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DIFFUSIONAL STUDY ON SODIUM AND POTASSIUM CHLORIDE IN FRESH BOVINE AND PORCINE MUSCLE

E.A.PEÑA RAMOS, N.F. GONZALEZ-MENDEZ, J.P. CAMOU, M.I. SILVEIRA, J.A. MARTINEZ AND L.G. CUMPLIDO.
CENTRO DE INVESTIGACION EN ALIMENTACION Y DESARROLLO, A.C., P.O. Box 1735, 83000, Hermosillo, Sonora, MEXICO.

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The effects of excessive sodium in the diet has prompted the industry to reduce its amount in some products for a special segment of consumers. This is accomplished by substituting sodium chloride by other chlorinated salts, mainly potassium salt. In the curing process of whole meat products like hams, the length of time required for uniformity of cure distribution is determined by the rate of salt diffusion in muscle tissue (Fox, 1980; González-Méndez et al., 1985). For this reason, it is convenient to know the diffusional behavior of low sodium salt mixtures (NaCl and KCl) in meats. Solute diffusion in meats is controled by Fick's law. However, since meats have a very heterogenous structure, diffusion coefficients (DC) or diffusion rate of curing ingredients have to be experimentally determined. It is possible to find in the literature studies over DC in meat (beef and pork) on solutes like chloride, nitrite, and nitrates (Dussap and Gros, 1980; Fox, 1980; Gros et al., 1984; González-Méndez et al., 1985; Djelveh and Gros, 1988), but there is a lack of information for NaCl, KCl, and their mixtures.

Gros et al. (1984) mentioned a possible influence by species for diffusion rate of chloride. Some studies have shown higher DC values for beef muscles than in those for pork (Dussap and Gros, 1979; Fox, 1980; Djelveh and Gros, 1988). Comparisson between chloride DC data for beef and pork muscle is difficult to make, since they were measured and calculated with different equations, temperatures and muscles. The objective of this study was to determine DC for chloride, sodium and potassium in *Longissimus dorsi* muscle from beef and pork.

MATERIALS AND METHODS

Longissimus dorsi muscles from beef and pork were obtained 24 h postmortem. They were selected free of pale, soft and exudative and dark, firm and dry conditions for pork and beef respectively. They were also selected with low content of intramuscular fat. Every muscle was divided in four diferent portions, and each one was placed inside of an acrilic mold (González-Méndez et al., 1985) and cured in a random maner with 60 g of NaCl and KCl mixtures. These mixtures of NaCl:KCl were: M1 (100:0), M2 (80:20), M3 (60:40), M4 (40:60), M5 (20:80) AND M6 (0:100). This curing was done at 2°C during 8 days. At the end of this time, meat portions were sectioned into 1 cm slices, and sodium, potassium and chloride concentration was determined. Sodium and potassium content were determined by atomic absorption spectrophotometry by emission (Varian Sectra AA-20) according to Grijalva et al. (1990). Chloride concentration was obtained using the procedure of González-Méndez et al. (1985).

Apparent diffusion coefficient calculation.- This was done using the equation by Dussap and Gros (1979) for a semifinite medium. DC was estimated by the non-linear regression method using DUD algorithm (Ralston and Jennrich, 1979). Unkown variables were DC and Mo (initial amount of solute in contact with meat). SAS (1991) was used, and Tukey test was done to compare means ($P<0.05$) of DC for each ion from different mixtures and for species.

RESULTS AND DISCUSSION

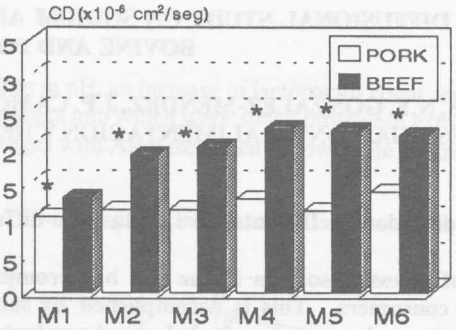
DC values for sodium, potassium and chloride in beef and pork are shown in table 1. Chloride's DC in pork for M1 were a little bit lower than results reported elsewhere, range was $1.20\text{-}2.21 \times 10^{-6}$ cm^2/sec (Wistreich et al., 1960; Fox, 1980; Dussap and Gros, 1979; Djelveh and Gros, 1988). On the other side, for beef, DC values are very different from other studies (Fox, 1980; Dussap and Gros, 1979; Djelveh and Gros, 1988). This might be because of the type of muscle and/or the equation used to calculate DC. In those studies the *Semitendinosus* muscle was used, and it is leaner than the *Longissimus dorsi*. Fat has been considered as a possible obstacle for chloride diffusion in meat (Fox, 1980).

