Evaluation of calcium chloride, potassium chloride and magnesium chloride for sodium reduction in emulsion-type pork sausage

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Abstract – The effects of substitution of sodium chloride (NaCl) by other chloride salts, such as calcium chloride ($CaCl_2$), potassium chloride (KCl) and magnesium chloride ($MgCl_2$) on quality characteristics of emulsion-type pork sausages were investigated. The pH, cooking loss, lightness and overall acceptability of sausages were gradually worse by substitution of $CaCl_2$ ($P<0.01$), whereas $MgCl_2$ raised water-holding capacity and instrumental colors except for redness by its substitution level ($P<0.05$). KCl did not affect quality characteristics of emulsion-type sausages. The partial replacements of NaCl with KCl up to 50% and with $MgCl_2$ up to 25% are acceptable for processing of emulsion-type pork sausages without quality degradation, however $CaCl_2$ at small amount (below 5%) could be available for NaCl substitution in emulsion-type sausages due to gradual degradation in water-holding capacity and color at over 5% substitution level.

Key words: chloride salts, pork sausage, sodium substitution

I. INTRODUCTION

Sodium chloride is an essential ingredient in the processed foods because it plays an important role in food safety and food quality. Sodium is essential for human health and its ion is associated with various physiologic processes in the human body. Sodium in conjunction with potassium plays major roles in generation of nerve impulses, maintenance of electrolytes and depolarization of the muscle cell membrane [1]. However, the too high concentration of sodium intake may result in pathological disorders such as hypernatremia, edema, thirst, lessened urine production [2]. Therefore, the purpose of this study is to investigate the physico-chemical properties of emulsion-type pork sausages by using potassium chloride (KCl), calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) with different partial substitution levels as replacers for sodium chloride (NaCl).

II. MATERIALS AND METHODS

Emulsion-type pork sausages were prepared to ten treatments with different partial substitution levels of three NaCl replacers ($CaCl_2$, KCl and $MgCl_2$). The partial replacement levels of $CaCl_2$, KCl and $MgCl_2$ were as followed: CON, no substitution; $CaCl_2$(5%, 15%, 25%); KCl (30%, 40%, 50%); $MgCl_2$ (5%, 15%, 25%). The emulsion-type pork sausages were manufactured by conventional processing procedure of lab., and raw materials were composed of 72.44% lean pork, 11.2% backfat, 13.8% ice, 0.01% sodium nitrite, 0.2% sodium tripolyphosphate, 0.5% sugar, 0.05% monosodium glutamate, and 0.4% spices. The measurements were pH, cooking loss, color, texture properties, and sensory characteristics, and statistical analysis was performed by SAS(2002) program based on the experimental results.

III. RESULTS AND DISCUSSION

The physico-chemical properties of emulsion-type pork sausages substituted NaCl with $CaCl_2$, KCl and $MgCl_2$ are presented in Table 1. In $CaCl_2$ treatments, all measurements except for springiness, sensory color and saltiness were observed significant differences compared to control ($P<0.05$). However, substitution NaCl by KCl affected all instrumental color except for yellowness and sensory color ($P<0.05$), but the others were not affected by KCl ($P>0.05$). $MgCl_2$ treatments showed significant differences in pH, cooking loss and all instrumental color except for redness ($P<0.05$) compared to control. The $CaCl_2$ affected sensitively most of quality properties of emulsion-type sausages by

substitution level compared to KCl or $MgCl_2$ treatments. Further, combination effects of replacer and substitution level were found in most measurements except for springiness, sensory saltiness and bitterness.

Table 1. Physico-chemical properties of emulsion-type pork sausages substituted NaCl with $CaCl_2$, KCl and $MgCl_2$

