RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume 40 Issue 2: 206-212 (June 2021)

Studies on the Impact of Partial Replacement of Sodium Chloride with Potassium Lactate on Quality Attributes of Buffalo Calf Meat Rolls

Surender Kumar, Sanjay Yadav, Ankita Pal, Vaquil

10.18805/ajdfr.DR-1630

ABSTRACT

Background: Because of low utility, feeding of male buffalo calves is ignored in India leading to high mortality and poor growth in surviving calves. However, the meat of buffalo calves has considerable collagen solubility and serves as a remarkable source for meat products. As the addition of potassium chloride in meat products is restricted owing to its bitter taste and metallic flavor, potassium lactate can serve as a potential source for sodium chloride and it also alleviates the function of sodium chloride in meat processing.

Methods: Low salt buffalo calf meat rolls were prepared by partially substituting sodium chloride with potassium lactate at 10%, 20%, 30%, 40% and 50% levels maintaining equivalent ionic strength. Sensory quality, physico-chemical attributes, proximate composition, instrumental texture, firmness, toughness and color were evaluated.

Result: Substitution up to 30% level did not cause any significant alteration in sensory quality but further enhancement in potassium lactate level resulted in a significant decrease in flavor, texture, juiciness, tenderness and overall acceptability. The replacement did not cause any significant decline in proximate composition, water holding capacity and emulsion stability of developed meat rolls. An increase in pH and decrease in cooking yield was noticed with an increase in the level of potassium lactate but a significant impact was noticed only at 50% substitution. Texture profile and instrumental color of potassium lactate treated rolls were comparable with control samples. Firmness and toughness decreased with enhancing the level of potassium lactate but the significant impact was recorded only at 50% level.

Key words: Buffalo calf, Low salt, Meat rolls, Potassium lactate, Quality attributes.

INTRODUCTION

The total livestock population of India is 535.78 million heads including 109.85 million buffaloes (20.45%) with the first rank in the world buffalo population (BAHFS, 2019). Buffalo is looking as a rescuer animal to meet man's increased requirements for food in the coming periods. In India, buffalo meat is mostly obtained from the slaughter of spent dairy buffaloes at the end of their productive life. The meat received from such used-up animals is dark, rough and tough in texture and exhibits inferior sensorial and processing characteristics (Kandeepan *et al.*, 2009; Naveena *et al.*, 2011). It is estimated that about 10 million male buffalo calves are born annually in India but owing to low utility; their feeding is ignored leading to high mortality and poor growth in surviving calves (FAO, 2014). However, these issues can be sorted out by utilizing the meat of young male buffalo calf which can serve as a low-cost alternative. The meat of such calves has remarkable collagen solubility (Kandeepan *et al.*, 2009) since the collagen cross-links get stabilized and the collagen becomes much less soluble with increased age (Maltin *et al.,* 1998).

Sodium chloride plays a vital role in meat processing owing to its preservative characteristics, ability to improve taste, flavor and solubilization of functional myofibrillar proteins (Choi *et al.,* 2014) and solubilized proteins facilitate water holding capacity, emulsification and retention of fat in the meat blend and stabilizes gel during cooking (Totosaus and Perez-Chabela, 2009) resulting in enhanced cooking yield and juiciness (Desmond, 2006). But excessive intake of sodium is a risk element for the development of cardiovascular diseases (Ozvural and Vural, 2008; He and MacGregor, 2010) which have surged dramatically in recent times and are presently the leading causes of mortality in industrialized countries (WHO/FAO, 2003; Food Standards Agency, 2009). It has viable consequences on colorectal cancer (Demeyer *et al*., 2008), stomach cancer and osteoporosis (Gilbert and Heiser, 2005).

Since the incorporation of potassium chloride in meat products is limited because of its bitter taste and metallic

Department of Livestock Products Technology, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar-125 004, Haryana, India.

Corresponding Author: Surender Kumar, Department of Livestock Products Technology, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar-125 004, Haryana, India. Email: hoodas246@gmail.com

How to cite this article: Kumar, S., Yadav, S., Pal, A. and Vaquil (2021). Studies on the Impact of Partial Replacement of Sodium Chloride with Potassium Lactate on Quality Attributes of Buffalo Calf Meat Rolls. Asian Journal of Dairy and Food Research. 40(2): 206-212. DOI: 10.18805/ajdfr.DR-1630.

