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Effect of Watermelon Rind Powder on Quality Attributes and Storage Stability of Raw Pork and Pork Meat balls

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ABSTRACT

This study was conducted to analyze the anti-oxidant and anti-microbial effect of wa-termelon rind powder on raw minced pork as well as on pork meatballs stored at refrigerated (4+1°C) temperature for a period of 21 days. Watermelon rind powder was incorporated to raw minced pork as well as pork meatball mixture at the rate of 1.0%, 1.5% and 2.0% on w/w basis. Based upon the Thiobarbituric Acid Reacting Substances (TBRAS) values, Total Plate Count (TPC), Total Psychrotrophic Count (TPSC), Total Coliform Count (TCC) and Yeast and Mould Count (YMC) it was concluded, watermelon rind powder was capable of enhancing the storage stability of the product. Incorporation of watermelon rind powder in pork meatball mixture en-hanced the desirable physico-chemical and textural properties, although sensory evaluation re-vealed poorer acceptability compared to control samples.

Keywords: *Watermelon rind powder, Minced pork, Pork meatball, Shelf-life*

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INTRODUCTION

Being rich in moisture, protein, fat, vitamins and minerals forms an essential component of human diet. It is a source of quality proteins constituting essential amino acids of high bio-availability (Higgs, 2000). Lipid oxidation in meat and meat products is one of the major causes of their quality loss, other being microbial spoilage (Kanner, 1994, Enan, et al., 1996 & Zhang et al., 2009). Processing of meat to meat products require a number of activities like physical altera-tion (eg. mincing), heat treatment (eg. frying, baking etc.), storage under controlled environment (marination) etc. Such activities lead to development of oxygenated free radicals which initiate the oxidation of polyunsaturated fatty acids causing destruction of the natural antioxidant sys-tems (Karakaya, et. al. 2011). Further, extended handling and improper sanitary conditions dur-ing processing would increase the microbial load of the product, both factors deteriorating the storage stability of the final product (Zagory, 1999). Meat preservation has mostly been carried out by addition of synthetic preservatives but these synthetic compounds, if consumed regularly for prolonged period of time may cause significant health hazard. Fruits and vegetables are known to be rich sources of anti-oxidant and anti-microbial compounds and their frequent con-sumption is associated with a lower risk of various diseases as well as cancer (Renaud et al., 1998 and Temple, 2000).

Watermelon (Citrullus lanatus) is a rich source of vitamins and serves as a good source of various phytochemicals (Perkins-Veazie et al., 2004). Watermelon rinds have high fibre content, significantly good free radical scavenging activity and good phenolic content, thus effective as an antioxidant (Al-Sayed et al., 2013). Leong et al. (2002) and Lewinsohn et al. (2005) have studied the therapeutic effect of watermelon and confirmed that those effects are due to its an-tioxidant content such as phenols, citrulline etc. The citrulline in watermelon rinds gives it anti-oxidant effects and protects it from free-radical damage. Additionally, citrulline converts to arginine, an amino acid vital to the heart, circulatory system and immune system. Studies done by Rimando et al. (2005) has led to the conclusion that watermelon rind might relax blood vessels and help in combating cancer and cardiovascular diseases. Ho et al. (2016) have produced noo-dles by partly replacing the wheat flour with watermelon rind powder whereas Naknaen et al. (2016) have produced cookies by incorporating watermelon rind powder with wheat flour. The substitution of wheat flour with watermelon rind powder improved the quality of end-products by enhancing the dietary fibre content and increasing the total phenolic content.

Meatballs are the processed comminuted form of meat and are an extremely popular del-icacy. Due to the comminuted nature of meat, it is prone to rapid lipid oxidation and microbial spoilage. No significant work related to the antimicrobial and anti-oxidant effect of watermelon rind powder in meat or meat products has been reported till date. In this study watermelon rind powder (WRP) was incorporated in raw minced pork as well as the meatball formulation. from which meatballs were prepared by steam cooking. The effect of WRP on the storage stability of the cooked product under refrigerated (4 + 1 °C) temperature was evaluated along with physico-chemical characteristics, textural properties and sensory parameters.

