DR-1837
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RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume Issue : ()

Effect of Bael (*Aegle marmelos* L.) Pulp Residue on Quality and Storability of Chicken Meatballs from Spent Layers

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10.18805/ajdfr.DR-1837

ABSTRACT

Background: Bael contains rich health promoting bioactive compounds such as flavonoids, polyphenols, carotenes, vitamins and organic acid. It has recently gained attention as an alternative to chemical additives. Despite having high nutritional value, the commercial industry does not emphasize it to make value added products and it is still being used only by the unorganized sector.

Methods: Bael pulp residue (BPR) powder was incorporated into chicken meatballs from spent layers at the levels of 1% 1.5% and 2% and stored under refrigerated temperature at 4±1°C for 15 days to see the effect of different parameters such as physico-chemical parameters, antimicrobial properties and sensory attributes.

Result: Results of this study showed that moisture, crude protein and crude fat percentage decreased, whereas crude fibre increased gradually ($p<0.05$) with the increase concentration of BPR powder in meatballs. Hardness and chewiness decreased significantly ($p<0.05$), whereas gumminess increased significantly ($p<0.05$) with the increase level of BPR powder in meatballs. TBA value decreased significantly ($p<0.05$), whereas DPPH radical scavenging activity increased significantly ($p<0.05$) with the increase concentration of BPR powder. Total plate count and yeast and mould count also decreased significantly ($p<0.05$) compare to control. Sensory parameters such as appearance, flavour and overall increased significantly ($p<0.05$) by inclusion of BPR powder in meatballs. It has also been observed that proximate, texture profile, sensory parameters of treated products were higher the value than control, whereas microbiological parameters and TBA value were lower the value than control with the increase of storage period from 0 to 15 days at 4±1°C.

Key words: Bael pulp residue, Bioactive compounds, Meatballs.

INTRODUCTION

Changes in existing food habits and lifestyle patterns have led the people to search for affordable and healthier foods with satisfactory taste and pleasant appearance. Consumers' expectations are healthy foods with all natural ingredients and do not contain any artificial flavour, colouring ingredient or chemical preservative, or any other artificial or synthetic ingredient.

Despite meat having a high biological value, having high protein, excellent source of some essential fats, soluble vitamins and minerals (Yadav *et al.,* 2020; Gálvez *et al.,* 2019), it has a number of ailments on the human body such as colon cancer, cardiovascular diseases and obesity on regular consumption (Boada *et al.,* 2016). It lacks dietary fibre in which documentary evidence supports that intake of fibre diminishes the threat of such diseases (Lockyer *et al.,* 2016). Therefore, the meat industry continuously seeks to adapt and develop new formulations designed to increase shelf life, quality and safety of foods. Their efforts are using natural ingredients such as antioxidants, vitamins, minerals or fibre from plants and plant materials which are rich in bioactive compounds (*e.g.* phenolics and flavonoids compounds) to improve the quality of meat.

The bael fruit contains bioactive compounds such as polyphenols, flavonoids, carotenes, vitamins, organic acids (Hazra *et al.,* 2020) and essential minerals (*i.e.* potassium, calcium, phosphorous, sodium, iron, copper and manganese (Manandhar *et al.,* 2018) that show multiple biological activities like, antibacterial, antihelminthic, anticancer, antiulcer, antidiarrhea, astringent, antidiabetic, anti-inflammatory and antioxidant properties, *etc.* (Lim, 2012; Sarkar *et al.,* 2020). It also contains a good source of dietary fibre (Sawale *et al.,* 2018).

This experiment was conducted to see the effect of bael pulp residue powder on quality and storability of chicken meatballs from spent layers stored at refrigerated temperature (4±1°C) so that quality of meat can be improved and shelf life can be increased.

MATERIALS AND METHODS

The study was carried out during the month of April, 2021 to September, 2021 as per the designed program in the

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How to cite this article: Dhara, D., Biswas, S. and Biswas, O. (2022). Effect of Bael (*Aegle marmelos* L.) Pulp Residue on Quality and Storability of Chicken Meatballs from Spent Layers. Asian Journal of Dairy and Food Research. DOI: 10.18805/ajdfr.DR-1837.

