THE EFFECT OF LOW SALT CONTENT AND LOW pH VALUE ON THE WATER BINDING CAPACITY OF COOKED SAUSAGE

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SUMMARY

The water binding capacity (WBC) was studied using laboratory scale sausages with various recipes. Salt contents of the sausages used were 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 % sodium chloride. pH values of the sausages were adjusted to 6.1, 5.8, 5.5 or 5.2. Isolated soy protein (ISP) contents of the sausages used were 0.0, 2.0 and 4.0 %. Meat was partly replaced with ISP-water mixture (1:3). The protein content and fat content of the sausages were kept constant. The WBC was calculated on the basis of meat or corresponding meat and ISP-water content, respectively. The recipes for the sausages contained either no added phosphate or 0.3 % added phosphate. Variables (144 different) were made in random order and three replicates were made of each.

The WBC of the cooked sausage is strongly influenced by salt content and pH value. WBC decreased when pH value, salt content or both were decreased in the sausages. WBC was low if the pH value of the sausages was 5.5 or 5.2, with or without added phosphate, in spite of high or low salt content. In sausages with pH values of 5.8 and 6.1 the salt content could be decreased to 1.4 % with added phosphate. In the sausages made without added phosphate it could be decreased to 1.6 %.

If the salt content and pH value of the sausages were low the replacement of meat by ISP did not improve the WBC of the sausages compared to all-meat sausages. At high pH values and high salt content the replacement of meat by ISP did not change the WBC of the sausages compared to all meat sausages.

At high pH values the salt content is not as essential as it is at low pH values. The salt content can be decreased, if the pH value of the sausages is high, without severely affecting the WBC.

INTRODUCTION

High salt (NaCl) intake and high blood pressure may have a causative correlation. Sausages may have a substantial role in the intake of salt for some individuals. It is well known that functional properties as well as shelf-life of sausages are reduced when salt content is reduced. The decrease of keepability can be compensated by lowering the pH value, but WBC will be reduced further.

ISP is widely used as partial replacement for meat proteins rather than than as functional additive. It does not require salt when used alone, in such as preformed emulsions, and would therefore be expected to improve the WBC of meat and ISP-water mixtures of low salt level.

The objective of this study was to determine the effect of low salt content and/or pH value on WBC of cooked sausage. Prevention of the decline of the WBC and structure was attempted by replacing part of the meat with ISP.

MATERIALS AND METHODS

The WBC of the sausages (meat or meat-ISP mixture) was determined using a laboratory sausage method of Puolanne and Ruusunen (Puolanne & Ruusunen 1978, Puolanne and Terrell 1983). The method comprises a miniature scale sausage preparation, with high water addition. The amount of added water was adjusted in all sausages to so high a level, that a measurable amount of released water could always be detected. The water released after cooking and cooling was manually separated from the sausage after peeling, and the remaining sausage was weighed. The WBC was calculated on the basis of the weight difference between uncooked sausage (without the weight of the casing) and the cooked, cooled and peeled sausage. The WBC was expressed as bound water g/100g meat or meat-ISP mixture, respectively.

The recipes of the sausages obtained on the bases of preliminary tests, are presented in Table 1. ISP was first hydrated with water in the chopper, and then the other ingredients were added the normal way. The salt content and the phosphate content were calculated on the basis of raw materials without additives.

Beef and pork lean meats were carefully trimmed from visible fat and connective tissue. In ISP-sausages lean meats (22 % protein and 77 % moisture) were partially replaced with ISP- (88 % protein and 5 % moisture): water mixture (1:3) so that the protein, fat, and moisture contents of the sausages were essentially the same in all-meat and in meat-ISP sausages.

The ISP (Purina Protein 500E, prod. Purina Proteins, St. Louis, MI, USA) content of the sausages were 0.0, 2.0 or 4.0 %. The salt content of the sausages were 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 % NaCl. pH values of the sausages were adjusted to 6.1, 5.8, 5.5 or 5.2 by 1 N HCl or 1 N NaOH with added water. pH values were measured by Findip's 555A pH & mV meter (prod. Findip's Ltd., Kauniainen, Finland) at the end of preparation of mass before cooking. Added phosphate was a commercial phosphate mixture. The amount of phosphate addition used was 0.3 %.

The WBC was determined in 144 different sausages (3 ISP levels x 6 salt levels x 4 pH values x 2 phosphate levels). From each variable three replicates were made. The sausages were made in random order.

Table 1. The recipes of water binding sausages (%).