MATERIALS AND METHODS

Sample collection: Matured watermelon fruits were purchased from the local market as per its seasonal availability. The fruits were washed, cleaned and dried. The juicy and bright red pomace along with its seeds were removed from the fruit and the rinds were separated. The rinds were transversely cut into thin slices which were then dried in a hot air oven at 47±2°C for 24 hrs. The dehydrated water-melon rind slices were ground to a fine powder and sieved through a fine mesh with an average particle size of <1.0 mm (Correia Da Costa et al., 2008). These samples were then aerobically packed in UV sterilized low density polyethylene (LDPE) containers and stored at -18 + 1°C until further utilization.

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Fresh pork samples were collected from government slaughter house, Haringhata Farm, West Bengal. Visible fat and tendon were removed. The meat was minced in two steps, firstly by us-ing 10mm plate and then by 5mm plate. Watermelon rind powder was added to the minced meat on w/w basis at the rate of 0% for control (CR), 1.0% for treatment 1 (R1), 1.5% for treatment 2 (R2) and 2.0% for treatment 3 (R3).

Preparation of meatballs: Meatballs were prepared according to the methodology as described by Kumar (2001) with slight modification. The ingredients required were procured from the lo-cal market. The lean pork was minced in two stages as mentioned above. The dry spice mix was prepared by drying all the ingredients in a hot air oven at 50°C for 4 hrs and then ground into a fine powder. The condiment mixture was prepared by blending peeled and sliced onion, ginger and garlic in the ratio 3:1:1 in a grinder till it became a smooth paste. All the chemicals incorpo-rated in the formulation were of food grade quality.

Minced pork along with other ingredients were used to prepare four batches of meatballs were namely control batch (CM), treatment 1 (M1), treatment 2 (M2) and treatment 3 (M3) as presented in Table 1. Twenty-five grams of the meatball mixture was then manually molded into balls using a metal shaper having diameter of 3.5 cms (Serdaroglu et al., 2004). These balls were then placed in metal containers and were steam cooked at 6.8 kg pressure and 121 °C tempera-ture for 20 min. (Kumar et al., 2013).

Table 1: Meatball Formulation

	TREATMENTS			
Ingredients (%)	CM	M1	M2	M3
Minced Lean Pork	70	69%	68.5%	68.0%
Rice Bran Oil	7.0	7.0	7.0	7.0
Ice Flakes	8.70	8.70	8.70	8.70
Salt	1.6	1.6	1.6	1.6
Tripolyphosphate	0.3	0.3	0.3	0.3
Sugar	0.3	0.3	0.3	0.3
Dry Spice Powder	1.8	1.8	1.8	1.8
Condiment mixture	4.0	4.0	4.0	4.0
Refined Wheat Flour	3.0	3.0	3.0	3.0
Egg Albumin	1.285	1.285	1.285	1.285
Sodium Nitrite	0.015	0.015	0.015	0.015
Watermelon Rind Powder	0	1.0	1.5	2.0

Analysis of physico-chemical and microbiological properties: The anti-oxidant effect of WRP on raw minced pork as well as cooked meatballs was analyzed by estimating the Thiobarbituric Acid Reacting Substances (TBRAS) values (Tarladgis et al., 1960) whereas the anti-microbial ability was determined by estimating Total Plate Count (TPC), Total Psychrotrophic Count (TPSC), Total Coliform Count (TCC) and Yeast and Mould Count (YMC) (APHA, 2001). These studies were carried on day 0, 3, 7, 14 and 21 of storage at refrigerated (4+1°C) tempera-ture. For all the microbiological analysis, readymade media from Hi-Media Laboratories ® Ltd., Mumbai, were used. For each sample four replicates were prepared and the counts were ex-pressed as colony forming units (cfu) per gram.