Submitted: 15-11-2021 **Accepted:** 23-02-2022 **Online:** 31-03-2022

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Raw materials

Spent layer birds, aged more than 80 weeks, were procured from the market and were subjected to ante-mortem inspection and maintained for 6 hours by giving water only. Those birds were slaughtered and dressed as per the standard procedure mentioned by Sahoo and Panda (1983) with little bit modification.

Bael pulp residue was placed into the sun for drying. After complete drying, powder was made by grinding it through a grinder. Then, this powder was sieved through a fine mesh for obtaining particle size of <1.0 mm (Costa *et al.,* 2009).

Peeled onion, garlic and ginger were blended in the ratio of 3:1:1, respectively, to make a fine paste. Other spice mixtures were turmeric (haldi) (10%), black pepper (8%), coriander (15%), aniseed (10%), red chilli (10%), caraway seed (10%), cinnamon (5%), cardamom (5%), clove (5%), cumin seed (10%), nutmeg (1%), mace (1%), dried ginger (10%). Those spices were powdered, weighed and mixed thoroughly.

Meatball emulsions

Meat was cut into small chunks and placed in the meat mincer by using a 10 mm plate followed by a 5 mm diameter plate subsequently. Then, emulsions were prepared by adding lean meat (70%), salt (1.6%), tripolyphosphate (0.3%), sugar (0.3%), ice flakes (8.7%), sodium nitrite (0.015%), rice bran oil (7.0%), dry spice mix (1.80%), refined wheat flour (5%), egg albumin (1.285%) and condiment mixture (4%).

Meatballs preparation

Meatball emulsion was equally divided into 4 parts; one was made for control and three were made for treatments. Treatments were incorporated with bael pulp residue powder at three different levels *viz.* 1.0%, 1.5% and 2.0%, respectively, on w/w basis. Now, uniformed meatballs (diameter 2 cm) were made from each part mechanically. Meatballs were put in metal containers and steam cooked at 121°C temperature for 20 minutes under a pressure of 6.8 kg (Kumar *et al.,* 2013). Cooked meatballs were cooled at room temperature. One portion from each part was taken for testing on 0 day and the rest were kept under refrigerated condition (4±1°C) for succeeding analysis.

Parameters tested

Proximate analyses were determined as per the methods described by AOAC, 2001. Texture profile analysis of cooked meatballs was determined by TA-HDi Texture Analyzer (Stable Micro Systems, UK).The peroxide value was estimated as per procedure mentioned by Koniecko (1979) with slight modifications. TBA value was determined by the same procedure mentioned by Tarladgis *et al.* (1960). DPPH scavenging activity was measured as per procedure mentioned by Kato *et al.* (1988). Microbiological parameters were determined by the same procedure mentioned in APHA, 2001. Sensory parameters were evaluated by 10-members sensory panelists of trained judges of different age groups and sexes by using 9-point Hedonic scale as described by Wichchukit and O'Mahony (2015).

Statistical analysis

IBM® SPSS® software was used for analyzing the data. Univariate data were analyzed by the statistical method of ANOVA according to Tukey's HSD (Honest Significant Difference) Test (Tukey, 1949).

RESULTS AND DISCUSSION

Proximate analysis

Proximate analysis (Table 1) showed that moisture percentage, crude protein and crude fat decreased ($p<0.05$) gradually with the increased concentration of BPR powder percentage. But, crude fibre increased ($p<0.05$) gradually with the increased concentration of BPR powder percentage. These results are congruent with the results reported by Das *et al.* (2014). Moisture, crude protein, Crude fibre and crude fat (%) of cooked meatballs gradually ($p<0.05$) decreased for all samples with the increase of storage period from 0 to 15 days at 4±1°C. Similar findings were reported by Giri *et al.* (2019).

