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Antioxidant Potential of Fruit-based Phytochemical on the Quality Attributes and the Shelf-life of Chevon Nuggets

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ABSTRACT

Background: The study was aimed to explore the antioxidant potential and functional value of guava (*Psidium guajava* L.) powder, bael (*Aegle marmelos* L.) pulp powder and dragon fruit (*Hylocereus undatus* L.) peel powder in muscle foods.

Methods: The fruit powders were incorporated at 1.5% level in Chevon nuggets and its effects on various physico-chemical, textural, sensory attributes and microbiological parameters of products were evaluated against control.

Result: Significantly ($P<0.05$) higher phenolics was found in bael pulp powder (82.32 mg GAE/g) and carotenoids (3.91 mg/kg) and Vitamin C (162 mg/kg) in guava powder. Incorporation of fruit powder significantly ($P<0.05$) increased the emulsion stability, cooking yield, moisture percentage and fat percentage of nuggets, whereas no significant effect was observed for protein percentage. Even sensory attributes were improved in treated nuggets, but the overall acceptability scores were significantly ($P<0.05$) higher for the control batch as adjudged by the panelists. The fruit powders were found to retard lipid peroxidation rate as well as microbial proliferation rate of the Chevon nuggets during refrigerated storage (4±1°C). When compared to the control batch addition of fruit powders had a significant ($P<0.05$) reduction on both the thiobarbituric acid (TBA) value and TPC, TCC, TPSC and YMC. Hence fruit powders can be potentially used as natural preservatives and their functionality can be explored in ready to eat meat foods without affecting their acceptability.

Key words: Anti-microbial activity, Anti-oxidative activity, Chevon nuggets, Natural antioxidants, Shelf-life.

INTRODUCTION

Chevon or goat meat is a significant protein source throughout the world especially in the developing countries. The black Bengal goat (*Capra hircus bengalensis*), distributed in the eastern part of India, has long been appreciated for its superior meat quality and carries a huge domestic demand with no social, cultural and religious restrictions (Biswas, 2010). Due to changing life style, work culture and increasing number of women entering workforce the "heat and serve" type ready to eat meat products are in great demand (Verma *et al.* 2013). This increased demand also increases the concerns for meat safety and quality. Lipid oxidation in meat and meat products is one of the major causes of their quality deterioration, the other being microbial spoilage. Production of value-added meat products require a number of activities like physical alteration, heat treatment *etc*. Such activities lead to development of oxygenated free radicals which in-turn initiates the oxidation of polyunsaturated fatty acids causing destruction of the natural antioxidant systems. Moreover, extensive handling and improper sanitary conditions both during production and storage would likely increase the microbial load of the end product. The above-mentioned factors lead to deterioration of the storage stability of the final product. Concerns over the use of synthetic preservatives and consumers' assurance over natural counterparts have prompted the food industry to extensively explore the potential of nature surrounding us. Fruits and fruit by products are known to be rich sources of antioxidant and antimicrobial compounds and their frequent consumption is associated with a lower risk of various diseases as well as cancer (Temple, 2000). Reports regarding use of guava, bael fruit and dragon fruit in the meat products either as antioxidant, antimicrobial or as a source of dietary fiber are very limited.

Therefore, our study was to determine the antioxidant and antimicrobial properties of fruit powder incorporation in improving quality and oxidative Chevon nuggets by incorporating easily available, economically viable dietary

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sources during refrigerated storage (4±1°C) and their effects on various physico-chemical, textural and sensory attributes of products.

MATERIALS AND METHODS

Goat meat (Chevon)

The experiment was conducted at the Department of Livestock Products Technology, West Bengal University of Animal and Fishery Sciences, Kolkata, during 2018-2019. Black Bengal goats aged 9-10 months and weighing 12-15 kg were procured from a local Farm at Belgachia, Kolkata. The goats were slaughtered as per the traditional halal method at the experimental slaughter house of Department of Livestock Products Technology. The dressed carcasses were brought to the laboratory immediately and chilled at 4±1°C for 12-18 hr and then deboned manually. The skin, external fascia, fat and all separable connective tissues were removed and the experimental samples for each trial were taken from the pooled deboned meat of a carcass. The boneless meat and fat were packed separately in low density polyethylene (LDPE) bags and stored in a deep freezer at -18±1°C until further use.