The physico-chemical parameters, texture profile analysis and sensory evaluation of the cooked meatballs were conducted on day zero only. Physico-chemical parameters of the cooked meatballs viz. percentage moisture, crude protein, fat and ash were determined by methods de-scribed by AOAC (2001). For determination of pH, 10 grams of the meatball sample was ho-mogenized with 50 ml distilled water (Troutt et al., 1992) using a mortar and pestle. The pH of the suspension was recorded using a digital pH meter (Systronics µ pH system 361). Standard equations were applied to determine the % moisture retention (El-Magoli et al., 1996), % fat re-tention, % cooking yield (Murphy et al., 1975) and % shrinkage (Adams, 1994) of the cooked meatball. The emulsion stability of the meatball mixture was determined by procedure estab-lished by Kondaiah et. al. (1985). Texture profile analysis was conducted using the procedure described by Bourne (1978) using a TA-HDi Texture Analyzer (Stable Micro Systems,UK). For sensory evaluation, a sensory panel of seven semi-trained panelists was set up. The meat balls were deep fried in rice bran oil at a temperature of 150-160˚C till the internal temperature of 65˚C is attained and served to the panelists. An 8 point hedonic scale was adopted, where 8 de-noted extremely desirable and 1 is unacceptable.

Statistical analysis: In total, 6 sets of experiments were conducted and each experiment had been replicated four times making n=24. All data obtained during this investigation were ana-lyzed statistically by using SPSS-24software package. For storage studies, data were analysed using two-way ANOVA with interaction taking treatment and storage time as main effects. For physics-chemical parametres and texture profile analysis one-way ANOVA was used. To com-pare means, Duncan's multiple range test (Duncan, 1955) was adopted. For analysis of data re-lated to different criteria of sensory evaluation The Kruskal-Wallis H test (Kruskal et al. 1952) was adopted. The values were presented as mean along with standard error (Mean ± SE) and significance level was identified at the 95% confidence level ($p<0.05$).

RESULTS AND DISCUSSION

Effect of WRP on the extent of lipid oxidation in both raw minced pork as well as cooked pork meat balls stored at refrigerated temperature of 4+1°C was studied and the obser-vations were presented in Table no. 2.

Effect of WRP on thiobarbituric acid reactive substances: With each passing day the TBA val-ue for both raw meat as well as cooked meatball increased significantly ($P<0.05$). When com-pared to control it was noted that addition of WRP resulted in significant decrease ($p<0.05$) in the rate of lipid oxidation. It is well established that meat products start exhibiting rancid fla-vour when MDA concentration rises above 0.6 mg/kg (Georgantelis et al., 2007) and after reach-ing a threshold limit value for rancidity of 2 mg/kg they are considered to be spoilt (Verma and Sahoo, 2000). In this study it was observed that for minced pork the control samples indicated initial TBA value of 0.607mg mda/kg and it reached a concentration of 2.649 mg on 21st day of storage but on treatment with 1.0%, 1.5% and 2.0% WRP the rate of MDA produced was re-duced by 6.23%, 16.19% and 22.23% respectively leading to a final value of 2.484, 2.22 and 2.06 mg mda/kg, respectively on the 21st day of storage . For cooked meatballs the initial TBA values for control, 1%WRP, 1.5% WRP and 2.0% WRP treated samples were 0.321, 0.317, 0.318 and 0.308 mg mda/kg respectively whereas it reached to a level of 0.706, 0.684, 0.655 and 0.608 mg mda/kg on 21st day of storage, indicating decreased the level of MDA produced by 3.12%, 7.22% and 13.88%, in 1%WRP, 1.5% WRP and 2.0% WRP treated samples, respec-tively. This anti-oxidant effect of WRP is largely due to presence of citrulline and phenols. Sim-ilar trend of reduction in TBA values due to natural antioxidants were demonstrated by Biswas et al. (2012) (curry leaf and mint leaf extract in ground pork), Tang et al. (2001) (tea catechins in cooked red meat, poultry and fish patties), Banerjee et al. (2014) (cauliflower powder in pork meat ball) and Thomas et al. (2016) (kordoi fruit juice in pork nuggets).

