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Possibility of partial replacement of sodium chloride with potassium chloride and ammonium chloride in production of meatballs in tomato sauce

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A b s t r a c t: The aim of this study was to examine the influence of reducing the sodium chloride content in meatballs in tomato sauce. The trial consisted of five groups. In the control group of meatballs and sauce, only sodium chloride was added. In group 1, half of the sodium chloride was replaced with potassium chloride, while in group 2, one third of the sodium chloride was replaced with potassium chloride. In group 3, one third of the sodium chloride was replaced with ammonium chloride, and in group 4, sodium chloride was reduced to half that of the control, and 1 g (0.25%) of ammonium chloride was also added. Partial replacement of sodium chloride with potassium chloride or ammonium chloride affected neither colour acceptability nor consistency of either meatballs or tomato sauce. The intensity of saltiness meatballs from group 4 was significantly lower than in the control and group 3 meatballs (P≤0.05). There was no statistical difference between saltiness acceptability of group 2 meatballs and that of groups 1 and 4 meatballs. All meatballs were acceptable and did not have so bitter a taste as to be sensorily rejected by assessors (P≤0.05). The bitterest sauces were the control and group 3 sauces, and they were significantly different from other groups; from groups 2 and 4 at the P≤0.01 level and from group 1 at the P≤0.05 level. The most acceptable saltiness and taste acceptability was achieved by group 4 meatballs, produced with 0.75% sodium chloride and 0.25% ammonium chloride, while the saltiness acceptability of tomato sauce was not influenced by partial replacement of sodium chloride with other chloride salts.

Key words: *meatballs, tomato sauce, sodium chloride reduction, potassium chloride, ammonium chloride*

Introduction

Dietary sodium intake in many cases exceeds recommendations of the World Health Organization (WHO), which has several negative health influences linked mostly to the appearance of essential hypertension and consequential cardiovascular disorders. There are many directives issued from WHO concerning how to reduce sodium intake *via* food and also investigations into sodium reduction in food production where sodium chloride is a main additive. Mostly, the meat industry is the target of these investigations. There are several studies on sodium reduction in cooked sausages, dry fermented sausages and dry meat. However, the meat industry is an important producer of ready-to-eat meals prepared or cooked in advance, with no further cooking or preparation required before being eaten. These ready-to-eat meals have become an important choice for modern consumers, with respect to the fast lifestyle of modern societies.

There are not much literature data on reducing the sodium content in ready-to-eat meals. Many investigations are focused on reducing sodium content in meat products, particularly in those which are not thermally treated (dry fermented sausages, dry ham). Since it is the only salt with a clearly salty taste, in food, sodium chloride cannot be totally replaced with other salts. However, it can be partially replaced, and to this purpose, potassium chloride and less often, other chloride salts are used (*Guàrdia et al.,* 2006*)*. Besides potassium chloride, magnesium and calcium salts and ascorbates are most comonly used as replacers *(Ruusunen and Puolanne,* 2005*)*.

The need to reduce sodium in meat products and generally in food will be an aim of the food industry in the future; fast food chains will also have to address this issue, even if people think the amount

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of salt consumed *via* fast food is not so large (*Moran et al., 2017*). Nonetheless, salt replacers present a difficult problem because of their degradation of desirable sensory characteristics, including texture and, of course, salty taste (*Kamenik et al.,* 2017*; Kang et al.,* 2014).

The aim of this study was to examine the influence of reducing the sodium chloride content in meatballs in tomato sauce, as well as the influence of partial replacement of sodium chloride with potassium chloride or ammonium chloride, with the target of achieving a normal, salty taste with less sodium.

Materials and Methods

The trial consisted of five groups (Tables 1 and 2). In the control group of meatballs and sauce, only sodium chloride was added. In group 1, half of the sodium chloride was replaced with potassium chloride, while in group 2, one third of the sodium chloride was replaced with potassium chloride. In group 3, one third of the sodium chloride was replaced with ammonium chloride and in group 4, sodium chloride was reduced by one half compared with the control, while 1 g (0.25%) of ammonium chloride was also added.

Meatball preparation

Meatballs were prepared from minced pork leg meat (grind plate 3 mm) purchased from a local market. Meat was well mixed with the ingredients presented in Table 1 to achieve optimal consistency to form into round shapes. Prepared meatballs were briefly fried in a thin layer of sunflower oil.

Tomato sauce preparation

Sauces were prepared from tomato juice (Tomatino classic, Polimark, Serbia) and the ingredients presented in Table 2. A roux was prepared from flour fried in sunflower oil for about 1 minute, and after that, water, tomato juice, salt/salt mixture and sugar were added. The sauces were simmered for 10 minutes.