	Salt + phosphate			Salt		
Meat (pork-beef ratio 1:1)	38.0 %	29.1 %	20.2 %	45.0 %	36.0 %	27.2 %
Backfat	20.2 "	20.6 "	21.0 "	18.0 "	18.4 "	18.8 "
Water/ice	41.8 "	48.3 "	54.8 "	37.0 "	43.6 "	50.0 "
ISP	0.0 "	2.0 "	4.0 "	0.0 "	2.0 "	4.0 "
	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
Calculated protein content	8.6 %	8.6 %	8.6 %	9.9 %	9.9 %	9.9 %
Calculated fat content	18.0 %	18.0 %	18.0 %	16.4 %	16.4 %	16.4 %

The results were analyzed by two-way variance analysis with Tukey's test (Ryan et al 1982). The combined effects of the four variables have not been analyzed in detail yet. Some overall results are given in the text, though.

RESULTS

The WBC results of the sausages with added phosphate are presented in Table 2 and without added phosphate in Table 3. The WBC increased when salt content or pH value increased in the sausages with or without added phosphate or ISP ($p<0.001$). The combined effect of salt content x pH value was highly significant ($p<0.001$) in sausages without added phosphate, and with added phosphate significant in sausages with 4.0 % ISP ($p<0.025$) and in the sausages with 0.0 % ISP ($p<0.01$). Although the increase of the salt content increased the WBC for all pH values, the WBC was lower for pH values 5.2 and 5.5 in all combinations. In the sausages with added phosphate and without replacement of meat with ISP-water mixture the pH value could be reduced from 6.1 to 5.8 with a salt content of 1.4 % or more, or the salt content could be reduced to 1.0 % with a pH value 6.1, without significantly affecting the WBC.

With a pH value of 6.1, the sausages without added phosphate (Figure 2) the steepest increase in WBC was between 1.0 and 1.2 % NaCl. With a pH value of 5.8 the WBC started to decrease sharply when the salt content was reduced to below 1.6 %.

With added phosphate (Figure 1) sausages with 2.0 % ISP did not differ significantly from all-meat sausages, but the replacement of meat protein partly with 4.0 % ISP did lower the WBC. Without added phosphate (Figure 2), the replacement of meat protein with ISP had no significant effect at the pH value of 6.1. For pH value 5.8 and high salt content, the best WBC was received with the replacement of meat protein with 2.0 % ISP.

DISCUSSION

This study like many other studies showed that the high WBC can not be achieved by using simultaneously a low pH value, a low salt content and no added phosphate. In this study, when the pH value was 5.2, the WBC was always very low irrespective of other variables. The same was true for pH value 5.5 but with added phosphate and 1.6 % NaCl or more, an increase in WBC could be acheived. With added phosphate and a pH value of 5.8 at least 1.4 % is needed. With a pH value of 6.1 it was possible to go to so low level as 1.2 %. Without added phosphate and pH value 5.8 the salt content could be decreased to

Table 2. The WBC results (m=mean value, s=standard deviation) of the sausages made with added phosphate expressed as bound water g/100 g meat or corresponding meat-ISP-water mixture. Means with different superscript letter in horizontal (ABC..) and in vertical (abc..) rows are significantly different ($p<0.05$) for each ISP contents.