Submitted: 22-01-2021 **Accepted:** 25-03-2021 **Online:** 15-04-2021

flavor, potassium lactate can be a potential alternative for sodium chloride and the inclusion of potassium lactate potentiates the function of sodium chloride, enhancing perceived saltiness, Z line solubilization and mitochondria swelling (Astruc *et al.,* 2008) and thus improves the palatability of the developed products (Pipek *et al.,* 2005). Potassium lactate provides an additional benefit as potassium being a counter ion to sodium and diminishes the injurious outcome of sodium on blood pressure (Wettasinghe and Shahidi, 1997; Puolanne *et al*., 1988). Moreover, dietary intake of potassium is associated with decreased risk of hypertension and cardiovascular diseases, opposite role to sodium (Geleijnse *et al.,* 2007; Aburto *et al*., 2013; Binia *et al*., 2015). So, keeping all these facts in view, an attempt was made to develop low salt buffalo calf meat rolls by partially replacing sodium chloride with potassium lactate.

MATERIALS AND METHODS

Procurement and processing of raw materials

Healthy male buffalo calves (about 10 months of age) maintained under similar feeding and managemental conditions were purchased from the local market and slaughtered and dressed according to standard procedure. The dressed carcasses were washed thoroughly and deboned manually following trimming off visible fat and connective tissue. Deboned meat was packed in colorless low-density polyethylene bags at -18±2°C. The frozen meat was taken out and thawed overnight at 4±2°C and utilized for the preparation of meat rolls.

Sodium chloride, STPP, sodium nitrite, citric acid, sugar (powder form), groundnut oil, bread crumbs powder, spice mix and eggs were purchased from the local market. Water was used in chilled form. Potassium lactate was procured from reputed firms. The condiment mix was prepared by mixing onion and garlic paste (ratio 2:1) and packed in low-density polyethylene bags and stored at -18±2°C till further use.

Preparation of buffalo calf meat rolls

For preparation of control meat rolls, sodium chloride (2%), sodium tripolyphosphate (0.5%), sodium nitrite (150 ppm), spice mix (2%), condiments paste (3%), chilled water (10%), groundnut oil (7%), bread crumbs powder (4%), whole egg liquid (8%), sugar (1%) and citric acid (0.05%) were blended with double minced meat. The stable emulsion was developed in a meat chopper. The emulsion was stuffed manually in autoclavable beakers and distributed uniformly. The beakers were covered with aluminium foil and steam-cooked in a closed container for 35 minutes. Then rolls were taken out and cooled to room temperature, packaged in polyethylene bags and stored at 4±2°C for quality evaluation.

For the development of low salt meat rolls, sodium chloride was partially replaced with potassium lactate maintaining equivalent ionic strength (IS) to that of 2% sodium chloride (0.342). Substitution of 10%, 20%, 30%, 40% and 50% of sodium chloride was done with salt replacer. All other ingredients were kept unaltered.

Ionic strength evaluation

Ionic strength was calculated as follows:

$$y = \frac{1}{2} \sum MZ^2$$

Where,

y = ionic strength, M= molality, Z= charge on the ion.

Sensory quality analysis

A semi-trained panel comprising of faculty members and research fellows analyzed the meat rolls for the sensory quality in terms of color and appearance, flavor, texture, juiciness, tenderness and overall acceptability using 8 points descriptive scale (Keeton, 1983), where a score of 8 indicated excellently and 1 represented extremely poor (Table 1). The warmed test samples were presented to the panelists after allocating suitable codes. Water was provided for rinsing the mouth between different samples.

Physico-chemical attributes and proximate composition

The pH of meat emulsions and cooked meat rolls was measured as per the method of Trout *et al*. (1992). Emulsion stability of control, as well as potassium lactate treated meat emulsions, was recorded following procedure of Baliga and Madaiah (1970). Water holding capacity was estimated as per the procedure of Wardlaw *et al*. (1973) with little modifications. The cooking yield was recorded by recording the weight of the cooked meat rolls and the initial raw weight of emulsion and indicated in percentage. Proximate composition was estimated as per standard methods of AOAC (2005).

