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SPECIFIC AND GENERAL EFFECTS OF IONS ON MEAT QUALITY

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The purpose of this paper is to report some results which provide an extension to the data presented in the paper which Dr. Lawrie read for us at the Utrecht meeting.

In that paper we indicated the value of a solution of sodium chloride as a material for post-slaughter injection into quarters of beef to improve the tenderness of the meat and to reduce the tendency for thawed-out frozen meat to exude drip. It was shown that a definite increase in tenderness could be achieved without introducing excessive saltiness but that, to reduce the drip below that characteristic of uninjected meat the salt content had to be such that it could be readily detected in the cooked meat.

It was further suggested from rather preliminary experiments that both sodium orthophosphate and pyrophosphate produced analogous changes in the extent of drip and in tenderness and these appeared to be produced at concentrations which had less effect in producing saltiness than was the case with sodium chloride. It was pointed out that the effects of ortho- or pyro-phosphate might be purely ionic or they might be due to pH shift or, especially in the case of pyrophosphate, they might be due to specific effects such as have been demonstrated by Bendall, Hamm, Kotter and others. The present work is an attempt to determine more clearly the effectiveness of pyrophosphate and to separate ionic, pH and specific effects.

EXPERIMENTAL

The plan of this experiment followed similar lines to the previous one in that the injection treatments were applied in pairs using a balanced incomplete block design to the opposite hinds, without loins, of a series of cow carcases chilled for 24 hours after slaughter. The injection treatments in this experiment consisted of injecting into the iliac artery sufficient of the following solutions to give a 10% increase in weight:-

Slide 1

1. 2.46% sodium chloride - pH 9.5 - $\mu = 0.42$
2. 2.46% sodium chloride adjusted with HCl to pH 6.5 - $\mu = 0.42$
3. 1.12% sodium pyrophosphate - pH 9.5 - $\mu = 0.42$
4. 2.24% sodium pyrophosphate adjusted with HCl to pH 6.5 - $\mu = 0.42$
5. 2.46% sodium chloride plus 1.12% pyrophosphate pH 9.4 - $\mu = 0.84$
6. 2.46% sodium chloride plus 2.24% pyrophosphate adjusted with HCl to pH 6.5 - $\mu = 0.84$

Following injection the hinds were frozen and stored for 1 week. Samples were taken from 4 muscles for determination of drip and the remaining meat was thawed out and two samples cooked - a grilled rump steak and a roast silverside. These were tasted by an experimental tasting panel.

RESULTS

The present data do not permit direct comparison of the effects of the injection of saline solutions with either uninjected meat or meat injected with pure water but only give us comparisons of the effects of these specific injection treatments. However by utilizing the results from the previous paper the present comparisons can be further interpreted.

The main results arising immediately from the present data are given in the three following tables.

Slide 2 From Table 1 it is seen that there was practically no difference between the drip from the samples treated with sodium chloride and pyrophosphate of the same ionic strength but the difference between these and the combined solution was significant at a P level of less than 0.1%. In this work the main difference in the pH of the muscle tissue as a result of using an injection solution at pH 9.5 as compared with one at 6.5 was very small amounting on the average to an increase of only 0.05 pH but the values for each pair of sides from the same carcass varied from -0.10 to +0.23 while variations of equal magnitude were found in the difference of pH in the musculature of the opposite sides of a carcass in which both sides were injected with fluid of the same pH. It is thus not surprising that the drip was not appreciably affected by the pH of the injection fluid. This ineffectiveness of pyrophosphate solution of pH 9.5 in modifying muscle pH is at variance with the results previously reported.

Slide 3 The data for tenderness are given in Table 2 and it is seen that the pattern of variation is similar to that for drip. In this case the difference between the two ionic strengths does not quite reach significance at the 5% level on a two-tailed test but, since we started with the a priori hypothesis, based on earlier work, that the higher the ionic strength the better the tenderness, the increased tenderness with $\mu = 0.34$ as compared with $\mu = 0.42$ can be accepted with confidence. As in the case of drip there is no evidence of difference between the sodium chloride and pyrophosphate at the same ionic strength or between the different pH values.

Slide 4 Table 3 gives the analytical data for percentage of sodium chloride and T.C.A. soluble phosphorus in the musculature and the scores for foreign flavour. The analytical data of course reflect the composition of the injection solution and simply serve to demonstrate that the injection fluid did reach the portions of the carcass where the analyses were made and reached them in the expected concentrations. The regions analysed correspond with the various muscles used for the drip determination and for the roast but the region used for the grill is not covered by the analytical data. The grills consistently give a higher salty flavour than the roasts but the reasons for this are not clear.

As Table 3 shows there is a definite difference in salty flavour (significant at P = 2.5%) between the two injection fluids at the same ionic strength - the pyrophosphate being the lower.