Table no. 3 indicates the effect of WRP on the microbial load in both raw minced pork as well as cooked pork meat balls stored at refrigerated temperature of 4+1°C. Values relating TPC, TPSC, TCC and YMC were recorded on 0,3,7,14 and 21 of storage. All values observed were statistically significant ($p<0.05$).

Effect of WRP on microbial quality of the pork meatballs: It was observed, for both raw minced pork as well as cooked pork meatballs, values of TPC, TPSC, TCC and YMC reduced significantly ($p<0.05$) with the increase in the WRP concentration. Spoilage defects in meat be-come evident when the microbial load at the surface reaches 7 log10 cfu/g (Jay, 1992). It was noted that for raw minced pork the TPC values for control samples at 7th day of storage was 7.147 log10 cfu/g whereas for samples treated with 1%WRP, 1.5% WRP and 2.0% WRP was 6.95, 6.393 and 5.754 log10 cfu/g, respectively. Addition of WRP to raw pork resulted in inhibi-tion of coliform and yeast and mould growth till the 3rd day of refrigeration. In case of cooked pork meatballs it was noted that the control meatballs had TPC, TPSC, TCC and YMC values of 6.841, 3.152, 1.85 and 1.851 log10 cfu/g respectively. Incorporation of 2.0% WRP to the meatball mixture resulted in reduction of TPC, TPSC, TCC and YMC values to 6.049, 2.75, 1.627 and 1.625 log10 cfu/g respectively. Moreover it was noted that addition of WRP to the meatball mixture resulted in inhibition of coliform till 14th day and yeast and mould growth till the 7th day of refrigeration. Significant work related to the antimicrobial effect of watermelon rind powder in the field of meat processing is scanty. Côté et al. (2011) have associated anti-microbial property of phyto-ingredients with high content of phenolic compounds and water-melon rinds have high phenolic content (Al-Sayed et al., 2013). Similar anti-microbial effect was observed by Xi et al., (2011) who added cranberry powder to cured pork and Hayrapetyan et al., (2012) who used pomegrate peel extract as a natural antimicrobial agent in chicken liver patties stored at 4 °C

Effect of WRP on Physico-chemical Parameters of the pork meatball: The effect of WRP in-corporation on various physico-chemical parameters of cooked pork meatballs are indicated in Table no 4. All the values are recorded on day zero i.e. on the day of production. For proximate parameters addition of WRP in increasing concentration resulted in significant decline ($p<0.05$) in the percentage of moisture, protein and fat but a reverse effect was observed in case of ash. The effect of 1.0% WRP and 1.5% WRP and of 1.5% WRP and 2.0% WRP on protein percent-age and that of control and 1.0% WRP on the ash percentage of the final product did not differ significantly ($p>0.05$). Such an outcome was observed due to the composition of the meatball mixture where the proportion of meat gradually reduced with rise in WRP concentration. The pH of watermelon rind powder was found to be 6.36 but addition of WRP resulted in gradual significant ($p<0.05$) fall in the pH of the final product from 6.696 to 6.571. No significant dif-ference ($p>0.05$) in pH values was observed for control and 1.0% WRP incorporated meatballs .WRP incorporation resulted in significant increase ($p<0.05$) in emulsion stability, shrinkage and % fat retention whereas decrease in % moisture retention and cooking yield. It was observed that 1.5% WRP incorporation had the highest% fat retention as well as emulsion stability. Effect on emulsion stability, shrinkage and % fat retention is mainly due to increase in fibre content of the final product, also WRP has high oil absorption capacity (OAC) (Al-Sayed et al., 2013). Lower pH and protein concentration of the meatball mixture results in poor % moisture retention in the final product, ultimately leading to a poorer cooking yield. Al-Sayed et al. (2013), Ho et al. (2016) and Naknaen et al. (2016) have worked with WRP and developed cakes, noodles and cookies respectively but their observations were not confirming with the above findings.The main reason for such an observation can be the difference in base material i.e. meat versus wheat flour as well as the level of incorporation, as well as the cooking method.