Texture profile analysis

The control samples had the higher hardness, cohesiveness, gumminess and chewiness values, whereas the samples treated with 1% BPR showed the highest springiness (Table 2). Reduction of hardness, springiness and cohesiveness were found with the increase of BPR in the meatballs. Hardness relies on the moisture percentage of meatballs. Springiness is the ability of the product to recapture its shape after deformation during the pressure cycle. Springiness values were related with the elastic properties of meatballs. Thus, decrease of springiness demonstrates that the elasticity of meatballs is diminished with the increase level of incorporation of BPR powder. Increases of gumminess and chewiness were seen with the increase of BPR in the meatballs. Gumminess and chewiness values are related by hardness, cohesiveness and springiness values of the product. Incorporation of BPR in the meatballs leads to increase in chewiness significantly ($P<0.05$). These results are in agreement with the results reported by Das *et al.* (2020) and Rindhe *et al.* (2018). There was a gradual decrease in hardness, springiness, cohesiveness, gumminess and chewiness of all samples with an increase of the storage period from 0 to 15 days.

Oxidation and antioxidant properties

As described by Kumar *et al.* (2015), during process of lipid oxidation, unsaturated fatty acids are oxidized and hydroperoxides are formed that decompose rapidly, resulting in a large number of secondary compounds including hydrocarbons, aldehydes, ketones, alcohols, esters and

Table 1: Effect of proximate parameters.

Parameters	Treatments	0 day	3rd day	5th day	7th day	15th day
Moisture (%)	Control	64.075±0.048^{a}	63.76±0.034^{a}	63.5225±0.011^{a}	63.055±0.032^{a}	62.5425±0.005^{a}
	BPR1%	63.55±0.008^{b}	63.5125±0.014^{b}	63.3825±0.028^{b}	62.685±0.077^{b}	62.12±0.012^{b}
	BPR1.5%	63.52±0.011^{b}	63.47±0.015^{b}	63.365±0.038^{b}	62.595±0.055^{b}	62.005±0.003^{b}
	BPR2%	63.2175±0.073^{c}	62.25±0.011^{c}	62.1875±0.008d^{c}	62.08±0.018^{c}	61.5725±0.185^{c}
Crude protein (%)	Control	18.4575±0.01^{c}	18.2275±0.01^{a}	18.18±0.004^{b}	17.83±0.051^{a}	17.6575±0.022^{a}
	BPR1%	18.3125±0.006^{b}	18.2475±0.005^{a}	18.13±0.011^{a}	17.475±0.159^{a}	17.62±0.023^{a}
	BPR1.5%	18.27±0.004d^{a}	18.2325±0.005^{a}	18.125±0.006^{a}	17.75±0.056^{a}	17.5925±0.022^{a}
	BPR2%	18.25±0.004^{a}	18.2175±0.007^{a}	18.115±0.013^{a}	17.74±0.062^{a}	17.57±0.02^{a}
Crude fibre (%)	Control	0.7175±0.005^{a}	0.69±0.004^{a}	0.675±0.003^{a}	0.655±0.003^{a}	0.625±0.003^{a}
	BPR1%	0.8775±0.006^{b}	0.8375±0.003^{b}	0.7925±0.003^{b}	0.715±0.01^{b}	0.6475±0.013^{a}
	BPR1.5%	0.9975±0.003^{c}	0.9175±0.005^{c}	0.86±0.004^{c}	0.805±0.003^{c}	0.775±0.003^{b}
	BPR2%	1.37±0.004^{d}	1.285±0.003^{d}	1.24±0.004^{d}	1.1775±0.003^{d}	1.105±0.003^{c}
Crude fat (%)	Control	13.8775±0.047^{c}	13.1625±0.038^{c}	13.105±0.016^{d}	13±0.007^{d}	12.26±0.024^{d}
	BPR1%	13.525±0.012^{b}	12.9975±0.006^{b}	12.825±0.018^{c}	12.5675±0.027^{c}	12.0275±0.014^{c}
	BPR1.5%	13.35±0.011^{a}	12.8575±0.025^{a}	12.7075±0.013^{b}	12.4275±0.013^{b}	11.8575±0.005^{b}
	BPR2%	13.28±0.004^{a}	12.7875±0.038^{a}	12.515±0.009^{a}	12.2675±0.02^{a}	11.75±0.011^{a}

N=4. Data (Mean ± standard error) with different small letter superscript in the same column differ significantly ($p<0.05$).

Table 2: Effect of texture profile parameters.