Texture profile analysis (TPA)

The textural profile (hardness, springiness, cohesiveness, gumminess and chewiness) of meat rolls was recorded by Texture Analyser (TA.HD plus), Stable Micro Systems Ltd., Surrey, England with the Texture Exponent Program. A compression platform of 70 mm diameter was used as a probe. The evaluation of TPA was executed following the mechanism outlined by Bourne (1978). Test samples (2 cm^3 size) were compressed to 50% of their original height. A time of 5 seconds was allowed between the two compression cycles. Force time deformation curves were recorded with a 50 kg load cell used at a cross-head speed of 2 mm/s.

Firmness and toughness

The force needed to shear a 1 cm^3 size sample of meat rolls transversely was recorded using the Warner-Bratzler shear probe of texture analyzer and indicated as firmness (kg/cm^3) and toughness (kg-sec).

Instrumental color

The instrumental color of meat rolls was analyzed employing a Konica Minolta chromameter CR-400 (Konica Minolta Sensing, Inc., Japan) with an 8 mm aperture after calibrating

with a white standard plate. Color values were indicated as CIE Lab, L* (lightness), a* (redness) and b* (yellowness).

Statistical analysis

The data obtained from twelve replicates (six replicates in case of *physico-chemical attributes and proximate composition*) were subjected to analysis of variance. One way analysis of variance (treatment being independent variable) was carried out. Duncan's multiple range test was followed to find out a significant difference in means. The critical difference was determined at a 5% level of significance (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Sensory quality

The color and appearance scores of control and potassium lactate substituted meat rolls were comparable (Table 1). Flavor scores did not differ significantly between control and 30% potassium lactate treated rolls but further increase in substitution at 40% and 50% levels imparted significantly lower flavor scores. The mean texture, juiciness and tenderness scores of rolls substituting NaCl with potassium lactate up to 30% were comparable with control. Further replacement of NaCl with potassium lactate resulted in a decline in scores for these sensory attributes. A similar trend was observed in OAA (overall acceptability) scores also. Rolls replacing 30% NaCl with potassium lactate were statistically at par with control indicating the product to be very acceptable to extremely acceptable by the panelists. Further increase in potassium lactate level resulted in a decrease in OAA scores. Rolls replacing NaCl with potassium lactate at 40% and 50 % levels had OAA scores between 6.0 and 7.0 indicating moderate to very good acceptability. Gou *et al*. (1996) observed no significant variation in the textural and flavor scores of fermented sausages up to 40% NaCl substitution with potassium lactate, although a slight potassium lactate flavor was noticed at 30% replacement. Gelabert *et al*. (2003) noticed flavor and texture defects in fermented sausage when NaCl was replaced at more than 40% level with mixtures of KCl and glycine or potassium lactate and glycine. Uncontrolled addition of potassium lactate could impart an unusual taste (Gimeno *et al.,* 2001).

Physico-chemical attributes

There was a gradual increase in pH of both emulsions and meat rolls with an increasing level of potassium lactate (Table 2). However, a significant difference was noticed in 50% potassium lactate treated rolls. The results were per the findings of Choi *et al*. (2014) who observed the lowest pH value for control samples and highest for the treatment having a combination of 10% potassium lactate and 30% calcium ascorbate. The pH of control and treated rolls increased on cooking in comparison to their raw counterparts. This increase was due to the increase in salt level owing to deprivation of moisture and alteration in net charge due to denaturation of proteins on cooking (Babu *et al*., 1994). Nath *et al*. (1996) noticed a 0.3 to 0.4 units increase in pH after cooking chicken meat patties.

Replacement of NaCl with potassium lactate (by maintaining equivalent ionic strength) did not result in any significant difference in the water holding capacity (WHC) in comparison to control. However, there was a slight

Table 1: Effect of partial replacement of sodium chloride with potassium lactate on sensory scores of buffalo calf meat rolls (Mean±SD). (n=12)