Effect of WRP on Textural Profile Analysis: Values displayed in Table 5 revealed effect of WRP on textural parameters of cooked meatball. Addition of WRP to meatball mixture had sig-nificant ($p<0.05$) effect on the end product. It was observed that the control meatballs had the highest hardiness, cohesiveness, gumminess and chewiness values whereas 2.0% WRP treated meatballs had the highest springiness values. It was also noted that with increase in the level of incorporation of WRP in the meatballs produced significantly ($p<0.05$) lower hardiness, cohe-siveness, gumminess and chewiness values and vice-versa for springiness values. It was also ob-served that addition of WRP at the rate of 1.0% and 1.5% to meatball mixture did not result in any significant difference ($p>0.05$) in springinesss values. Previously it was observed that incor-poration of WRP resulted in decrease of the pH values of meatball, lower pH resulted in higher protein denaturation thus reducing the strength of the protein gel matrix resulting in poorer har-diness, cohesiveness, gumminess and chewiness of

Table 2: Effect of addition of watermelon rind powder on the Thiobarbituric Acid Reacting Substances (TBRAS) values ofof raw minced pork and cooked pork meatballs stored at refrig-erated (4+1°C) temperature

			Raw Minced pork Storage Days		
Treatment	Day 0	Day 3	Day7	Day 14	Day 21
CR	0.607 + 0.022eA	1.00 + 0.019dA	1.544 + 0.026cA	2.146 + 0.02bA	2.649 + 0.023 aA
R1	0.59 + 0.024eB	0.952 + 0.021dB	1.468 + 0.031cB	1.983 + 0.038bB	2.484 + 0.023 aB
R2	0.585 + 0.035eC	0.93 + 0.02dC	1.409 + 0.025cC	1.939 + 0.031bC	2.22 + 0.026 aC
R3	0.575 + 0.035eD	0.902 + 0.016dD	1.33 + 0.034cD	1.891 + 0.055 bD	2.06 + 0.022 aD
			Cooked pork Meatballs		
CM	0.321 + 0.015eA	0.377 + 0.014dA	0.439 + 0.013cA	0.562 + 0.017bA	0.706 + 0.013 aA
M1	0.317 + 0.016eB	0.373 + 0.013dB	0.417 + 0.017cB	0.555 + 0.018bB	0.684 + 0.017 aB
M2	0.318 + 0.015eC	0.360 + 0.017dC	0.409 + 0.013cC	0.508 + 0.016 bC	0.655 + 0.014 aC
M3	0.308 + 0.015eD	0.339 + 0.016dD	0.39 + 0.014cD	0.483 + 0.015 bD	0.608 + 0.014 aD

CR- control raw minced pork, R1- 1.0% WRP treatment, R2- 1.5% WRP treatment, R3- 2.0% WRP treatment CM- control pork meatball, M1- 1.0% WRP treatment, M2- 1.5% WRP treatment, M3- 2.0% WRP treatment
Data (mean ± SE) with different lower case superscripts in the same row differ significantly ($p < 0.05$)
Data (mean ± SE) with different upper case superscripts in the same column differ significantly ($p < 0.05$) n=24
All values are expressed with the unit mg mda/kg

Table 3: Effect of addition of watermelon rind powder on the microbiological parameters of raw minced pork and cooked pork meatballs at refrigerated (4+1°C) temperature