Parameter	Treatment	0 day	3rd day	5th day	7th day	15th day
Hardness	Control	50.235±0.0004^{d}	49.8015±0.0006^{d}	49.3008±0.0005^{d}	48.731±0.0004^{d}	48.3408±0.0005^{d}
(N/cm^2)	BPR1%	42.216±0.0003^{c}	41.2013±0.0005^{c}	40.7015±0.0003^{c}	40.951±0.0004^{c}	40.6238±0.0005^{c}
	BPR1.5%	41.5318±0.0005^{b}	41.1005±0.0003^{b}	10.6108±0.0005^{a}	40.2883±0.0005^{b}	39.964±0.0004^{b}
	BPR2%	40.8133±0.0005^{a}	40.524±0.0004^{a}	40.038±0.0004^{b}	39.5105±0.0003^{a}	39.274±0.0004^{a}
Springiness	Control	0.6108±0.0005^{a}	0.601±0.0004^{a}	0.591±0.0004^{a}	0.5818±0.0005^{a}	0.5515±0.0003^{a}
(cm)	BPR1%	0.6425±0.0003^{d}	0.6325±0.0003^{d}	0.6228±0.0005d^{d}	0.6125±0.0003^{d}	0.58±0.0004^{d}
	BPR1.5%	0.6383±0.0005^{c}	0.628±0.0004^{c}	0.6178±0.0005^{c}	0.6073±0.0003^{c}	0.5745±0.0003^{c}
	BPR2%	0.6353±0.0002^{b}	0.625±0.0004^{b}	0.615±0.0004^{b}	0.6048±0.0005^{b}	0.573±0.0004^{b}
Gumminess	Control	12.2083±0.0028^{d}	12.109±0.0004^{d}	12.001±0.0004^{d}	11.902±0.0004^{d}	11.8808±0.0005^{d}
(N/cm^2)	BPR1%	11.347±0.0007^{a}	11.235±0.0004^{a}	11.1618±0.0005^{a}	11.059±0.0004^{a}	11.039±0.0004^{a}
	BPR1.5%	11.4018±0.0005^{b}	11.304±0.0004^{b}	11.216±0.0004^{b}	11.114±0.0004^{b}	11.091±0.0004^{b}
	BPR2%	11.5808±0.0005^{c}	11.4848±0.0005^{c}	11.375±0.0004^{c}	11.288±0.0004^{c}	11.267±0.0004^{c}
Cohesiveness	Control	0.2700±0.0004^{a}	0.265±0.0004^{c}	0.26±0.0004^{b}	0.255±0.0004^{d}	0.244±0.0004^{d}
	BPR1%	0.2383±0.0002^{a}	0.233±0.0004^{d}	0.229±0.0004^{c}	0.225±0.0004^{c}	0.215±0.0004^{c}
	BPR1.5%	0.2293±0.0003^{b}	0.2258±0.0005^{a}	0.2218±0.0005^{a}	0.2155±0.0003^{a}	0.208±0.0004^{b}
	BPR2%	0.2208±0.0005^{c}	0.217±0.0004^{b}	0.212±0.0004^{a}	0.208±0.0004^{b}	0.2003±0.0002^{a}
Chewiness	Control	9.898±0.0004^{c}	9.8118±0.0005^{c}	9.7158±0.0005^{c}	9.6218±0.0005^{c}	9.4478±0.0005^{c}
(N/cm)	BPR1%	9.434±0.0004^{a}	9.345±0.0004^{a}	9.262±0.0004^{a}	9.1708±0.0005^{a}	9.04±0.0004^{a}
	BPR1.5%	9.8908±0.0006^{b}	9.802±0.0004^{b}	9.705±0.0004^{b}	9.612±0.0004^{b}	9.438±0.0004^{b}
	BPR2%	10.215±0.0004^{d}	10.1208±0.0005^{d}	10.085±0.0004^{d}	9.9288±0.0005^{d}	9.7478±0.0006^{d}

N=4. Data (Mean ± standard error) with different small letter superscript in the same column differ significantly ($p<0.05$).

acids. These compounds are responsible for unpleasant smells in meat products. Bael fruit has good antioxidant properties (Hazra *et al.,* 2020). This is the reason for having low TBA value but having high value of DPPH radical scavenging activity with the increase concentration of BPR powder in the meatballs and the same trend has been seen during increase of storage period (Table 3). TBA value increased gradually and DPPH radical scavenging activity decreased gradually with the increase of storage period from 0 to 15 days.