Treatments	Colour and appearance	Flavour	Texture	Juiciness	Tenderness	OAA
Control NaCl (100%)	7.88^{a}±0.31	7.88^{a}±0.31	7.83^{a}±0.39	7.83^{a}±0.39	7.83^{a}±0.33	7.83^{a}±0.39
NaCl+K-lactate (90%+10%)	7.83^{a}±0.33	7.88^{a}±0.31	7.79^{a}±0.40	7.83^{a}±0.39	7.79^{a}±0.40	7.79^{a}±0.33
NaCl+K-lactate (80%+20%)	7.83^{a}±0.39	7.75^{a}±0.40	7.75^{a}±0.40	7.79^{a}±0.40	7.75^{a}±0.40	7.75^{a}±0.40
NaCl+K-lactate (70%+30%)	7.79^{a}±0.40	7.50^{a}±0.48	7.54^{ab}±0.50	7.54^{ab}±0.50	7.63^{ab}±0.48	7.58^{a}±0.47
NaCl+K-lactate (60%+40%)	7.79^{a}±0.40	6.79^{b}±0.40	7.13^{bc}±0.31	7.17^{bc}±0.39	7.21^{bc}±0.50	6.92^{b}±0.47
NaCl+K-lactate (50%+50%)	7.75^{a}±0.45	6.08^{c}±0.51	6.92^{c}±0.36	6.88^{c}±0.43	7.00^{c}±0.43	6.21^{c}±0.40

Means with different superscripts in a column differ significantly (P≤0.05).

Table 2: Effect of partial replacement of sodium chloride with potassium lactate on physico-chemical attributes of buffalo calf meat rolls (Mean±SD). (n=6)

Treatments	pH (Raw emulsion)	pH (Cooked)	Water holding capacity (%)	Emulsion stability (%)	Cooking yield (%)
Control NaCl (100%)	5.98^{b}±0.05	6.11^{b}±0.06	42.78^{a}±2.33	79.90^{a}±0.87	85.07^{a}±1.34
NaCl+K-lactate (90%+10%)	6.02^{b}±0.04	6.14^{b}±0.06	42.15^{a}±2.95	79.83^{a}±0.79	84.99^{a}±1.40
NaCl+K-lactate (80%+20%)	6.02^{b}±0.03	6.15^{b}±0.04	42.06^{a}±2.50	79.70^{a}±0.82	84.87^{a}±1.43
NaCl+K-lactate (70%+30%)	6.04^{ab}±0.03	6.17^{ab}±0.02	41.45^{a}±2.44	79.60^{a}±0.89	84.39^{ab}±1.25
NaCl+K-lactate (60%+40%)	6.06^{ab}±0.04	6.19^{ab}±0.05	40.22^{a}±2.52	79.21^{a}±0.97	83.55^{ab}±1.09
NaCl+K-lactate (50%+50%)	6.10^{a}±0.03	6.23^{a}±0.02	39.69^{a}±2.47	78.62^{a}±1.08	82.46^{b}±1.44

Means with different superscripts in a column differ significantly (P≤0.05).

decrease in WHC with an increasing level of substitution. The results were in conformance with the findings of Choi *et al*. (2014) who reported no significant difference in WHC on NaCl substitution with a combination of potassium lactate and calcium ascorbate when equivalent ionic strength was maintained among the treatments as in the control samples due to similar protein solubilizing ability. Gimeno *et al*. (1998) also revealed that there was no significant change in WHC after substitution of NaCl with a mixture of NaCl, KCl, $MgCl_2$ and $CaCl_2$ at equivalent ionic strength to that of control. No significant variation was observed in emulsion stability of rolls when NaCl was substituted with potassium lactate although a decreasing trend was observed. Alves *et al*. (2017) also observed no significant differences in percent water and fat release among the treatments when NaCl was replaced by KCl in low-fat bologna-type sausages.

The cooking yield of control and samples substituting NaCl with potassium lactate up to 40% was statistically similar to control. However, substitution above that level resulted in a significant decline in cooking yield in comparison to control. This might be due to a marginal decrease in WHC and emulsion stability which resulted in significant decrease in cooking yield at the highest level of substitution. Choi *et al*. (2014) indicated no a significant impact on cooking loss or moisture content of the low sodium frankfurter sausages when 40% NaCl was replaced by KCl or a combination of potassium lactate and calcium ascorbate. Pietrasik and Gaudette (2015) concluded that ionic strength and not the type of ions played a vital role in preserving protein extraction ability and moisture retention potential. Reduction of sodium chloride up to 25% level did not affect the yield and purge loss of frankfurters during storage (Tobin *et al*., 2013).

Proximate composition

Replacement of NaCl with potassium lactate did not result in any distinguished variation in the moisture content of buffalo calf meat rolls (Table 3). Similarly, the protein, fat and ash content were also comparable with the control sample. This might be due to similar composition of emulsion and no effect of substitution of NaCl potassium lactate on proximate composition.