Table 1 Composition of meatballs, g

Group	Minced pork (leg)	Sodium chloride	Potassium chloride	Ammonium chloride	Ground garlic
Control	400	6.00	–	–	2.00
1	400	3.00	3.00	–	2.00
2	400	4.00	2.00	–	2.00
3	400	4.00	–	2.00	2.00
4	400	3.00	–	1.00	2.00

Table 2 Composition of sauce, g

Group	Tomato juice	Water	Sunflower oil	Flour	Sugar	Sodium chloride	Potassium chloride	Ammonium chloride
Control	400	400	6.00	6.00	6.00	6.00	–	–
1	400	400	3.00	3.00	3.00	3.00	3.00	–
2	400	400	4.00	4.00	4.00	4.00	2.00	–
3	400	400	4.00	4.00	4.00	4.00	–	2.00
4	400	400	3.00	3.00	3.00	3.00	–	1.00

Meal preparation

Meatballs were cooked in prepared tomato sauce for 45 minutes. Half an hour after cooking, the product was presented to sensory assessors for evaluation.

Sensory evaluation

Sensory evaluation was performed by seven assessors (trained by proficiency testing) using numeric scales. Each sensory characteristic was evaluated for both ingredients of complete meal, meatballs and sauce. Colour acceptability, consistency, saltiness acceptability, taste acceptability and overall impression were evaluated with a 1−5 point scale, where 1 was the least acceptable and 5 was the most acceptable. Intensity of saltiness and bitterness of the meatballs and sauces were evaluated with a 1−5 point scale, where 1 was the least and 5 was the most expressed attribute, respectively. Meals (meatballs and sauce) were evaluated using a rank test.

Statistical evaluation

The results obtained were statistically evaluated using Microsoft Excel 2010 and are presented as mean±SD. Statistical differences between means of the examined parameters were determined on the level 0.05 and 0.01 by Student´s t-test.

Results and discussion

The results of sensory evaluation of colour and consistency of meatballs and tomato sauce are presented in Table 3.

Colour and consistency of meatballs from all groups were acceptable, and all assessors evaluated them similarly. Mean values were not statistically different ($P \geq 0.05$). Also, assessors were very consistent in the case of evaluating tomato sauce for these two characteristics. Both colour and consistency of all tomato sauce groups were acceptable and there were no significant differences between means ($P \geq 0.05$).

The intensity of saltiness and bitterness of the meatballs and tomato sauces are shown in Table 4.

Usually, 1.8−2.0% sodium chloride is used in minced meat products. This trial was purposely designed for a maximum salt level of 1.5%, in accordance with results of *Lilic et al*. (2005). Group 4 meatballs had the smallest amount of salt, and this group was evaluated as having the lowest saltiness intensity (Table 4). It was significantly lower than the salt intensities of control and group 3 meatballs ($P \leq 0.05$).

There was no statistical difference between saltiness acceptability of group 2 meatballs and that of groups 1 and 4 meatballs. It was expected that sauce with the largest amount of sodium chloride would be the saltiest, but in fact, group 3 tomato sauce was the saltiest ($P \leq 0.05$). Since one third of the sodium chloride was replaced with ammonium chloride in this group, it is clear that ammonium chloride increased saltiness, particularly in this liquid medium with high water content. Group 3 tomato sauce was significantly more salty compared with the other groups.

Although the evaluations for intensity of bitterness were different, all meatballs were acceptable and did not have so bitter a taste as to be sensorily rejected by the assessors. There was no significant difference in meatball bitterness ($P \geq 0.05$), even where half of the sodium chloride was replaced with potassium chloride (group 1 compared with control). Despite that, the bitterness intensity of tomato

Table 3 Sensory evaluation of colour acceptability and consistency, mean±SD, n = 7

Group	Meatballs		Tomato sauce	
	Colour acceptability	Consistency	Colour acceptability	Consistency
Control	4.86±0.35	4.57±0.49	4.57±0.49	4.71±0.45
1	4.71±0.70	4.00±0.93	4.57±0.73	4.57±0.73
2	4.86±0.35	4.29±0.88	4.29±1.03	4.57±0.49
3	4.86±0.35	4.71±0.70	4.57±0.49	4.57±0.73
4	4.86±0.35	4.71±0.45	4.71±0.45	4.71±0.45

Table 4 Sensory evaluation of intensity of saltiness and bitterness, mean±SD, n = 7

Group	Meatballs		Tomato sauce	
	Intensity of saltiness	Intensity of bitterness	Intensity of saltiness	Intensity of bitterness
Control	3.86±0.64 ^{a}	2.29±1.03	3.71±0.70^{a,q}	4.29±0.45^{b,y}
1	3.14±0.99	3.43±1.68	1.71±0.88^{y}	3.00±1.07^{a}
2	2.86±1.12	2.29±1.28	3.29±0.88^{x,q}	3.29±0.45^{x}
3	4.14±1.12^{a}	3.00±1.41	4.71±0.70^{b,z}	4.00±1.31^{b}
4	2.71±0.88^{b}	1.86±0.99	2.29±1.16^{b,q}	2.57±0.90^{a,x}

Legend: $^{(a,b)}$ Values (mean±SD) with different superscript letters are significantly different (P≤0.05);
$^{(x,y;\ q,z)}$ Values (mean±SD) with different superscript letters are significantly different (P≤0.01)

sauces was very differently evaluated. The bitterest sauces were the control and group 3 sauces, which were significantly bitterer than sauce groups 2 and 4 at the level of P≤0.01 and than group 1 sauce at the level of P≤0.05.