Microbiology

Result of total plate count and yeast and mould count (Table 4) showed that incorporation of BPR on cooked meatballs was very much effective ($P<0.05$) in controlling the microbial counts throughout the storage period of 15 days at 4±1°C. Microbial counts in meat products decreased with the increase of BPR in meatballs. BPR is having antimicrobial properties due to contain of polyphenolic compounds. Similar results were found by Ruhil *et al.* (2011) where he reported that bael is effective

Table 3: Effect of oxidation and anti-oxidative parameters.

Parameter	Treatment	0 day	3rd day	5th day	7th day	15th day
TBA value	Control	0.2605±0.0007^{c}	0.3958±0.0005^{d}	0.492±0.0004^{d}	0.5987±0.0005^{d}	1.0545±0.0016^{d}
(mg MDA/kg)	BPR1%	0.2545±0.0007^{b}	0.3385±0.0007^{c}	0.3915±0.0007^{c}	0.442±0.0004^{c}	0.8128±0.0005^{c}
	BPR1.5%	0.2505±0.0007^{a}	0.3025±0.0007^{b}	0.3588±0.0005^{b}	0.4025±0.0007^{b}	0.7635±0.0007^{b}
	BPR2%	0.2483±0.0009^{a}	0.2628±0.0009^{a}	0.3058±0.0009^{a}	0.3468±0.0008^{a}	0.7127±0.0009^{a}
DPPH radical	Control	25.0525±0.013^{a}	22.5525±0.017^{a}	20.08±0.011^{a}	18.5475±0.013^{a}	12.515±0.019^{a}
scavenging	BPR1%	28.01±0.015^{b}	25.5575±0.013^{b}	23.0625±0.015^{b}	20.655±0.006^{b}	15.5025±0.009^{b}
activity	BPR1.5%	30.01±0.013^{c}	27.545±0.014^{c}	25.065±0.006^{c}	22.63±0.004^{c}	17.5125±0.011^{c}
(% inhibition)	BPR2%	32.505±0.007^{d}	30.125±0.01^{d}	27.515±0.006^{d}	25.025±0.006^{d}	20.02±0.009^{d}

N=4. Data (Mean ± standard error) with different small letter superscript in the same column differ significantly ($p<0.05$).

Table 4: Effect of microbial parameters.

Parameter	Treatment	0 day	3rd day	5th day	7th day	15th day
Total plate	Control	2.1491±0.0052^{c}	2.6599±0.001^{d}	3.1382±0.0014^{d}	4.2226±0.0002^{d}	5.2652±0.00012^{d}
count	BPR1%	2.1351±0.0042^{bc}	2.4354±0.0017^{c}	2.9093±0.0024^{c}	4.0007±0.0003^{c}	5.1822±0.00002^{c}
(log_{10}cfu/g)	BPR1.5%	2.1238±0.0036^{b}	2.4057±0.0018^{b}	2.8761±0.0027^{b}	3.9338±0.0003^{b}	5.0361±0.00003^{b}
	BPR2%	2.089±0.0039^{a}	2.3659±0.0021^{a}	2.852±0.0026^{a}	3.876±0.0004^{a}	4.7405±0.00005^{a}
Yeast and	Control	0.25±0.25^{a}	1.4675±0.0293^{b}	1.930±0.0108^{d}	2.1925±0.0048^{d}	2.4925±0.0075^{d}
mould	BPR1%	N.D.	1.285±0.0457^{ab}	1.7425±0.0165^{c}	2.0625±0.0085^{c}	2.1925±0.0048^{c}
(log_{10}cfu/g)	BPR1.5%	N.D.	1.2375±0.0572^{a}	1.655±0.021^{b}	1.93±0.0108^{b}	2.1625±0.0063^{b}
	BPR2%	N.D.	1.14±0.0648^{a}	1.5375±0.0246^{a}	1.8725±0.0111^{a}	2.0975±0.0063^{a}

N=4. Data (Mean ± standard error) with different small letter superscript in the same column differ significantly ($p<0.05$).