Raw materials and chemicals

Fresh guava, bael and dragon fruits were purchased from local market of Belgachia, Kolkata, brought to the laboratory and washed properly with clean portable water. For this study, whole sliced guava fruit, bael pulp and the peel of dragon fruits were dried separately in a hot air oven (50±1°C) for 7-8 hrs. The dried guava, bael pulp and dragon fruit peel were ground to a fine powder and sieved through a fine mesh with an average particle size of <1.0 mm. These samples were then individually and aerobically packed in UV sterilized low density polyethylene (LDPE) containers and stored at 4±1°C until further utilization.

All the spice ingredients were cleaned, dried in hot air oven at 60°C for 2 hr, cooled in a dessicator and then ground using proportionate quantity to obtain the dry spices mix used for the preparation of nuggets. Similarly, a condiment mixture is prepared having onion, ginger and garlic in the ratios 3:1:1 and this mixture is also added to the meat during emulsion formation. All the chemicals used were of analytical grade and were procured from standard firms (Himedia). Rest all products used *viz*. common salt, oil, refined wheat flour etc. were from commercial food grade suppliers.

Estimation of dietary fiber, total phenolics, carotenoid and Vitamin C content of fruit powder

The dietary fiber content of fruit powder were determined by the methods of AOAC (1995).

Total phenolics content

The concentration of total phenolics in guava powder (GP), bael pulp powder (BPP) and dragon fruit peel powder (DFPP) was determined by the Folin-Ciocalteu (F-C) assay (Escarpa and Gonzalez, 2001) with slight modifications.

Total carotenoid content

The method used for determining total carotenoids was performed on a UV-Vis spectrophotometer (Prache *et al*., 2003).

Vitamin C content

Sample preparation, chromatography conditions, identification and quantification of vitamin C in fruit powder by HPLC method was performed using the method described by Czech Agriculture and Food Inspection Authority (2005).

Preparations of chevon nuggets

One kg formulation of emulsion was made for each treatment. Control formulation consisted of 70% minced meat, 10% refined mustard oil, 10% ice flakes, 1.6% salt, 0.3% tripolyphosphate, 0.3% sugar, 1.8% dry spices powder, 3% condiments and 0.3% refined wheat flour. Sodium nitrite at 150 ppm was also added to the above formulations. In treated formulations, guava powder (1.5%), bael pulp powder (1.5%), dragon fruit peel powder (1.5%) powder were incorporated by replacing an equal amount minced meat in the control formulation. The emulsions were made in a bowl chopper (Talsa Ltd, Germany). Meat emulsion (approx.750 g) was placed into stainless steel moulds (18×12×4 cm), tightly packed and cooked in a steam at atmospheric pressure for 35 min. The temperature of the steam oven during cooking was above 100°C. The meat blocks were cooled to room temperature and then cut into nuggets of suitable sizes. About 200 g nuggets were packed in separate polyethylene pouches and stored at 4±1°C. They were evaluated for physico-chemical parametres (viz. pH, proximate composition), textural profile and sensory evaluation on day 0. To determine the storage stability the thiobarbituric acid values and microbial quality were analysed at 5 days interval up to 20 days. Each component was measured in triplicate and the entire experiment was replicated thrice.

Analytical methods

The moisture, protein, fat and ash content of fruit powder and Chevon nuggets were determined by the methods of AOAC (1995). Emulsion stability of goat meat nuggets was determined as per procedure of Baliga and Madaiah (1971). The pH of the nuggets was determined by the method suggested by Troutt *et al*., (1992). Thiobarbituric acid number (mg malonaldehyde/kg) of the samples was determined using the extraction method described by Witte *et al*., (1970). Total plate count (TPC) and psychrophilic count were determined by APHA (1992) using pour plate method. The sensory parameters of the Chevon nuggets were evaluated by mean descriptive analysis method using 8 points hedonic scale (Keeton *et al*., 1984).

Statistical analysis

All the data obtained during the present investigation were analyzed statistically to draw valid conclusion by using SPSS (Version 24.0) software. The data obtained were analyzed by randomized block design (4 treatments×6 no of samples) and subsequent one-way ANOVA analysis except storage study parameters were analyzed by complete randomized design for (3 treatment×6 no of samples ×5 storage days) by two-way ANOVA. Further the significance between the data was compared by Tukey's Post Hoc Test by SPSS-24® software package. A probability value of p<0.05 was described as significant and p<0.01 was noted as highly significant.