The higher ionic strength solutions give significantly higher scores than either of these as is to be expected.

Differences in other attributes of eating quality such as flavour and juiciness between the different injection treatments are not significant, though rather naturally the acceptability scores follow the tenderness in giving greatest preference to the samples injected with the combined solutes. The increased salt flavour found in these samples has therefore not been considered objectionable, or at least not sufficiently so to offset any improved tenderness.

DISCUSSION

The results just described are quite straightforward as regards to the relative effects of the solutions used. In order to interpret them, and in particular to consider the relative importance of ionic strength and specific pyrophosphate ion effects, it is necessary to consider them in relation to the previous data.

From what has already been said it is obvious that, in the present data, there is no need to attempt to separate pH effects as pH changes in the musculature are negligible.

Slide 5 The next slide shows the present data for drip superimposed on those given for sodium chloride solution in the earlier paper. It is not necessary that the present data for pure salt solution should lie on the previous curve but the previous curve should give a good indication of the effect of change of ionic strength for sodium chloride. It is seen that with drip all the present data do in fact lie parallel to the curve previously given for sodium chloride (and reasonably close to the original points) and thus demonstrate that there is no necessity to postulate any action of the pyrophosphate other than that due to the ionic strength of its solution.

Slide 6 With tenderness, as seen in the next slide, the points for pyrophosphate plus salt lie below the previous curve but in view of the statistical analyses indicated earlier there is no reason to assume anything other than a general ionic effect and certainly no synergistic action.

Slide 7 The data for foreign flavour, in this last slide, when plotted in this way again demonstrate close agreement with the 1960 figures and illustrate the markedly lower saltiness of pyrophosphate than of sodium chloride of equivalent ionic strength.

Before concluding it should be pointed out that what has just been said may be an oversimplification of the situation. Since the buffering action of the muscle tissue has been able to maintain a remarkably constant pH in spite

of the initial differences in pH of the injection solution it would be dangerous to argue that equality of ionic strength of the injection fluid implies equality of ionic strength in the muscle tissue. Any attempt to calculate the ionic strength of the tissue on the basis of our existing knowledge of the extent and nature of the buffer capacity of the system would be equally dangerous. Also our knowledge of the fate of the pyrophosphate ion in this complex system is very slight though we hope that paper chromatography studies which are at present under way may throw some light on this.

While the work of others has demonstrated specific effects of pyrophosphate in certain circumstances such as in comminuted meats and in muscle breis the present work indicates that when it is injected into chilled meat post-rigor in the concentrations, and under the conditions discussed, there is as yet no need to postulate any action other than a general ionic one.

Summary

Further studies have been made of the effect of injecting sodium chloride and sodium pyrophosphate into beef quarters. The effects on the eating quality of, and the extent of drip from, thawed-out frozen meat have been measured.

In this work pH changes and their effects were negligible and though the conclusion is not unequivocal owing to our lack of knowledge of physical chemistry of the complex system, there appears little reason to consider the effect of pyrophosphate as due to anything other than a general ionic strength effect.

Resumé

D'autres études furent faites sur l'effet de l'injection de chlorure et pyrophosphate de soude dans les quartiers de boeuf. Les effets sur le goût et la quantité de drip provenant de la viande décongelée ont été estimés.

Dans cette étude les changements de pH et leurs effets furent négligeable et quoique la conclusion n'est pas claire due a notre manque de connaissance de la chimie physique du système complèxe, il y a peu de raison a considérer l'effet de la pyrophosphate à étre due à rien autre que l'effet de la concentration ionique generale.

Zusammenfassung

Die Wirkung der Einspritzung (in Blutgefässe) von Natriumchlorid- und Natriumpyrophosphatlösung in Rinderviertel, vor dem Gefrieren, auf den Geschackswert und das Auftreten von Tropfverlusten nach dem Auftauen wurde untersucht.

Der Einfluss einer pH - Aenderung der Lösung auf den pH Wert des Fleisches und die resultierende Fleischqualität nach dem Auftauen war vernachlässigbar klein und obgleich unser Einblick in die physikalische Chemie des komplexen Systems nicht ganz eindeutig ist, besteht kaum Grund die Wirkung der Pyrophosphate anders auszu legen als durch eine allgemeine Wirkung der Ionenstärke.