The highest chloride's DC in pork was obtained in mixtures M4 and M6 ($P<0.05$) and the lowest value was in M1, this also happened for beef. Sodium ion had a maximum DC in M4 in pork meat. However, this value was statistically similar to DC in M2, M3 and M5. For this reason, independently of the amount of potassium in the mixture, sodium's DC does not present a significant variation. For beef, sodium's DC significantly varied due to mixture effect. In both types of meats a positive effect was observed in the presence of potassium ion in the mixture over the sodium's DC values. This ion was diffused slower in potassium presence. Potassium ion diffusion, for both beef and pork, showed an ascending behavior when sodium concentration was increased in the mixture. These results show a possible interaction between ions in the mixture (Na and K). When comparing values between DC for sodium and potassium within a mixture, it is possible to note that they diffused with a similar velocity in mixtures M3 and M4. When these ions were not in the mixture, M1 and M6, sodium's DC was higher than for potassium in both species.

Figure 1 shows the comparisson between DC values for chloride in beef and pork. DC values in beef are higher than in pork, this agrees with findings by Gros et al. (1984). Figure 2 shows sodium's DC in beef and pork, where no differences were obtained within the same mixture. Potassium's DC for beef and pork are shown in figure 3. In this figure it can be observed that Potassium's DC for M2, M5 and M6 were different ($P<0.05$) for pork and beef.

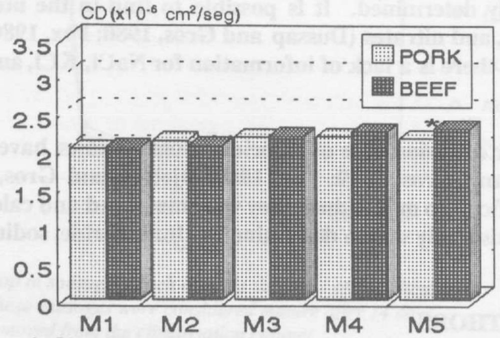
Table 1. Diffusion Coefficients (x 10^6 cm^2/seg) for pork and beef *L. dorsi*.

	Pork			Beef		
	Chloride	Sodium	Potassium	Chloride	Sodium	Potassium
M1	1.044	2.027		1.309	2.047	
M2	1.135	2.104	2.386	1.892	2.071	2.239
M3	1.146	2.189	2.218	2.010	2.205	2.134
M4	1.286	2.199	2.139	2.270	2.268	2.048
M5	1.123	2.172	1.833	2.240	2.304	1.965
M6	1.388		1.311	2.173		1.904



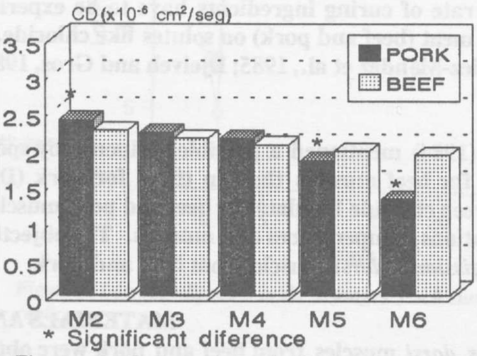
* Significant diference

Figure 1. Comparison between pork and beef chloride diffusion coefficients (DC) for each mixture (M).



* Significant diference

Figure 2. Comparison between pork and beef sodium diffusion coefficients (DC) for each mixture (M).



* Significant diference

Figure 3. Comparison between pork and beef potassium diffusion coefficients (DC) for each mixture (M).

CONCLUSIONS

DC values were higher in all tratments for sodium and potassium when they were combined, independently of cure mixture and species, than when they were alone. DC for chloride and potassium were higher ($P<0.05$) in beef (except potassium in M2) than in pork. In contrast, DC for sodium were not affected by species.

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