RESULTS AND DISCUSSION

Dietary fibre, total phenolics, total carotenoids and Vitamin C content of fruit fiber powder

The Dietary fibre, total phenolics, total carotenoids and Vitamin C content of GP, BPP and DFPP are presented in Table 1. The dietary fibre content of DFPP recorded the significantly(p<0.05) higher value followed by GP and BPP. Bael pulp powder possessed significantly (P<0.05) higher phenolics content followed by DFPP and GP. Significantly (P<0.05) higher total carotenoids and Vitamin C were found in GP in comparison to BPP and DFPP. The DF content of GP in the present study is similar with the findings of Jimenez-Escrig *et al*. (2001) who reported total dietary fibre content in dried guava as 48.55 to 49.42%. Suvimol and Anprung (2008) reported total DF of bael fruit pulp as 10.84g/100g DW. Plant phenolic compounds are one of the most desirable bioactive compounds with strong antioxidative capacity (Roohinejad *et al*., 2017). Because of their ability to scavenge free radical, chelate pro-oxidant metals, potential role as reducing agents and quenchers of singlet oxygen (Mohajer *et al*., 2016). According to Corrêa *et al*., (2011), total phenolics, expressed as equivalent of gallic acid (GAE), varied from 158 to 447 mg GAE/100 g in guava. Suvimol and Pranee (2008) observed that bael fruit pulps had total phenolic content of 87.34 mg GAE/g DW, whereas Jain *et al*., (2011) reported the total polyphenols (mg GAE/g) in bael fruit extract as 95.33, which corresponds to the values obtained in the present study. The total phenolic contents of dragon fruit peel were reported as 36 mg GAE/100g (Manihuruk *et al*., 2017). In this study, significantly higher carotenoids were observed in guava powder, which correlated with the values (0.78 to 2.93 mg/100 g) as reported by Thaipong *et al*., (2006) in pink pulp guava. As compared to Charoensiddhi and Anprung (2008) who reported that bael fruit pulps had total carotenoid content of 32.98 µg/g DW we analyzed that the carotenoid content of BPP was 0.15 mg/kg. For DFP the total carotenoids (mg of β-carotene/100 g of edible portion) was found to be 0.86±0.01 by Can-Cauich *et al*. (2017) which is in confirmation with the values we observed in our study. The variation in carotenoid content might be due to the variety of the fruit and drying method used for powder preparation.

Proximate composition

The pH and proximate composition of Chevon nuggets treated with 1.5% of GP, BP and DFPP are presented in Table 2. Addition of fruit powder significantly (P<0.05) affected the pH of nuggets. The pH values of Chevon nuggets with fruit powder were lower than the control batch. The low pH values of treated nuggets could be attributed to the added fruit powder, which were a good source of ascorbic acid. This observation was in confirmation with Manihuruk *et al*. (2017) who demonstrated that addition of guava powder in sheep nuggets and dragon fruit peel extract in beef sausages, respectively, lowered the pH of the final product.

Incorporation of fruit powder significantly (*P*<0.05) affected the moisture, fat and ash percentage of nuggets, however, protein percentage did not show any significant (P>0.05) effect. The highest moisture, fat and ash percentage were recorded with nuggets treated with DFPP. The trend observed in case of moisture and ash percentage was DFPP>GP>BPP>Control whereas in case of fat percentage it was DFPP>GP≥Control>BPP. The higher moisture percentage in fruit powder treated nuggets could be due to absorption of added water by the powder incorporated during product preparation. Similar results were recorded in sheep meat emulsion with guava powder (Verma *et al*., 2013) and Chevon nuggets prepared with BPR (Das *et al*., 2014). However, Manihuruk *et al*. (2017) observed that addition of dragon fruit peel extract did not affect the moisture, fat or ash content of beef sausage.

The results regarding protein percentage in the present study corresponded to the observations of Verma *et al*., (2013), who also reported that there was no significant difference in protein percentage of sheep meat nuggets treated with 0.5% and 1% guava powder. Proximate composition of emulsion and nuggets were not affected significantly (p>0.05) due to addition of BPR (Das *et al*., 2014). According to Manihuruk *et al*., (2017), protein content of beef sausages was unaltered due to incorporation of red dragon fruit peel extract. The high fat percentage of dragon fruit peel

Table 1: Dietary fibre, total phenolics, total carotenoids and vitamin C of fruit fibre powder.