			Total plate count of raw minced pork (log10 cfu/g)		
			Storage Days		
Treatment	0	3	7	14	21
	2.751 + 0.028eB	4.946 + 0.027dA	7.147 + 0.026cA	10.652 + 0.030bA	17.048 + 0.028aA
R1	2.75 + 0.024eB	4.749 + 0.025dB	6.95 + 0.027cB	10.249 + 0.025bB	16.748 + 0.025aB
R2	2.852 + 0.024eA	4.153 + 0.029dC	6.353 + 0.026cC	9.653 + 0.028bC	14.95 + 0.025aC
R3	2.852 + 0.026eA	3.751 + 0.026dD	5.754 + 0.028cD	9.051 + 0.030 bD	13.353 + 0.024aD
			Total plate count of cooked pork meatballs (log10 cfu/g)		
CM	4.243 + 0.027eB	4.547 + 0.026dA	4.95 + 0.029cA	5.644 + 0.03bA	6.841 + 0.03 aA
M1	4.345 + 0.026eA	4.442 + 0.028dA	4.849 + 0.027cB	5.447 + 0.03bB	6.642 + 0.028 aB
M2	4.347 + 0.027eA	4.25 + 0.026dB	4.743 + 0.027cC	5.147 + 0.028bC	6.348 + 0.029 aC
M3	4.246 + 0.029eB	4.048 + 0.027dC	4.447 + 0.029cD	4.845 + 0.030 bD	6.049 + 0.0274aD
			Total psychrotopic count of raw minced pork (log10 cfu/g)		
CR	4.647 + 0.025eA	6.244 + 0.031dA	7.344 + 0.026cA	8.648 +0.026bA	10.248 + 0.026aA
R1	4.147 + 0.025eB	6.05 + 0.026dA	7.146 + 0.024cB	8.34 + 0.031bA	9.953 + 0.024aA
R2	4.046 + 0.029eB	5.653 + 0.027dB	6.647 + 0.028cC	7.84 + 0.017bB	9.348 + 0.028aB
R3	3.942 + 0.026eB	5.05 + 0.025dC	6.149 + 0.027cD	7.451 + 0.02 bC	8.945 + 0.024aC

Total psychrotopic count of cooked pork meatballs (log10 cfu/g)					
CM	1.444+ 0.026eA	1.845 + 0.024dA	2.152 + 0.028cA	2.655 +0.027bA	3.152 + 0.025aA
M1	N.D.	1.544 + 0.027dB	1.949 + 0.028cB	2.547 + 0.027bB	3.053 + 0.026aA
M2	N.D.	1.35 + 0.027dC	1.745 + 0.028cC	2.345 + 0.028bc	2.85 + 0.026aB
M3	N.D.	1.05 + 0.026dD	1.647 + 0.026cC	2.244 +0.025bd	2.75 + 0.031aC
Total Coliform Count of Raw Minced pork (log10 cfu/g)					
CR	N.D.	1.251 + 0.026dA	1.55 + 0.027cA	1.946 +0.026bA	2.35 + 0.025aA
R1	N.D.	N.D.	1.475 + 0.011cB	1.875 + 0.011bB	2.175 + 0.011aB
R2	N.D.	N.D.	1.459 + 0.013cB	1.858 + 0.012bB	2.157 + 0.014aB
R3	N.D.	N.D.	1.425 + 0.011cC	1.825 + 0.011 bC	2.125 + 0.011aC
Total coliform count of cooked pork meatballs (log10 cfu/g)					
CM	N.D.	N.D.	N.D.	1.547 +0.025bA	1.85 + 0.028aA
M1	N.D.	N.D.	N.D.	N.D.	1.669 + 0.016aB
M2	N.D.	N.D.	N.D.	N.D.	1.65 + 0.019aB
	N.D.	N.D.	N.D.	N.D.	1.627 + 0.013aC
Yeast and mould count of raw minced pork (log10 cfu/g)					
	N.D.	1.149 + 0.025aA	1.65 + 0.029cA	1.945 + 0.025bA	2.152 + 0.024aA
	N.D.	N.D.	1.475 + 0.011cB	1.875 + 0.011bB	2.074 + 0.012aB
	N.D.	N.D.	1.458 + 0.014cC	1.859 + 0.012bB	2.06 + 0.012aB
	N.D.	N.D.	1.425 + 0.012cD	1.826 + 0.012bC	2.031 + 0.019aC
Yeast and mould count of cooked pork meatballs (log10 cfu/g)					
	N.D.	N.D.	1.15 + 0.03cA	1.653 + 0.028bA	1.851 + 0.026aA
M1	N.D.	N.D.	N.D.	1.471 + 0.015bB	1.671 + 0.015aB
M2	N.D.	N.D.	N.D.	1.453 + 0.012bC	1.655 + 0.013aB
M3	N.D.	N.D.	N.D.	1.426 + 0.012 bD	1.625 + 0.012aC

