. The flavour and juiciness scores significantly (P≤0.01) decreased on addition of PMF (Table 4). However, the scores for flavour up to 7% PMF and juiciness up to 4% PMF were 'Very acceptable' as per the 8 point hedonic rating by the sensory panel. The scores for texture, tenderness and overall acceptability of 4% treatment were comparable with that of control. Though 7% treatment had significantly (P≤0.01) lower scores than that of control for the overall acceptability, the scores were above 'Very acceptable' which also had cooking yield equivalent to that of control. Nandhini *et al.* (2018) reported that addition of more than 10% of boiled pearl millet significantly reduced the overall acceptability of chicken cutlets. In a similar study,

Table 3: Texture profile analyses of chicken meat balls with pearl millet flour (Mean±SE#).

	Treatments				Significance of treatment effect##
	C	PMF4	PMF7	PMF10	
Hardness (g)	5187.30ᵃ±210.58	5616.19ᵃ±187.59	6008.80ᵃ±222.27	7018.20ᵇ±263.01	**
Adhesiveness	-1.0130ᵃ±0.0501	-0.9538ᵃ±0.0939	-0.7260ᵇ±0.0183	-0.7190ᵇ±0.0192	**
Springiness (cm)	0.7428±0.0156	0.7363±0.0102	0.7480±0.0126	0.7502±0.0201	NS
Cohesiveness (ratio)[1]	0.2438ᵃ±0.0109	0.2608ᵃᵇ±0.0071	0.2625ᵃᵇ±0.0063	0.2870ᵇ±0.0134	*
Gumminess[2]	1272.83ᵃ±99.49	1469.13ᵃᵇ±83.19	1581.29ᵇ±83.93	2007.69ᶜ±93.28	**
Chewiness[3]	867.85ᵃ±38.31	1164.97ᵇ±60.77	1169.97ᵇ±44.79	1508.16ᶜ±53.57	**
Resilience[4]	0.0617ᵃ±0.0008	0.0683ᵃᵇ±0.0015	0.0705ᵇ±0.0014	0.0823ᶜ±0.0048	**

C - Control; PMF4- 4% Pearl millet flour; PMF7- 7% Pearl millet flour; PMF10- 10% Pearl millet flour.

[1]Area under second curve /Area under first curve.

[2]Hardness × Cohesiveness.

[3]Hardness × Springiness × Cohesiveness.

[4] Area during the withdrawal of the first compression/Area of the first compression.

[a-c]Means in a same row with different letters are significantly different.

[#]Standard error of the mean.

[##]Significance of treatment effect: *P≤0.05, **P≤0.01, NS- Not significant.

Table 4: Effect of inclusion of pearl millet flour on the sensory quality of chicken meat balls (Mean±SE#).

Quality attributes	Treatments				Significance of treatment effect##
	C	PMF4	PMF7	PMF10	
Appearance and colour score	7.75±0.13	7.75±0.13	7.50±0.15	7.50±0.15	NS
Flavour score	7.75^{a}±0.13	7.25^{b}±0.13	7.17^{b}±0.21	5.67^{c}±0.14	**
Juiciness score	7.58^{a}±0.15	7.17^{b}±0.11	6.75^{c}±0.13	5.42^{d}±0.15	*
Texture score	7.67^{a}±0.14	7.50^{a}±0.15	6.58^{b}±0.15	5.75^{c}±0.13	**
Tenderness score	7.83^{a}±0.11	7.67^{a}±0.14	7.08^{b}±0.15	6.00^{c}±0.12	**
Overall acceptability score	7.75^{a}±0.13	7.42^{ab}±0.15	7.17^{b}±0.11	6.00^{c}±0.17	**

C - Control; PMF4- 4% Pearl millet flour; PMF7- 7% Pearl millet flour; PMF10- 10% Pearl millet flour.

$^{a-d}$Means in a same row with different letters are significantly different.

#Standard error of the mean.

##Significance of treatment effect: *P≤0.05, **P≤0.01, NS- Not significant.

Santhi and Kalaikannan (2015) observed that the addition of a different variety of pearl millet up to 4% in low fat chicken meat balls had acceptable sensory properties. In the same way, the sensory attributes of chicken nuggets prepared with 10% pearl millet flour (Para and Ganguly, 2015) and low-fat chicken meat balls prepared with a combination of 3.50% pearl millet flour and 5.00% wheat flour (Santhi et al., 2020) was found to be good. Similar to our study, Naveena *et al*. (2006) showed that inclusion of finger millet (*Eleusine coracana*) flour (FMF) in chicken patties up to 7.5% improved the cooking yield but the overall acceptability scores in sensory evaluation was acceptable only up to 5% and was lower for 7.5% and they recommended an addition of FMF up to 5% as binder in chicken patties. Inclusion of finger millet at 6% level to Japanese quail meat nuggets (Shinde *et al.,* 2019) and emu meat nuggets (Chatli *et al.,* 2015) and at 5% level to chicken meat cutlets (Gamit *et al.,* 2020) was sensorially acceptable. Ramadan *et al*. (2013) used sorghum fine bran at 5% and sorghum coarse bran at 5% levels in burger patties and found that it was organoleptically acceptable.

CONCLUSION

Incorporation of pearl millet flour in chicken meat balls up to 7% did not significantly alter the physico-chemical, textural and sensory properties of the products. Considering the nutritional contents and the health benefits of pearl millet, it is a prudent choice to include it in developing functional meat products. It is concluded that, low fat chicken meat balls could be fortified with pearl millet flour up to a level of 7% without affecting the quality characteristics.

Conflict of interest: None.

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