Parameters	Fruit fibre powder		
	Guava powder	Bael pulp powder	Dragon fruit peel powder
Dietary fibre (g/100g)	56.93±0.12[b]	26.99±0.10[c]	59.83±0.19[a]
Total phenolic (mg GAC/g)	43.99±0.08[c]	82.32±0.49[a]	65.71±0.12[b]
Total carotenoid (mg/kg)	3.91±0.03[a]	0.15±0.00[c]	1.87±0.04[b]
Vitamin C (mg/kg)	162±0.45[a]	8.60±0.09[b]	2.62±0.06[c]

GAC = Gallic acid equivalent.

Mean±S.E. values bearing different superscripts in row differ significantly (p<0.05).

might have increased the fat content of nuggets treated with DFPP in the present study. Ash percentage in the present study correlated with the results of Das *et al*. (2014).

Texture profile analysis

Addition of GP, BPP and DFPP to Chevon nuggets resulted in significant (P<0.05) changes in hardness, springiness, cohesiveness, gumminess and chewiness values (Table 3). Hardness, cohesiveness, gumminess and chewiness values were significantly (P<0.05) decreased after addition of fruit powder except springiness, which increased significantly (P<0.05) in treatment groups. The lowest values for hardness, cohesiveness, gumminess and chewiness were recorded in nuggets treated with DFPP. In the present study, incorporation of fruit powder in Chevon nuggets made them softer. These findings were in coherence with the observations of Vidyarthi *et al*. (2022) in fish nuggets treated with different fruit powder. Rajkumar *et al*. (2016) reported significantly lower springiness and loss of elasticity in nuggets incorporated with aloe-vera gel and lower gumminess in mutton nuggets treated with apple pomace (Huda *et al*., 2014). However, Verma *et al*. (2013) did not find any significant changes in sheep meat nuggets after addition of guava powder. The contradictory results in textural parameters might be due to the difference in the type and amount of fiber added in the products.

Sensory properties

The treatment of Chevon nuggets with GP, BPP and DFPP had significant (P<0.05) effect on sensory attributes *viz*. appearance, flavor, texture, tenderness and juiciness and results (Table 4). The nuggets treated with GP had significantly (P<0.05) higher scores for appearance and flavour as compared to control and other treatment groups, whereas

Table 2: Physiochemical properties and proximate composition of chevon nuggets.

Parameters	Chevon emulsion			
	Control	T1	T2	T3
Emulsion pH	6.26±0.01	6.24±0.01	6.26±0.01	6.22±0.01
Emulsion stability	84.10±0.05^{d}	88.50±0.18^{c}	86.04±0.06^{b}	89.89±0.14^{a}
Cooking yield	91.58±0.23^{c}	93.91±0.14^{b}	94.28±0.08^{b}	95.02±0.06^{a}
	Chevon nuggets			
pH	6.37±0.01^{a}	6.36±0.01^{ab}	6.36±0.01^{ab}	6.34±0.01^{b}
Moisture	62.97±0.05^{d}	66.40±0.05^{b}	63.84±0.03^{c}	67.64±0.05^{a}
Protein	14.32±0.01	14.78±0.04	14.49±0.01	14.36±0.07
Fat	10.89±0.03^{b}	11.24±0.02^{b}	10.25±0.01^{c}	11.75±0.02^{a}
Ash	2.07±0.02^{d}	2.85±0.02^{b}	2.17±0.01^{c}	2.93±0.02^{a}

Mean±S.E. values bearing different superscripts in row differ significantly (p<0.05), Control = Chevon emulsion without phytochemicals, T1 = With 1.5% guava powder, T2 = With 1.5% bael pulp powder, T3 = With 1.5% dragon fruit peel powder.

Table 3: Texture profile analysis of Chevon nugget from different treatment groups.

Parameter	Fruit fibre powder			
	Control	GP	BPP	DFPP
Hardness (N/cm^2)	60.31±0.003^{a}	47.22±0.003^{c}	50.423±0.001^{b}	43.52±0.003^{d}
Springiness (cm)	0.70±0.002^{d}	0.74±0.003^{a}	0.72±0.002^{c}	0.73±0.003^{b}
Cohesiveness	0.33±0.003^{a}	0.30±0.001^{b}	0.29±0.002^{c}	0.25±0.002^{d}
Gumminess (N/cm^2)	15.21±0.003^{a}	11.31±0.004^{c}	14.28±0.003^{b}	10.87±0.002^{d}
Chewiness (N/cm)	12.01±0.002^{a}	10.21±0.002^{c}	11.91±0.002^{b}	8.22±0.001^{d}

GP- Guava powder, BPP- Bael pulp powder, DFPP- Dragon fruit peel powder, Mean±S.E. values with different superscript a-d in the same rows differ significantly (p<0.05)

Table 4: TBA values (mg malonaldehyde/kg) of Chevon nuggets stored at 4±1°C.