Measurements	Treatments										SEM	Level of significance[1)]				
	CON	$CaCl_2$			KCl			$MgCl_2$				Substitution level			Replacer	Combined
Substitution level[2)] (%)	0	5	15	25	30	40	50	5	15	25		C	P	M		
pH	5.86^{a}	5.81^{abc}	5.78^{bcd}	5.65^{f}	5.81^{abc}	5.81^{abc}	5.83^{ab}	5.68^{ef}	5.72^{de}	5.76^{cd}	0.02	***	ns	***	***	***
Cooking loss (%)	18.45^{c}	21.07^{b}	21.80^{b}	23.24^{a}	17.27^{e}	17.49^{de}	18.18^{cd}	15.40^{g}	15.98^{g}	15.65^{g}	0.17	***	ns	***	***	***
Instrumental color[3)]																
CIE L*	79.73^{bc}	80.22^{ab}	78.84^{d}	78.72^{d}	79.32^{c}	79.44^{bc}	80.00^{ab}	80.02^{ab}	80.43^{a}	80.29^{ab}	0.10	***	*	**	**	***
CIE a*	7.01^{de}	7.32^{c}	7.75^{a}	7.70^{a}	7.57^{b}	7.31^{c}	6.85^{f}	7.09^{d}	7.05^{de}	6.95^{ef}	0.03	***	***	ns	***	***
CIE b*	6.95^{d}	6.73^{e}	7.26^{bc}	7.51^{a}	7.02^{d}	7.02^{d}	6.93^{d}	7.11^{cd}	7.22^{bc}	7.35^{ab}	0.06	**	ns	**	*	***
Chroma	9.82^{ef}	9.95^{de}	10.62^{a}	10.76^{a}	10.32^{b}	10.14^{c}	9.75^{f}	10.04^{cd}	10.09^{cd}	10.11^{cd}	0.05	***	**	*	***	***
Hue angle	44.85^{bc}	42.61^{f}	43.10^{ef}	44.28^{cd}	42.81^{f}	43.83^{de}	45.37^{bc}	45.11^{b}	45.68^{ab}	46.61^{a}	0.28	*	***	*	***	***
Texture properties																
Hardness (kg)	0.26^{ab}	0.25^{ab}	0.21^{c}	0.22^{c}	0.26^{ab}	0.28^{a}	0.26^{ab}	0.25^{ab}	0.25^{ab}	0.28^{a}	0.01	**	ns	ns	***	***
Cohesiveness (%)	0.56^{c}	0.65^{a}	0.56^{c}	0.57^{c}	0.58^{c}	0.59^{bc}	0.59^{bc}	0.65^{a}	0.58^{c}	0.58^{c}	0.02	**	ns	ns	ns	*
Springiness (mm)	1.01	1.03	1.00	1.01	1.03	1.00	1.01	1.07	1.02	1.00	0.02	ns	ns	ns	ns	ns
Gumminess (kg)	0.14^{bc}	0.16^{ab}	0.12^{d}	0.13^{cd}	0.15^{abc}	0.16^{ab}	0.15^{abc}	0.17^{a}	0.14^{bc}	0.16^{ab}	0.01	***	ns	ns	ns	***
Chewiness (kg, mm)	0.14^{bcd}	0.17^{ab}	0.12^{d}	0.13^{cd}	0.15^{bcd}	0.16^{abc}	0.16^{abc}	0.18^{a}	0.15^{bcd}	0.16^{abc}	0.01	***	ns	ns	*	**
Adhesiveness (%)	0.11^{abc}	0.11^{abc}	0.10^{c}	0.10^{c}	0.10^{c}	0.12^{ab}	0.11^{abc}	0.11^{abc}	0.11^{abc}	0.13^{a}	0.01	*	ns	ns	ns	**
Sensory properties[4)]																
Color	6.36^{b}	7.00^{ab}	7.07^{ab}	7.00^{ab}	6.93^{ab}	6.71^{b}	7.43^{a}	7.36^{a}	7.07^{a}	7.14^{a}	0.65	ns	**	ns	***	**
Saltiness	6.79	7.21	6.43	6.50	6.57	6.50	7.21	6.93	7.29	7.14	0.81	ns	ns	ns	ns	ns
Bitterness	6.81	6.50	6.57	6.00	7.07	6.79	6.57	6.50	6.64	6.79	0.87	*	ns	ns	ns	ns
Chewiness	6.93^{ab}	6.79^{ab}	5.50^{c}	5.36^{c}	7.00^{ab}	6.64^{b}	7.00^{ab}	7.43^{a}	6.64^{b}	7.21^{ab}	0.73	**	ns	ns	***	***
Overall acceptability	7.00^{ab}	7.21^{a}	6.36^{bc}	5.86^{c}	6.79^{ab}	6.50^{b}	6.86^{ab}	6.79^{ab}	6.71^{ab}	7.21^{a}	0.74	**	ns	ns	ns	**

[1)] C, $CaCl_2$; P, KCl; M, $MgCl_2$; Replacer, between $CaCl_2$, KCl and $MgCl_2$; Combined, combination of replacer and substitution level; ns, not significant; *, $P<0.05$; **, $P<0.01$; ***, $P<0.0001$.
[2)] % against NaCl, [3)] L*, lightness; a*, redness; b*, yellowness, [4)] 1=extremely poor, 9= extremely good.
[a-g] Means with different superscript differ significantly ($P<0.05$) by evaluation of combination effect of replacer and substitution level.

IV. CONCLUSION

In the emulsion-type pork sausages, $CaCl_2$ decline pH and water-holding capacity gradually with increase of substitution levels and consequently made texture properties and instrumental color values the worst. On the contrary, $MgCl_2$ formulated up to 25% substitution level could be better cooking yield, color, texture and sensory properties as well. KCl substitutions up to 50% did not change the sausage quality and thus those formulations could be acceptable. Therefore, partial replacements of $MgCl_2$ and KCl up to 25% and 50%, respectively, are acceptable for emulsion-type sausages without quality degradation, whereas $CaCl_2$ could be substituted to NaCl at small amount (5%).

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