Salt content			1.0 %	1.2 %	1.4 %	1.6 %	1.8 %	2.0 %
ISP content	pH value							
0.0 %	6.1	m	42.82^{a}	55.69^{a}	$56.^{66a}$	58.79^{a}	59.30^{a}	59.57^{a}
		s	13.48	1.68	0.65	0.86	3.99	5.65
	5.8	m	$25.82^{b}B$	$33.11^{b}B$	$45.24^{a}AB$	$53.61^{a}A$	$54.00^{a}A$	$57.12^{a}A$
		s	9.18	5.14	5.89	3.92	1.80	2.73
	5.5	m	$16.98^{b}C$	$25.03^{c}BC$	$26.05^{b}BC$	$39.08^{b}AB$	$42.61^{b}A$	$45.84^{b}A$
		s	1.86	4.10	7.31	3.06	6.23	8.27
	5.2	m	$13.78^{b}B$	$16.72^{d}AB$	$22.13^{b}AB$	$29.73^{c}A$	$24.15^{c}AB$	$27.85^{c}AB$
		s	3.78	1.64	3.42	1.60	10.52	5.30
2.0 %	6.1	m	$39.61^{a}B$	$50.03^{a}AB$	$55.40^{a}AB$	$56.64^{a}AB$	$60.92^{a}A$	$59.23^{a}A$
		s	11.96	10.29	3.05	1.58	5.36	5.48
	5.8	m	$22.87^{b}C$	$38.47^{b}B$	$47.00^{b}AB$	$52.28^{a}A$	$57.08^{a}A$	$53.19^{b}A$
		s	7.71	3.79	6.23	1.29	4.01	1.85
	5.5	m	$14.17^{bc}C$	$21.27^{c}BC$	$22.27^{c}ABC$	$30.43^{b}ABC$	$37.08^{b}AB$	$39.40^{b}A$
		s	2.04	2.48	6.62	3.30	10.28	10.22
	5.2	m	$9.86^{c}C$	$16.09^{c}BC$	$17.23^{d}BC$	$23.39^{c}AB$	$23.30^{c}AB$	$31.00^{c}A$
		s	3.14	2.82	6.38	7.00	4.27	2.88
4.0 %	6.1	m	$36.20^{a}B$	$47.19^{a}AB$	$49.70^{a}AB$	$50.10^{a}AB$	$54.05^{a}A$	$55.06^{a}A$
		s	13.59	3.76	2.41	1.46	5.58	8.15
	5.8	m	$18.08^{b}B$	$28.40^{b}B$	$43.10^{b}AB$	$45.38^{a}A$	$48.04^{a}A$	$48.82^{a}A$
		s	2.43	5.30	11.08	2.63	1.37	10.29
	5.5	m	$9.31^{b}A$	$17.51^{c}AB$	$18.35^{c}ABC$	$22.72^{b}ABC$	$28.76^{b}AB$	$34.26^{b}A$
		s	11.53	8.73	12.33	6.89	8.55	2.00
	5.2	m	11.48^{b}	14.84^{c}	11.33^{b}	15.54^{b}	21.19^{b}	17.24^{c}
		s	8.43	2.85	5.68	3.82	1.55	2.77

1.6 %. For the pH value 6.1 and 0.0 or 2.0 % ISP content, salt content could be decreased to 1.4 %. In this study the WBC was determined by adding water to the extent that a part of it was always released during cooking. This is to be avoided in the industrial processing. The salt contents of the sausages were lower than which are normally used in the sausages, especially when no added phosphate is used. This study tells more about the theoretical WBC than the functional properties of meat and ISP in an industrial production.

The lean meat used in this study was carefully trimmed from visible fat and connective tissue. This kind of meat cannot be compared with the meats commercially used in the preparation of industrial sausages. Therefore the equivalence of 1 part lean meat to 1 part ISP-water mixture (1:3) gives to ISP lower WBC related to meat, than is obtained in normal industrial production.

It can be concluded on basis of this laboratory study that salt content can be reduced only by high pH values, or pH value can be lowered only by high salt contents and with added phosphate. The use of ISP did not cause an addition of WBC in low pH value and/or low salt sausages compared to all-meat sausages.

Pilot scale or industrial scale tests with normal levels of water addition and levels of meat-ISP replacement are needed to test the effect of low pH value on the keepability and functional properties of the sausages with low salt content.

The partial replacement of meat by ISP-water mixture may provide enough cost reduction to allow production of low salt and pH value sausages with reduced added water.

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Table 3. The WBC results (m=mean value, s=standard deviation) of the sausages made without added phosphate expressed as bound water g/100 g meat or corresponding meat-ISP-water mixture. Means with different superscript letters in horizontal (ABC...) and vertical (abc...) rows are significantly different ($p<0.05$) for each ISP contents.