The findings of proximate composition were per Alves *et al*. (2017) who depicted that replacement of NaCl with KCl along with the incorporation of lysine and liquid smoke did not significantly alter moisture, protein, ether extract and an ash content of low-fat bologna type sausages. Horita *et al*. (2011) formulated low-fat bologna sausages by partially replacing NaCl with other chloride salts and did not observe any difference in proximate composition.

Texture profile analysis (TPA)

Texture profile analysis of low salt buffalo calf meat rolls showed that hardness of the products did not vary significantly on replacement of NaCl with potassium lactate from 10% to 50% level although a non-significant decline was observed with an increase in the level of salt replacer (Table 4). No significant difference was displayed in springiness, cohesiveness, gumminess and chewiness between control and treated rolls.

The findings were in agreement with those reported by Choi *et al*. (2014) who reported that frankfurter sausages containing NaCl up to 60% of control had similar hardness, springiness, cohesiveness and chewiness values as the control sample. The springiness of bologna-type sausages did not show significant changes between the control and

Table 3: Effect of partial replacement of sodium chloride with potassium lactate on proximate composition of buffalo calf meat rolls (Mean±SD). (n=6)

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Control NaCl (100%)	64.27^{a}±0.51	19.42^{a}±0.70	7.72^{a}±0.48	2.95^{a}±0.32
NaCl+K-lactate (90%+10%)	64.56^{a}±0.94	19.12^{a}±0.59	7.46^{a}±0.84	3.01^{a}±0.26
NaCl+K-lactate (80%+20%)	64.23^{a}±1.06	19.51^{a}±0.72	7.36^{a}±0.72	2.92^{a}±0.21
NaCl+K-lactate (70%+30%)	63.91^{a}±0.84	19.62^{a}±0.62	7.52^{a}±0.58	2.88^{a}±0.34
NaCl+K-lactate (60%+40%)	64.28^{a}±0.74	19.25^{a}±0.67	7.75^{a}±0.59	2.98^{a}±0.24
NaCl+K-lactate (50%+50%)	64.18^{a}±0.60	19.34^{a}±0.54	7.71^{a}±0.61	3.04^{a}±0.27

Means with different superscripts in a column differ significantly (P≤0.05).

Table 4: Effect of partial replacement of sodium chloride with potassium lactate on texture profile of buffalo calf meat rolls (Mean±SD). (n=6)

Treatments	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N)
Control NaCl (100%)	43.63^{a}±4.46	0.85^{a}±0.02	0.62^{a}±0.08	26.59^{a}±2.16	22.56^{a}±1.97
NaCl+K-lactate (90%+10%)	43.35^{a}±4.15	0.83^{a}±0.04	0.61^{a}±0.03	26.38^{a}±3.72	21.91^{a}±3.40
NaCl+K-lactate (80%+20%)	42.21^{a}±2.58	0.84^{a}±0.03	0.64^{a}±0.04	27.09^{a}±3.32	22.71^{a}±3.34
NaCl+K-lactate (70%+30%)	41.32^{a}±3.54	0.82^{a}±0.03	0.69^{a}±0.05	28.43^{a}±3.14	23.15^{a}±1.91
NaCl+K-lactate (60%+40%)	40.18^{a}±2.58	0.83^{a}±0.05	0.62^{a}±0.07	24.68^{a}±2.33	20.43^{a}±2.10
NaCl+K-lactate (50%+50%)	38.08^{a}±3.11	0.84^{a}±0.03	0.66^{a}±0.05	25.18^{a}±1.56	21.10^{a}±1.33

Means with different superscripts in a column differ significantly (P≤0.05).

Table 5: Effect of partial replacement of sodium chloride with potassium lactate on firmness (Kg/cm^3) and toughness (Kg-sec) of buffalo calf meat rolls (Mean±SD). (n=6)

Treatments	Firmness (Kg/cm^3)	Toughness (Kg-sec)
Control NaCl (100%)	0.94^{a}±0.03	10.42^{a}±0.33
NaCl+K-lactate (90%+10%)	0.93^{a}±0.04	10.40^{a}±0.29
NaCl+K-lactate (80%+20%)	0.93^{a}±0.07	10.19^{ab}±0.23
NaCl+K-lactate (70%+30%)	0.91^{a}±0.06	10.06^{ab}±0.39
NaCl+K-lactate (60%+40%)	0.88^{ab}±0.11	9.95^{ab}±0.22
NaCl+K-lactate (50%+50%)	0.80^{b}±0.04	9.85^{b}±0.35

Means with different superscripts in a column differ significantly (P≤0.05).