Table 5: Effect of sensory parameters.

Parameter	Treatment	0 day	3rd day	5th day	7th day	15th day
Appearance	Control	7.005±0.003^{a}	7.0075±0.003^{a}	7.000±0.004^{a}	6.855±0.003^{a}	6.515±0.012^{a}
	BPR1%	7.1025±0.003^{b}	7.105±0.003^{b}	7.11±0.004^{b}	7.0075±0.005^{b}	6.6275±0.007^{b}
	BPR1.5%	7.155±0.003^{c}	7.155±0.003^{c}	7.1525±0.005^{c}	6.985±0.012^{b}	6.6725±0.007^{c}
	BPR2%	7.2025±0.002^{d}	7.2025±0.002^{d}	7.200±0.004^{d}	7.1175±0.005^{c}	6.7175±0.005^{d}
Flavour	Control	6.6025±0.003^{a}	6.6025±0.003^{a}	6.6075±0.006^{a}	6.445±0.003^{a}	6.1225±0.003^{a}
	BPR1%	7.0825±0.002^{b}	7.085±0.003^{b}	7.0825±0.005^{b}	6.8075±0.005^{b}	6.52±0.012^{b}
	BPR1.5%	7.1725±0.002^{c}	7.1725±0.003^{c}	7.1725±0.005^{c}	7.005±0.003^{c}	6.6125±0.002^{c}
	BPR2%	7.2475±0.002^{d}	7.2475±0.002^{d}	7.245±0.005^{d}	7.1075±0.005^{d}	6.6925±0.002^{d}
Overall	Control	6.705±0.003^{a}	6.705±0.003^{a}	6.595±0.003^{a}	6.475±0.003^{a}	6.0025±0.002^{a}
	BPR1%	7.1025±0.003^{b}	7.105±0.003^{b}	7.0025±0.002^{b}	6.905±0.003^{b}	6.425±0.003^{b}
	BPR1.5%	7.1775±0.002^{c}	7.1775±0.002^{c}	7.0675±0.003^{c}	6.9725±0.003^{c}	6.495±0.003^{c}
	BPR2%	7.2475±0.002^{d}	7.2475±0.002^{d}	7.1375±0.002^{d}	7.0425±0.005^{d}	6.555±0.003^{d}

N=4. Data (Mean ± standard error) with different small letter superscript in the same column differ significantly ($p<0.05$).

against bacteria and fungus. Das *et al.* (2014) and Vidyarthi *et al.* (2021) also reported that BPR is effective against total plate count.

Sensory analysis

Table 5 shows the organoleptic attributes. Appearance was significantly ($P<0.05$) higher than control. Increase of flavour was observed with the increase of BPR in the meatballs. This could be due to the reason that BPR might have acted as stabilizing agent for retaining the flavour by inhibiting the lipid oxidation. Overall acceptability scores in treated products remained stable. All attributes were acceptable even on the 15th day of storage. Similar findings reported by Anandh (2014).

Conclusion

BPR powder has had positive effects in meatballs on almost all the parameters. Among the treatments, 2% BPR powder incorporated in chicken meatballs form spent layers showed the best results by analysing above mentioned data of physico-chemical parameters, antimicrobial properties and sensory attributes. Commercial industries are making meat products or other similar products that contain chemical preservatives, synthetic antioxidants, antimicrobial contents and other chemicals which are unhealthy and result in some degenerative diseases and saturated fats. But, by using natural products, industries can avoid input of all types of chemicals in their products. Therefore, the incorporation of BPR powder can be

used in meat and meat products or similar muscle food products for preserving meat quality, extending shelf-life, preventing economic loss and fulfilling customer satisfaction.

ACKNOWLEDGEMENT

This is a part of Ph.D. thesis work. The author is thankful to the Department of Livestock Products Technology, West Bengal University of Animal and Fishery Sciences and acknowledges the financial assistance for carrying out the research work.

Conflict of interest: None.

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