Treatments	Storage days				
	0 Day	5th day	10th day	15th day	20th day
Control	0.118±0.01^{fA}	0.129±0.01^{dA}	0.223±0.01^{cA}	0.253±0.01^{bA}	0.296±0.02^{aA}
GP	0.114±0.01^{fA}	0.121±0.02^{dB}	0.212±0.02^{cB}	0.245±0.02^{bB}	0.286±0.01^{aB}
BPP	0.108±0.02^{fB}	0.117±0.02^{dC}	0.210±0.01^{cB}	0.239±0.02^{bC}	0.285±0.02^{aB}
DFPP	0.104±0.01^{fB}	0.111±0.01^{dD}	0.203±0.02^{cC}	0.229±0.01^{bD}	0.281±0.01^{aC}

GP- Guava powder, BPP- Bael pulp powder, DFPP- Dragon fruit peel powder, Mean ± S.E. values for all data (both rows and columns) differ significantly (p<0.05).

BPP treated nuggets had the highest texture, tenderness and juiciness scores. Overall, the acceptability of control nuggets was significantly (P<0.05) higher than other treatment groups; however, the sensory attributes of treated nuggets were acceptable as evaluated by the sensory panelists. Elhadi *et al*. (2017) reported that color, flavor, tenderness and juiciness scores of moringa leaf powder incorporated chicken patties were significantly (P<0.05) lower than the control samples. No significant (P<0.05) effect on sensory properties was found in sheep meat nuggets treated with guava powder (Verma *et al*., 2013) or *M. oleifera* leaves extract enriched cooked Chevon patties (Das *et al*., 2012). Das *et al*. (2014) observed that the overall acceptability of the Chevon nuggets increased with the added BPR, however, the difference was statistically nonsignificant. In the present study, appearance, flavour, texture, tenderness and juiciness scores were higher in treatment groups, although overall acceptability scores were reported to be higher in control group.

Thiobarbituric acid (TBA) values

The thiobarbituric acid (TBA) value (mg malonaldehyde/kg) of the Chevon nuggets treated with GP, BPP and DFPP were recorded on day 0 and then at 5 days interval upto 20th day (Table 5). The treatment and storage time had a statistically significant (P<0.05) effect on TBA values of Chevon nuggets. Incorporation of fruit powder significantly (P<0.05) reduced the lipid oxidation rate of Chevon nuggets during refrigerated storage. Nuggets treated with DFPP had the lowest TBA value during entire storage period followed by BPP, then GP and finally control. Although, the TBA values were

Table 5: Sensory parameter analysis of Chevon nuggets from different treatment groups.

Parameters	Fruit fibre powder			
	Control	GP	BPP	DFPP
Appearance	6.73±0.26^{b}	6.74±0.38^{a}	6.69±0.23^{c}	6.31±0.22^{d}
Flavor	6.70±0.40^{ab}	6.80±0.35^{a}	6.63±0.32^{b}	6.46±0.33^{c}
Texture	6.58±0.40^{b}	6.09±0.35^{d}	6.60±0.36^{a}	6.21±0.48^{c}
Tenderness	6.69±0.37^{b}	6.65±0.36^{c}	6.81±0.37^{a}	6.10±0.42^{d}
Juiciness	6.67±0.38^{ab}	6.54±0.49^{b}	6.73±0.43^{a}	6.02±0.20^{c}
Overall acceptability	6.87±0.45^{a}	6.69±0.43^{c}	6.71±0.37^{b}	6.68±0.50^{c}

GP- Guava powder, BPP- Bael pulp powder, DFPP- Dragon fruit peel powder, Mean±S.E. values for all data (both rows and columns) differ significantly (p<0.05).

Table 6: Effect of incorporation of fruit powder on microbiological parameters of chevon nuggets.