Table 6: Effect of partial replacement of sodium chloride with potassium lactate on instrumental colour values of buffalo calf meat rolls (Mean±SD). (n=12)

Treatment	L* (lightness)	a* (redness)	b* (yellowness)
Control NaCl (100%)	62.40^{a}±0.88	9.14^{a}±0.39	16.54^{a}±0.48
NaCl+K-lactate (90%+10%)	61.95^{a}±0.91	9.29^{a}±0.51	16.38^{a}±0.41
NaCl+K-lactate (80%+20%)	61.60^{a}±0.81	9.56^{a}±0.44	16.49^{a}±0.38
NaCl+K-lactate (70%+30%)	62.23^{a}±0.98	9.36^{a}±0.41	16.27^{a}±0.51
NaCl+K-lactate (60%+40%)	61.90^{a}±0.85	9.53^{a}±0.46	16.62^{a}±0.43
NaCl+K-lactate (50%+50%)	62.18^{a}±0.93	9.42^{a}±0.42	16.33^{a}±0.45

Means with different superscripts in a column differ significantly (P≤0.05).

salt substituted sample (Yang *et al*., 2007). The texture of the product relies on the structure and integrity of the protein matrix developed during cooking and lowering or substituting NaCl content with other salts in the sausages resulted in softer texture as compared to control (Pietrasik and Gaudette, 2015).

Firmness and toughness

A gradual decreasing trend was observed in firmness and toughness values of meat rolls with the increase in substitution of NaCl with salt substitute (Table 5). However, a significant decrease was noticed in rolls substituting NaCl with potassium lactate at a 50% level. Hand *et al*. (1982) reported that substitution of NaCl with 100% KCl or $MgCl_2$ significantly decreased the firmness of turkey frankfurters but 35% substitution did not affect firmness significantly.

Instrumental color

The L* (lightness) values did not change significantly with the substitution of sodium chloride with potassium lactate (Table 6). Similarly, no significant difference was noticed in a* (redness) and b* (yellowness) values between control and potassium lactate treated rolls.

The results revealed that the substitution of NaCl with potassium lactate did not impart any negative influence on instrumental color values of buffalo calf meat rolls. The results were in conformance with the findings of Gou *et al*. (1996) who did not observe any significant change in color values by the substitution of NaCl with potassium lactate in meat products. Horita *et al*. (2011) observed no significant difference in instrumental color values of emulsified mortadella sausages when 50% of NaCl was substituted with KCl. The 50% substitution of NaCl with KCl did not alter significantly readings of L*, a* and b* values of bologna-type sausages (Alves *et al*., 2017).

CONCLUSION

The study stated that the replacement of sodium chloride with potassium lactate up to 30% did not cause any significant alteration in sensory quality but further enhancement in potassium lactate level resulted in a significant decrease in sensory scores of buffalo calf meat rolls. The partial salt substitution did not result in any significant difference in proximate composition, water holding capacity, emulsion stability, instrumental texture profile and color. However, an increase in pH and decrease in cooking yield, firmness and toughness values were noticed with elevation in the level of potassium lactate with a significant impact at 50% substitution. It was concluded that buffalo calf meat rolls replacing 30% sodium chloride with potassium lactate (maintaining equivalent ionic strength) were comparable with control in terms of sensory quality, physico-chemical properties, proximate composition and instrumental characteristics.

ACKNOWLEDGEMENT

The authors are thankful to the Head of Department, Department of Livestock Products Technology, College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar for providing necessary facilities.

REFERENCES

Aburto, N.J., Ziolkovska, A., Hooper, L., Elliott, P., Cappuccio, F.P. and Meerpohl, J.J. (2013). Effect of lower sodium intake on health: Systematic review and meta analyses. British Medical Journal. 346: 1326. http://dx.doi.org/10.1136/bmj.f1326.

