S7P25.WP

DETERMINATION OF DIFFUSION COEFFICIENTS OF CHLORIDE, SODIUM AND POTASSIUM IONS IN PORK MEAT

E.A. PEÑA, N.F. GONZALEZ-MENDEZ, M.I. GRIJALVA, M.I. SILVEIRA*, J.A. MARTINEZ, J.P. CAMOU and L.G. CUMPLIDO

Centro de Investigación en Alimentación y Desarrollo, A.C., Apartado postal 1735, Carretera a la Victoria Km 0.6, 8300 Hermosillo, Sonora, México

* Universidad de Sonora. Centro Coordinador de la Investigación, Avenida Rosales y Boulevard Transversal, 83000 Hermosillo, Sonora, México

INTRODUCTION

Amongst the proposed methods to reduce salt in processed meats (sodium content reduction), it can be found the one that substitutes sodium chloride by other chlorinated salts (Hand *et al.*, 1982; Maurer, 1983; Terrell, 1983; Keeton, 1984; Frye *et al.*, 1986; Pasin *et al.*, 1989).

Knowledge of the velocity of which salt and/or cure ingredients migrate is very important to establish the required time for a good distribution and to optimize the methods that contribute over ingredient penetration, diffusion and distribution like injection, tumbling and/or massaging, resting periods and electrical stimulation (Ockerman and Organisciak, 1978; Ockerman and Dowiercial, 1980; Ockerman and Kwiatek, 1985; Kemp and Fox, 1985). Diffusion coefficient allows to know said velocity. It has been experimentally determined apparent coefficients (Da) for chloride, nitrite and nitrate in pork and beef (Dussap y Gros, 1980; Fox, 1980; Gros *et al.*, 1984; González-Méndez *et al.*, 1985; Djelveh and Gros, 1988). There were not found studies on Da for sodium (Na) and potassium (K) ions nor their mixtures.

The objective of this study was to experimentally determine the behaviour of diffusion velocity for NaCl and KCl, in their ionic form (Cl^-, Na^+ and K^+), added individually or mixed to pork *m.longissimus dorsi.*

MATERIALS AND METHODS

Pork *longissimus dorsi*, 24 hours post-mortem, free of the pale, soft and exudative condition was used. Each muscle was cut in four parts.

Method

An acrylic mold containing the muscle and salts was used (González-Méndez *et al.*, 1985).

Salt mixtures

Sodium and potassium chloride (Sigma) with a 99.5 and 99.9% purity, respectively, were used. Mixtures of NaCl:KCl were: M1 (100:0), M2 (80:20), M3 (60:40), M4 (40:60), M5 (20:80) and M6 (0:100). Every mixture was applied to a piece of muscle randomly selected.

Dry salting

Every mold was assembled and the muscle's free surface was put in contact with 60g of salts accordingly to González-Méndez *et al.* (1985). Salting was done at 2 °C for eight days. Two repetitions were done for each salt mixture.

Sample preparation

Every salted muscle was sectioned in 1cm thick slices (González-Méndez *et al.*, 1985).

Sodium, potassium and chloride analyses

These analyses were done on each muscle slice. Sodium and potassium were analyzed by atomic absorption espectrophotometry by emission (Varian Sectra AA-20) accordingly to Grijalva *et al.* (1990). Chloride quantification was done with a chloride analyzer (Corning, model 925) following the method by González-Méndez *et al.* (1985).

Apparent diffusion coefficient calculation

This was done using the equation by Dussap and Gros (1980) on its logarithmic way. Concentration (C) of each ion from each muscle slice was determined through the length (z) of the muscle piece. Values of ln C were plotted as a function of z^2. From a simple linear regression slope Da was calculated which is equal to -1/4Dat.

Statistical analysis

The Statistical Analysis System (SAS 1986) was used. Tukey's test ($P<0.05$) was used to compare average ion's Da from the different mixtures.

RESULTS AND DISCUSSION

Table 1 shows Da values from sodium, potassium and chloride for each studied mixture. The value for the apparent diffusion coefficient for chloride ion agreed with the ones reported by Fox (1980) and González-Méndez *et al.* (1985). This value ranged from 2.32 to 2.83 x 10^{-6} cm^2/sec and they were not significant different ($P>0.05$). This shows that Na and K ions have no influence on chloride ion migration.

