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The loss of minerals and proteins during the marination of meat.

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Background

It is well known that marinating meat may cause great losses of proteins and minerals (Howat et al., 1983; Gault, 1985; Seuss and Martin, 1993). For instance, up to 25 % of the nitrogenous material was lost in marinating meat of 1 cm thickness in acetic acid (Gault, 1985). The losses have a negative impact on the nutritional value, as well as the taste, of the marinated meat. In spite of this, few attempts have been made to investigate the underlying principles of the phenomenon.

Objectives

To obtain a physical insight into the principles that determine the amount of minerals and proteins lost during the marination of thin pieces of meat.

Method

Slices 5 mm thick of beef *semitendinosus* were marinated in acetic acid. Two concentrations of the acetic acid were investigated, 0.017 M (0.1 %) and 0.042 M (0.25 %). The weight of the marinade divided by the weight of the meat was taken as 1, 3, 10 and 30 respectively. The unmarinated meat and the marinade were analysed with respect to minerals and nitrogen.

Results and Discussion

We point out that we, in order to minimise diffusion barriers, consider thin pieces of meat. For simplicity we denote the nitrogenous material as proteins. We also introduce the dilution parameter, R, as the initial weight of the marinade divided by the weight of the meat. The chemical analysis of the unmarinated meat and the marinades after 2 days of marination are given in Table 1. The numbers shown are raw data obtained during single experiments only. The relative uncertainties may be large, in particular for calcium. The results show that the concentration of the components decreases as the dilution parameter increases.

Let us consider a completely water soluble component α. At equilibrium, the chemical potential of α is the same in the meat as it is in the marinade. If deviations from ideal behaviour are neglected, the concentration, C, will be equal in the meat and the marinade. Thus, we have

$$C_\alpha^{\text{Meat}} = C_\alpha^{\text{Marinade}} \qquad (1)$$

It is appropriate to mention here that a somewhat more realistic approximation would be obtained by taking excluded volume effects, caused primarily by the myofibrillar proteins, into account.

Using eq. (1) and neglecting any density differences in the system, the concentration of the component α in the marinade at equilibrium becomes

$$C_\alpha^{\text{Marinade}} = C_\alpha^{\text{Ref}}/(1+R) \qquad (2)$$

where C_α^{Ref} is the concentration in the unmarinated reference. From the chemical analysis of the marinade in Table 1, we may use eq. (2) to predict the amount of different components in the unmarinated reference. The predicted numbers for the mineral and protein content of the reference are shown in Table 2. The results for potassium and magnesium agree well with the chemical analysis of the reference. This confirms that eq. (1) is applicable. It indicates that practically all the potassium and magnesium are either present as free ions or bound to components which are water soluble. The situation is different for protein and calcium. For a small dilution parameter, about 25 % of the protein content appears to be water soluble. This is close to the expected content of sarcoplasmic proteins. For a higher dilution parameters, the protein content of the marinade increases. This is related to the decrease in pH with increasing dilution parameter. At a sufficiently low pH, the myofibrillar proteins are extracted from the meat. The results for calcium, which to some degree is bound to the myobibrillar structure, are similar to those of the proteins.

Some of the mineral and protein losses in the present study are extremely large. Close to 100% of the magnesium and potassium was removed from the meat at high dilution parameters. The fact that previous investigations (Howat et al., 1983; Gault, 1985; Seuss and Martin, 1993) have found smaller losses is most likely due to marinating meat of larger dimensions. Presumably, diffusion barriers prevent the components from the interior of the meat from reaching the marinade. One should also note that the same arguments used in the present work can also be used to estimate the amount of different components in the fresh marinade that is taken up by thin pieces of meat during marination.

Conclusions

The present conclusions are drawn from experiments with thin pieces of meat, where diffusion barriers are expected to be small. The water soluble meat components appear to be distributed with a similar concentration in the marinade as they are in the meat. Components which to some degree are bound to the myofibrillar proteins have a reduced concentration in the marinade. As the

myofibrillar proteins are extracted, the concentration of these particular components increases in the marinade. The same principles discussed in this work can be applied to the uptake of water soluble components by the meat from the marinade.

References

Gault, N. F. S. (1985) *Meat Science*, 15, 15.
Howat, P. M., Sievert, L. M, Myers, P. J, Koonce, K. L. and Bidner, T. D (1983) Journal of Food Science 48, 662.
Seuss, I. & Marint, M. (1993) *Fleischwirtschaft*, 73 (3), 292.

Table 1. Raw data from chemical analysis of the various marinades after 48 hours of marination. The uncertainty in some numbers may be large.

		R	Protein %	K (ppm)	Mg (ppm)	Ca (ppm)
Meat		-	22.7	3610	270	40
HAc (%)	0.1	1	3.27	2250	129	5.2
	0.1	3	1.38.	1018	67	2.9
	0.1	10	0.61	338	23	0.7
	0.1	30	0.33	132	8.5	2.2
	0.25	1	3.20	2203	110	6.5
	0.25	3	1.51	1085	82	3.1
	0.25	10	0.80	361	23	1.6
	0.25	30	0.62	129	6.9	1.0

Table 2. Estimation of the amount of proteins and minerals in the unmarinated meat using the chemical analysis of the marinade and eq. (2). The chemical analysis of the unmarinated meat is also given.

		R	Protein %	K (ppm)	Mg (ppm)	Ca (ppm)
Meat		-	22.7	3610	270	40
HAc (%)	0.1	1	6.5	4500	260	10
	0.1	3	5.5.	4100	270	12
	0.1	10	6.7	3700	250	8
	0.1	30	10.2	4100	260	48
	0.5	1	6.4	4400	220	13
	0.25	3	6.0	4300	330	12
	0.25	10	8.8	4000	250	18
	0.25	30	19.2	4000	210	31