Alves, L.A.A.D.S., Lorenzo, J.M., Goncalves, C.A.A., Santos, B.A.D., Heck, R.T., Cichoski, A.J. and Campagnol, P.C.B. (2017). Impact of lysine and liquid smoke as flavor enhancers on the quality of low-fat Bologna-type sausages with 50% replacement of NaCl by KCl. Meat Science. 123: 50-56.

AOAC. (2005). Official Methods of Analysis, 16th edition, Association of Official Analytical Chemists, Washington, DC.

Astruc, T., Labas, R., Vendeuvre, J.L., Martin, J.L. and Taylor, R.G. (2008). Beef sausage structure affected by sodium chloride and potassium lactate. Meat Science. 80: 1092-1099.

Babu, N.P., Kowale, B.N., Rao, V.K. and Bisht, G.S. (1994). Effect of cooking and storage on lipid oxidation and development of cholesterol oxides in chicken meat. Indian Journal of Poultry Science. 29: 254-262.

BAHFS. (2019). Basic Animal Husbandry and Fisheries Statistics. http://dahd.nic.in/dahd/statistics/animalhusbandry-statistics division.aspx.

Baliga, B.R. and Madaiah, N. (1970). Quality of sausage emulsion prepared from mutton. Journal of Food Science. 35(4): 383-385.

Binia, A., Jaeger, J.H.Y., Singh, A. and Zimmermann, D. (2015). Daily potassium intake and sodium to potassium ratio in the reduction of blood pressure: meta-analysis of randomized controlled trials. Journal of Hypertension. 33: 1509-1520.

Bourne, M.C. (1978). Texture profile analysis. Food Technology. 33: 62-62, 72.

Choi, Y.M., Jung, K.C., Jo, H.M., Nam, K.W., Choe, J.H., Rhee, M.S. and Kim, B.C. (2014). Combined effects of potassium lactate and calcium ascorbate as sodium chloride substitutes on the physicochemical and sensory characteristics of lowsodium frankfurter sausage. Meat Science. 96(1): 21-25.

Demeyer, D., Honikel, K. and De Smet, S. (2008). The World Cancer Research Fund Report 2007: A challenge for the meat processing industry. Meat Science. 80: 953-959.

Desmond, E. (2006). Reducing salt: A challenge for the meat industry. Meat Science. 74(1): 188-196.

FAO. (2014). Indian meat industry perspective. Food and Agriculture Organization. http://www.fao.org.

Food Standards Agency. (2009). Salt Reduction Targets. (Press release, May 18, 2009).

Gelabert, J., Gou, P., Guerrero, L. and Arnau, J. (2003). Effect of sodium chloride replacement on some characteristics of fermented sausages. Meat Science. 65(2): 833-839.

Geleijnse, J.M., Witteman, J.C.M., Stijnen, T., Kloos, M.W., Hofman, A. and Grobbee, D.E. (2007). Sodium and potassium intake and risk of cardiovascular events and all cause mortality: The Rotterdam Study. European Journal of Epidemiology. 22(11): 763-770.

Gilbert, P.A. and Heiser, G. (2005). Salt and health: the CASH and BPR perspective. British Foundation Nutrition Bulletin. 30: 62-69.

Gimeno, O., Astiasaran, I. and Bello, J. (2001). Calcium ascorbate as a potential partial substitute for NaCl in dry fermented sausages: effect on colour, texture and hygienic quality at different concentrations. Meat Science. 57: 23-29.

Gimeno, O., Astiasaran, I. and Bello, J. (1998). A mixture of potassium, magnesium and calcium chlorides as a partial replacement of sodium chloride in dry fermented sausages. Journal of Agricultural and Food Chemistry. 46(10): 4372-4375.

Gou, P., Guerrero, L., Gelabert, J. and Arnau, J. (1996). Potassium chloride, potassium lactate and glycine as sodium chloride substitutes in fermented sausages and in dry cured pork loin. Meat Science. 42: 37-48.

Hand, L.W., Terrell, R.N. and Smith, G.C. (1982). Effect of complete or partial replacement of sodium chloride on processing and sensory properties of hams. Journal of Food Science. 47: 1776-1778, 1782.

He, F.J. and MacGregor, G.A. (2010). Reducing population salt intake worldwide: From evidence to implementation. Progress in Cardiovascular Diseases. 52(5): 363-382. http://doi.org/10.1016/j.pcad.2009.12.006.