TABLE 1

NO.	TREATMENT SOLUTION				% DRIP Mean of 4 Samples From 4 Muscles from 5 Animals
	NaCl %	$Na_4P_2O_7$ %	pH	μ	
1.	2.5	-	9.5	0.42	19.6
2.	2.5	-	6.5	0.42	19.1
3.	-	1.1	9.5	0.42	20.7
4.	-	2.2	6.5	0.42	20.5
5.	2.5	1.1	9.4	0.84	16.0
6.	2.5	2.2	6.5	0.84	13.9

TABLE 2

NO.	TREATMENT SOLUTION				MEAN TENDERNESS SCORE Mean for 9 Tasters from 2 Joints from 5 Animals
	NaCl %	$Na_4P_2O_7$ %	pH	μ	
1.	2.5	-	9.5	0.42	4.4
2.	2.5	-	6.5	0.42	3.8
3.	-	1.1	9.5	0.42	4.3
4.	-	2.2	6.5	0.42	4.0
5.	2.5	1.1	9.4	0.84	4.4
6.	2.5	2.2	6.5	0.84	4.7

TABLE 3

TREATMENT NO.	% IN MUSCLE TISSUE		FOREIGN FLAVOUR SCORE
	Cl (Expressed as NaCl)	P (T.C.A.Soluble)	Mean for 9 Tasters on 2 Joints from 5 Animals
	Mean of 4 Samples from 4 Muscles from 5 Animals		
1.	0.40	0.28	1.0
2.	0.39	0.29	0.9
3.	0.07	0.35	0.5
4.	0.15	0.39	0.4
5.	0.44	0.33	1.1
6.	0.50	0.38	1.4

FIGURE 1. (SLIDE 5)

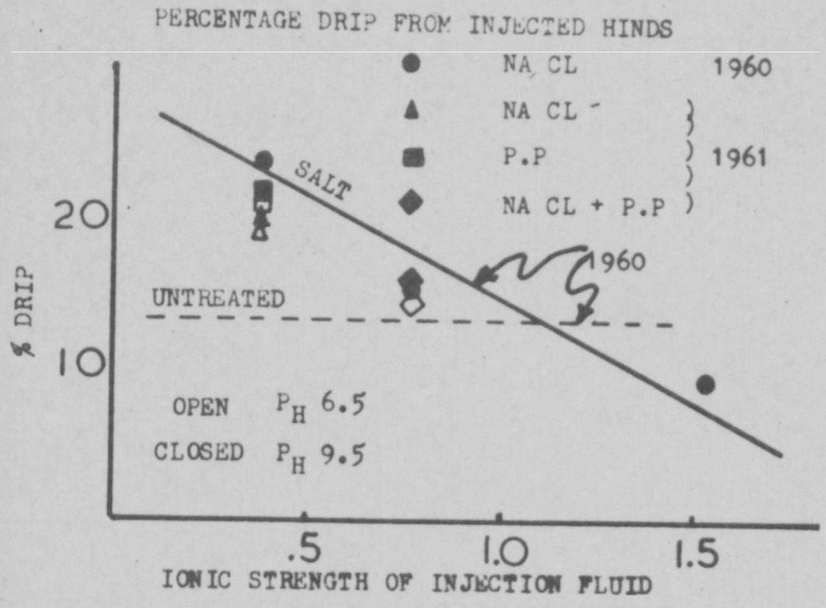

FIGURE 2 (SLIDE 6)

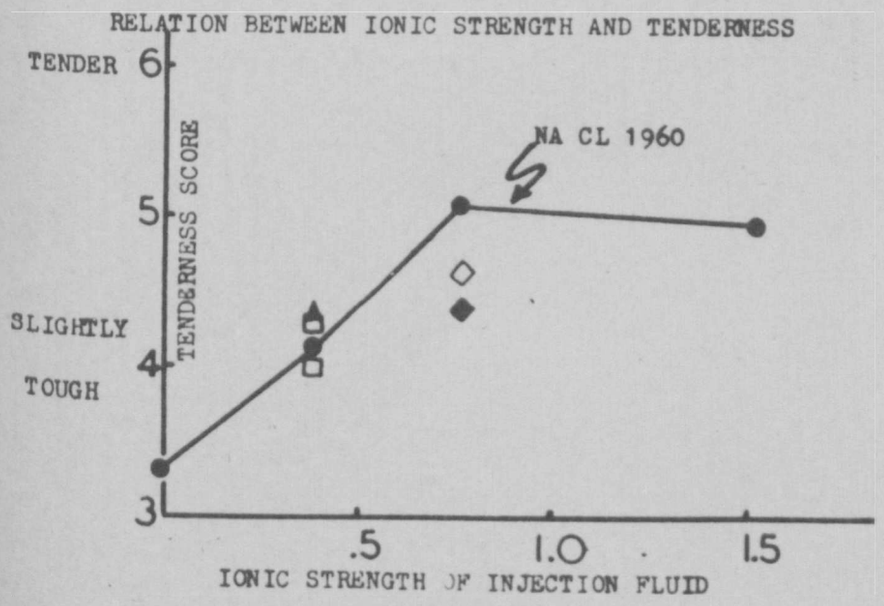

FIGURE 3 -(SLIDE 7)