Salt content			1.0 %	1.2 %	1.4 %	1.6 %	1.8 %	2.0 %
ISP content	pH value							
0.0 %	6.1	m	$24.71^{a}C$	$38.62^{a}B$	$42.10^{a}AB$	$43.76^{a}A$	$44.86^{a}A$	$44.87^{a}A$
		s	2.57	2.10	0.64	1.89	2.18	0.35
	5.8	m	$20.11^{ab}D$	$23.90^{b}CD$	$30.27^{b}BC$	$38.10^{a}AB$	$40.64^{a}A$	$43.43^{a}A$
		s	0.82	4.45	2.14	2.70	3.97	2.62
	5.5	m	$13.87^{cb}C$	$15.72^{bc}BC$	$18.14^{c}BC$	$20.00^{b}ABC$	$23.36^{b}AB$	$26.61^{b}A$
		s	2.18	2.02 –	0.58	1.89	3.74	5.32
	5.2	m	$6.95^{c}B$	$6.49^{c}B$	$10.88^{d}AB$	$10.86^{c}AB$	$12.28^{c}AB$	$16.39^{c}A$
		s	6.00	5.32	2.11	0.76	0.22	0.46
2.0 %	6.1	m	$21.03^{a}D$	$36.70^{a}C$	$40.40^{a}ABC$	$43.50^{a}AB$	$44.52^{a}AB$	$46.04^{a}A$
		s	2.14	2.26	1.18	0.20	3.61	2.86
	5.8	m	$17.55^{ab}B$	$18.32^{b}B$	$23.68^{b}B$	$38.44^{b}A$	$41.38^{a}A$	$44.08^{a}A$
		s	2.35	3.34	4.92	2.04	0.12	1.20
	5.5	m	$12.66^{b}A$	$14.21^{b}A$	$15.02^{c}A$	$16.23^{c}A$	$20.46^{b}A$	$18.92^{b}A$
		s	5.02	3.42	2.36	3.18	3.80	2.44
	5.2	m	$5.54^{c}B$	$7.51^{c}AB$	$8.43^{d}AB$	$10.56^{d}AB$	$8.75^{c}AB$	$12.46^{b}A$
		s	2.41	2.06	1.38	1.04	3.41	0.60
4.0 %	6.1	m	$18.84^{a}D$	$32.93^{a}C$	$39.86^{a}B$	$43.70^{a}AB$	$46.51^{a}A$	$44.41^{a}AB$
		s	1.34	4.60	2.24	2.65	1.40	1.07
	5.8	m	$14.75^{ab}C$	$14.98^{a}C$	$23.74^{b}B$	$32.22^{b}A$	$36.29^{b}A$	$38.55^{b}A$
		s	4.65	6.70	1.59	2.91	1.62	2.33
	5.5	m	$10.47^{b}C$	$11.37^{b}BC$	$12.61^{c}ABC$	$12.79^{c}ABC$	$13.98^{c}AB$	$15.64^{c}A$
		s	0.71	0.66	1.23	1.39	1.80	2.16
	5.2	m	5.12^{c}	7.14^{c}	8.87^{c}	8.81^{c}	5.49^{d}	9.10^{d}
		s	0.72	2.20	3.22	3.14	7.15	3.10