Results of sensory evaluation of saltiness and taste acceptability and overall impression of the prepared meals of meatballs in tomato sauce are presented in Table 5.

Group 4 meatballs had the most pleasant taste, which was more acceptable than the taste of groups 1 and 3 meatballs (P≤0.01). However, groups 2 and 4 meatballs were not significantly different in terms of taste than control meatballs (P≥0.05). Although groups 3 and 4 meatballs contained relatively small amounts of sodium chloride, it can be assumed the larger amount of ammonium chloride added intensified the salty taste of sodium chloride, and consequently, made the taste of group 3 meatballs less acceptable compared with group 4 meatballs. The overall impression of the meatballs was significantly different between groups 1 and 4 (P≤0.01) and between the control and groups 3 and 4 (P≤0.01).

The most favourably evaluated sauce, taking into account saltiness and taste acceptability, was group 4 sauce. The taste acceptability of group 3 sauce achieved the worst score, and it was statistically lower than that of groups 2 and 4 sauces (P≤0.05). There were no significant differences between other mean scores (P≥0.05). For overall impression, however, the only differences were between groups 3 and 4 sauces (group 4 sauce achieved a better overall

Table 5 Sensory evaluation of saltiness and taste acceptability and overall impression, mean±SD, n = 7

Group	Meatballs			Tomato sauce		
	Saltiness acceptability	Taste acceptability	Overall impression	Saltiness acceptability	Taste acceptability	Overall impression
Control	3.14±1.36^{a}	3.71±1.48	3.29±1.48 ^{a}	2.86±1.12	3.14±1.25	3.00±1.31
1	3.29±0.70	3.57±0.73^{x}	3.57±0.73^{x}	3.14±1.36	3.57±1.29	3.57±1.29
2	3.71±1.03	3.71±1.28	3.71±1.28	2.29±1.16	4.29±0.70^{a}	3.57±1.40
3	2.86±1.46^{a}	3.43±1.29^{x}	3.14±1.55 ^{a}	3.14±1.25	2.57±1.68^{b}	2.29±1.39^{a}
4	4.57±0.73^{b}	4.71±0.45^{y}	4.71±0.45^{b,y}	3.57±1.18	4.14±0.64^{a}	3.71±1.03^{b}

Legend: $^{(a,b)}$ Values (mean±SD) with different superscript letters are significantly different (P≤0.05)
$^{(x,y)}$ Values (mean±SD) with different superscript letters are significantly different (P≤0.01)

impression; P≤0.05), while other scores were quite similar (P≥0.05).

The best-ranked was meal was group 4, and it was significantly better than the rankings achieved by group 1, control and group 3 meals. Five assessors ranked group 4 as the best meal choice, while the second-ranked meal was the group 2 meal.

Conclusion

Partial replacement of sodium chloride with potassium chloride or ammonium chloride in different amounts affected neither colour acceptability nor consistency of meatballs or tomato sauce.

Intensity of saltiness was a direct result of the amount of sodium chloride added, but also of the ammonium chloride added, so meatballs and tomato sauces with the larger amount of added ammonium chloride were more salty than others.

Bitterness was not influenced by partial replacement of sodium chloride with potassium chloride or ammonium chloride in different amounts in the meatballs, but the tomato sauce produced only with sodium chloride and that with the larger amount of ammonium chloride were more bitter.

The saltiness and taste acceptability of group 4 meatballs were evaluated as the best; these meatballs were produced with 0.75% sodium chloride and 0.25% ammonium chloride. The saltiness of tomato sauce was not influenced by partial replacement of sodium chloride with other chloride salts, but taste acceptability was better in group 2, produced with 1% sodium chloride and 0.5% potassium chloride, and in group 4, produced with 0.75% sodium chloride and 0.25% ammonium chloride.

The overall impression was very similar for all groups of meatballs and tomato sauce. However, group 4 were scored as having the best overall impression.

According to the results obtained, to achieve meatballs in tomato sauce with reduced sodium chloride (and therefore, sodium) content, partial replacement with ammonium chloride is a suitable choice for this product.

Conflict of Interest. The authors declare that they have no conflicts of interest.

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