CR- control raw minced pork, R1- 1.0% WRP treatment, R2- 1.5% WRP treatment, R3- 2.0% WRP treatment
CM- control pork meatball, M1- 1.0% WRP treatment, M2- 1.5% WRP treatment, M3- 2.0% WRP treatment
Data (mean ± SE) with different lower case superscripts in the same row differ significantly ($p < 0.05$)
Data (mean ± SE) with different upper case superscripts in the same column differ significantly ($p < 0.05$)
ND- Not Detected. n=24, All values are expressed with the unit log10 cfu/g

the end product but higher % fat retention results in increased springiness. Varying phyto-ingredients have varying effect on the textural parameters of the end product. Similar trend was observed by Huda et. al. (2014) who incorpo-rated apple pomace to mutton. Addition of guava powder to mutton nuggest resulted in reduc-tion in hardiness, springiness, gumminess and chewiness whereas increased cohesiveness, as compared to control (Verma et al.,2013). Incorporation of starfruit juice in pork nuggets resulted in decrease in the values for hardiness, cohesiveness, gumminess, chewiness and springiness (Thomas et al.,2016) whereas addition of cauliflower powder to pork meatballs reduced hardi-ness , chewiness and cohesiveness values but springiness and gumminess values first increased and then decreased (Banerjee et al., 2014).

Table 4: Effect of addition of watermelon rind powder on the physico-chemical parameters of cooked pork meatballs (mean + S.E.)

Treatment	Moisture %	Protein%	Fat%	Ash%	pH	% Moisture Retention	% Fat Retention	% Cooking Yield	Shrinkage %	Emulsion Stability
CM	64.66+ 0.33a	16.4 + 0.09a	12.75+ 0.12a	2.485 + 0.036c	6.69+ 0.04 a	61.51+ 0.35a	63.51 + 0.18 d	94.88+ 0.37 a	3.61+ 0.19 d	92.27 + 0.55c
M1	63.44+ 0.31b	16.3 + 0.09 b	11.77 + 0.10b	2.519 + 0.074 c	6.68+ 0.03a	59.79+ 0.27 b	83.57 + 0.15 c	94.31+ 0.2 b	6.12+ 0.12 a	92.68 + 0.057 b
M2	62.81+ 0.28 c	16.24 + 0.09bc	11.45 + 0.13c	2.676 + 0.053b	6.62+ 0.04 b	58.42 + 0.61 c	89.21 + 0.21 a	93.06+ 0.76 c	5.64+ 0.18 b	92.92 + 0.12 a
M3	62.32+ 0.63 d	16.19 + 0.09 c	10.894 + 0.234d	2.846 + 0.074a	6.57+ 0.01 c	57.83+ 0.64 d	87.54 + 0.26 b	92.84+ 0.41 d	5.16+ 0.14 c	92.352 + 0.14c

CM- control pork meatball, M1- 1.0% WRP treatment, M2- 1.5% WRP treatment, M3- 2.0% WRP treatment

Data (mean ± SE) with different lower case superscripts in the same column differed significantly (p <0.05). n=24

Table 5: Effect of addition of watermelon rind powder on the texture profile analysis parame-ters of cooked pork meatballs (mean + S.E.)