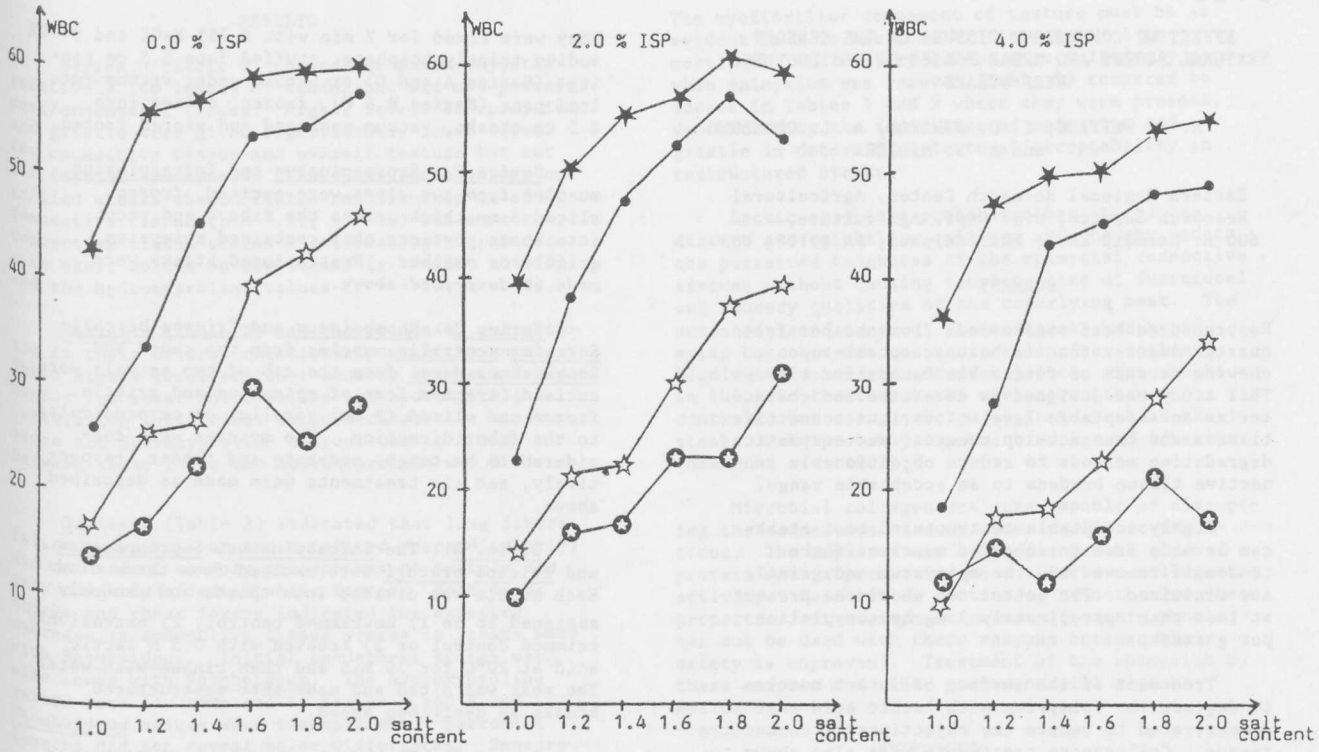

Figure 1. The WBC results (expressed as bound water g/100g meat or corresponding meat-ISP-water mixture) of the sausages made with added phpsphate at different pH values (✶= 6.1, ●= 5-8, ☆= 5.5 and ✪= 5.2).

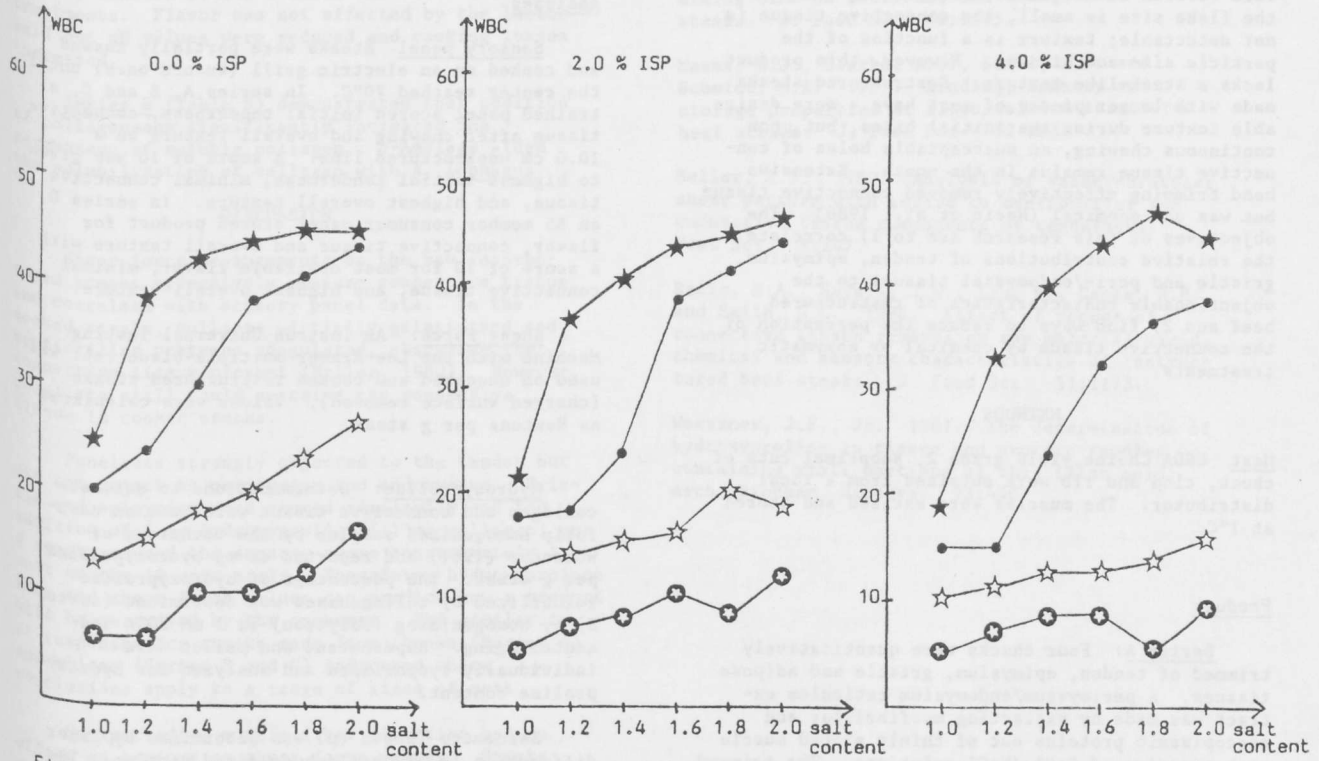

Figure 2. The WBC results (expressed as bound water g/100g meat or corresponding meat-ISP-water mixture) of the sausages made without added phosphate at different pH values (✶= 6.1, ● = 5.8, ☆= 5.5 and ✪ = 5.2).