Treatments	Storage day				
	0 Day	5 Day	10 Day	15 Day	20 Day
			Total plate count		
Control	3.55±0.01^{eA}	3.85±0.01^{dA}	4.44±0.01^{cA}	4.86±0.02^{bA}	5.36±0.01^{aA}
GP	3.54±0.01^{eA}	3.75±0.01^{dB}	3.95±0.01^{cB}	4.65±0.01^{bAB}	4.95±0.00^{bAB}
BPP	3.53±0.01^{eA}	3.75±0.01^{dB}	4.21±0.01^{cC}	4.63±0.01^{bB}	4.92±0.04^{cB}
DFPP	3.50±0.04^{eB}	3.74±0.01^{dB}	3.93±0.01^{cD}	4.62±0.02^{bC}	4.75±0.01^{dD}
			Total coliform count (TCC)		
Control	ND	ND	ND	1.57±0.03^{b}	1.86±0.01^{aA}
GP	ND	ND	ND	ND	1.54±0.01^{aB}
BPP	ND	ND	ND	ND	1.47±0.01^{aC}
DFPP	ND	ND	ND	ND	1.32±0.01^{aD}
			Total psychotropic count (TPSC)		
Control	1.37±0.15^{e}	2.44±0.02^{dA}	3.56±0.01^{cA}	4.77±0.06^{bA}	5.16±0.01^{aA}
GP	ND	0.93±0.01^{dB}	1.72±0.01^{cB}	2.54±0.01^{bB}	3.44±0.01^{aB}
BPP	ND	0.95±0.01^{dAB}	1.73±0.00^{cB}	2.54±0.01^{bB}	3.45±0.01^{aB}
DFPP	ND	0.81±0.02^{dC}	1.71±0.01^{cC}	2.53±0.01^{bB}	3.43±0.01^{aC}
			Yeast and mould count (YMC)		
Control	ND	ND	1.16±0.01^{cA}	1.66±0.01^{bA}	1.85±0.01^{aA}
GP	ND	ND	ND	1.35±0.01^{bB}	1.58±0.02^{aAB}
BPP	ND	ND	ND	1.36±0.01^{bAB}	1.55±0.01^{aB}
DFPP	ND	ND	ND	1.34±0.01^{bC}	1.54±0.01^{aC}

Unit- Log10 cfu/g, GP- Guava powder, BPP- Bael pulp powder, DFPP- Dragon fruit peel powder, N.D.- Not detected, Mean±S.E. Values for all data (both rows and columns) differ significantly (p<0.05).

increased significantly throughout the storage period, irrespective of any treatment, the values were below the threshold limit of 1-2 mg/kg for rancidity (Watts, 1962). The significant (P<0.05) increase in TBA value with storage period in all groups might be attributed to increased lipid oxidation and production of volatile metabolites in the presence of oxygen during aerobic storage, however, the values were within the acceptable limit till the 20th day. These findings indicated that the phenolic compounds in the fruit powder mitigated the lipid peroxidation and development of oxidative rancidity in the nuggets. The carotenoids and Vitamin C content might have also contributed to its strong antioxidant ability. Verma *et al*. (2013) reported that the increase in TBARS number in guava powder treated samples was very slow and remained lowest (0.68 mg malonaldehyde/kg sample) up to the 15th day.

Microbiological parameters

The total plate count (TPC), psychrophilic count and coliform count (log10 cfu/gm) of the Chevon nuggets treated with 1.5% GP, BPP and DFPP and control were recorded at 5 days interval up to 20th day (Table 6). Incorporation of fruit powder significantly (P<0.05) improved the microbial stability of treatment groups and the best results were observed in nuggets treated with DFPP. On day 0, no psychrophilic growth was observed in any of the treated nuggets, however, the count increased significantly (P<0.05) in all the groups throughout the storage period. There was no growth of coliforms in fruit powder treated nuggets up to 15th day of storage period. The antimicrobial activity of fruit powder in Chevon nuggets in the present study might be due to the presence of many bioactive components, including vitamins, minerals and carotenoids. According to Barba *et al*. (2017) plant extracts are known for their high antimicrobial activity against both foodborne pathogenic and spoilage microorganisms. Similar results were obtained by Das *et al*. (2014) in Chevon nuggets incorporated with BPR.

CONCLUSION

Guava, bael pulp and dragon fruit peel powder are rich sources of phenolic compounds, total carotenoids and vitamin C. Incorporation of fruit powder can be used as a functional ingredient to modify the physicochemical properties of emulsion meat products and improve textural parameters without affecting their acceptability. Fruit powder's strong antioxidant and antimicrobial properties can be used in the meat industry to maintain the microbial stability and minimise oxidation of meat and meat products throughout storage upto 20 days.

Conflict of interest: None.

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