Treatment	Hardiness (N/cm2)	Springiness (cm)	Cohesiveness	Gumminess (N/cm2)	Chewiness (N/cm)
CM	54.26+ 0.01a	0.63 + 0.03 c	0.29+ 0.01a	13.68+ 0.02a	10.82+ 0.02a
M1	43.39+ 0.02 b	0.64+ 0.02 b	0.25+ 0.01 b	12.44 + 0.03 b	9.76+ 0.02 c
M2	39.87+ 0.03 c	0.64+ 0.01 b	0.25+ 0.02 c	11.58 + 0.03 c	10.81+ 0.01 b
M3	38.81+ 0.04 d	0.66+ 0.02a	0.22+ 0.01 d	9.99+ 0.02 d	7.04+ 0.02 d

CM- control pork meatball, M1- 1.0% WRP treatment, M2- 1.5% WRP treatment, M3- 2.0% WRP treatment

Data (mean ± SE) with different lower case superscripts in the same column differ significantly (p <0.05) n=24

Table 6: Effect of addition of watermelon rind powder on the sensory quality of cooked pork meatballs.

Treatment	Colour	Outer Texture	Odour	Flavour	Tenderness	Juciness	Overall Accepatability
CM	6 + 0.57 b	6.5+ 0.74 a	6.37+ 0.66 a	6.08+ 0.77 a	6.15+ 0.54 a	5.5+ 0.51 a	5.5+ 0.77 a
M1	5.87+ 0.49 d	6.06+ 1.08 b	5.96+ 0.66 b	5.65+ 0.54 c	6.06 + 0.78 b	5.31+ 0.66b	5.04+ 0.55 d
M2	5.92+ 0.43 c	5.98+ 1.02 c	5.5+ 0.775 d	5.25+ 0.42d	5.69+ 0.96 c	4.96+ 0.66d	5.10+ 0.64 c
M3	6.23 + 0.53 a	5.98+ 0.9 d	5.75+ 0.77 c	5.96+ 0.67b	5.46+ 0.78 d	5.21+ 0.57c	5.17+ 0.8 b

CM- control pork meatball, M1- 1.0% WRP treatment, M2- 1.5% WRP treatment, M3- 2.0% WRP treatment

Data (mean ± SE) with different lower case superscripts in the same row differ significantly (p <0.05). n=24

Sensory evaluation of pork meatballs: Sensory evaluation was practiced on day zero of product manufacture and the results are represented in Table 6. Addition of WRP had a significant effect(p<0.05) on sensory parameters but no particular trend was observed. It was observed that treatment with 2.0% WRP resulted in the most impressive colour whereas rest of the parameters i.e. outer texture, odour,flavour, tenderness, juiciness and overall acceptability the control meat-balls revealed the best results. Same was observed by Ho et al., (2016) have produced noodles by replacing the wheat flour by watermelon rind powder.

CONCLUSIONS

WRP incorporation to raw pork and cooked pork meatballs at concentrations of 1.0%, 1.5% and 2.0% have proved to improve the storage life by retarding the rate of lipid oxidation and microbial spoilage when stored at refrigerated temperature of 4+1°C. Thus establishing WRP as effec-tive anti-oxidant agent for both raw pork as well as cooked pork meatballs. The incorporation of WRP to the meatball mixture improved the physico-chemical characteristic as well as the textur-al properties of the final product but still sensorial evaluation indicated a score between fair and good and for most of the parameters the control product had better results even for the overall acceptability of the consumers. In nutshell it maybe concluded that watermelon rind powder can be successfully be utilized as additives to meatball mixtures to yield products having extended shelf-life, better cooking yield and enhanced functional properties.

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