Horita, C.N., Morgano, M.A., Celeghini, R.M.S. and Pollonio, M.A.R. (2011). Physico-chemical and sensory properties of reduced-fat mortadella prepared with blends of calcium, magnesium and potassium chloride as partial substitutes for sodium chloride. Meat Science. 89(4): 426-433. http://doi.org/10.1016/j.meatsci.2011.05.010.

Kandeepan, G., Anjaneyulu, A.S.R., Kondaiah, N., Mendiratta, S.K. and Lakshmanan, V. (2009). Effect of age and gender on the processing characteristics of buffalo meat. Meat Science. 83(1): 10-14.

Keeton, J.T. (1983). Effect of fat, NaCl and phosphate levels on the chemical and sensory properties of pork patties. Journal of Food Science. 48: 878-881.

Maltin, C.A., Sinclair, K.D., Warriss, P.D., Grant, C.M., Porter, A.D. and Delday, M.I. (1998). The effects of age at slaughter, genotype and finishing system on the biochemical properties, muscle fibre type characteristics and eating quality of bull beef from suckled calves. Animal Science Journal. 66(2): 341-348.

Nath, R.L., Mahapatra, C.M., Kondiah, N. and Singh, J.N. (1996). Quality of chicken meat patties as influenced by microwave and conventional oven cooking. Journal of Food Science and Technology. 33(2): 162-164.

Naveena, B.M., Sen, A.R., Muthukumar, M., Babji, Y. and Kondaiah, N. (2011). Effects of salt and ammonium hydroxide on the quality of ground buffalo meat. Meat Science. 87: 315-320.

Ozvural, E.B. and Vural, H. (2008). Utilization of interesterified oil blends in the production of frankfurters. Meat Science. 78(3): 211-216 http://doi.org/10.1016/j.meatsci.2007.06.012.

Pietrasik, Z. and Gaudette, N.J. (2015). The effect of salt replacers and flavor enhancer on the processing characteristics and consumer acceptance of Turkey sausages. Journal of the Science of Food and Agriculture. 95(9): 1845-1851 http://doi.org/10.1002/jsfa. 6885.

Pipek, P., Sikulova, M., Jelenikova, J. and Izumimoto, M. (2005). Colour changes after carcasses decontamination by steam and lactic acid. Meat Science. 69: 673-680.

Puolanne, E., Saarela, E. and Ruusunen, M. (1988). The effect of NaCl- KCl-$MgSO_4$-mixture (Pan) on the quality of cooked sausage. In: Proceedings of the 34th international Congress of Meat Science and Technology. Part B, Brisbane, Australia. (pp. 302-304).

Snedecor, G.W. and Cochran, W.G. (1980). Statistical Methods. Oxford and IBH Publishing Co, Calcutta.

Tobin, B.D., O'Sullivan, M.G., Hamill, R.M. and Kerry, J.P. (2013). The impact of salt and fat level variation on the physiochemical properties and sensory quality of pork breakfast sausages. Meat Science. 93(2): 145-152. http://doi.org/10.1016/ j.meatsci.2012. 08.008.

Totosaus, A. and Perez-Chabela, M.L. (2009). Textural properties and microstructure of low-fat and sodium-reduced meat batters formulated with gellan gum and dicationic salts. Journal of Food Science and Technology. 42: 563-569.

Trout, E.S., Hunt, M.C., Johson, D.E., Clans, J.R., Castner, C.L. and Kroff, D.H. (1992). Characteristics of low-fat ground beef containing texture modifying ingredients. Journal of Food Science. 57: 19-24.

Wardlaw, F.R., McCaskill, L.H. and Acton, J.C. (1973). Effects of postmortem changes on poultry meat loaf properties. Journal of Food Science. 38: 421-423.

Wettasinghe, M. and Shahidi, F. (1997). Oxidative stability, cooking yield and texture of pork treated with a low-sodium salt. Journal of Muscle Foods. 8: 373-382.

WHO (World Health Organization). (2003). Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series 916. Geneva, World Health Organization.

Yang, H.S., Choi, S.G., Jeon, J.T., Park, G.B. and Joo, S.T. (2007). Textural and sensory properties of low-fat pork sausages with added hydrated oat meal and tofu as texture modifying agents. Meat Science. 75(2): 283-289. http://dx.doi.org/10.1016/j.meatsci. 2006.07.013.