Da values for sodium ranged from 1.04 to 3.06 x 10^{-6} cm^2/sec, they were not significant different ($P>0.05$). For the potassium ion, the apparent diffusion coefficient was 1.76 to 3.26 x 10^{-6} cm^2/sec and there was no difference ($P>0.05$).

Both ions showed similar Da range. No Da values were found, for this two ions, in the literature.

CONCLUSION

The experimental model and its mathematical expression used in this study were confirmed by means of chloride's Da determination. This value was not different ($P>0.05$) between different mixtures, and it was found to be similar to the ones reported in the literature.

It is suggested to continue this kind of experiment in order to understand the reasons of Da variation for Na and K. It is probable that part of this is due to variability of tissue content (connective, adipose, etc.) in the meat material, which could interfere with ion migration.

ACKNOWLEDGEMENTS

The present study was done under a grant from Secretaría de Educación Pública (DGCSA), 1991 and 1992.

REFERENCES

DJELVEH, G., and GROS, J.B. 1988. Measurement of Effective Diffusivities of Ionic and Non-ionic Solutes through Beef and Pork Muscles using a Diffusion Cell. *Meat Sci.* 23:11-20.

DUSSAP, C.G., and GROS, J.B. 1980. Diffusion-sorption model for the penetration of salt in pork and beef muscle. In: LINKO, P., MALKKI, Y., OLKKU, J., and LARINKARI, J. (eds). *Food Process Engineering. Vol. 1.- Food Processing Systems*. Applied Science Publishers Ltd., London. pp.407-411.

FOX, J.B. 1980. Diffusion of chloride, nitrite and nitrate in beef and pork. *J. Food Sci.* 45:1740-1744.

FRYE, C.B., HAND, L.W., CALKINS, C.R., and MANDIGO, R.W. 1986. Reduction or replacement of sodium chloride in a tumbled ham product. *J. Food Sci.* 51:835-837.

GONZALEZ-MENDEZ, N.F., GROS, J.B., POMA, J.P., and RAMOS, E. 1985. Influencia de la congelación sobre la difusión del cloruro sódico en el músculo *Longissimus dorsi* del puerco. *Revista de Agroquímica y Tecnología de Alimentos.* 25(2):279-286.

GRIJALVA, M.I., VALENCIA, M.E., and WYATT, J. 1990. Contenido de sodio, potasio y calcio en platillos típicos consumidos en Sonora, México. *Archivos Latinoamericanos de Nutrición.* XL(6):293-301.

GROS, J.B., DUSSAP, C.G., and GONZALEZ-MENDEZ, N.F. 1984. Solute diffusivities in meat: A review. In: McKENNA, B.M. (ed). *Engineering and Food. Volume 1.- Engineering Sciences in the Food industry.* Elsevier Applied Science Publishers, London and New York. pp.287-297.

HAND, L.W., TERRELL, R.N., and SMITH, G.C. 1982. Effects of complete or partial replacement of sodium chloride on processing and sensory properties of hams. *J. Food Sci.* 47:1776-1778,1782.

KEETON, J.T. 1984. Effects of potassium chloride on properties of country-style hams. *J. Food Sci.* 49:146-148.

KEMP, J.D., and FOX, J.D. 1985. Effect of needle tenderization on salt absorption, yields, composition and palatability of dry-cured hams produced from packer style and skinned green hams. *J. Food Sci.* 50:295-299.

MAURER, A.J. 1983. Reduced sodium usage in poultry muscle foods. *Food Tech.* 37(7):60-65.

OCKERMAN, H.W., and ORGANISCIAK, C.S. 1978. Diffusion of curing brine in tumbled and non-tumbled porcine tissue. *J. Food Prot.* 41(3):178-181.

OCKERMAN, H.W., and DOWIERCIAL R. 1980. Influence of tumbling and electrical stimulation on distribution and content of sodium nitrite and sodium chloride in bacon. *J. Food Sci.* 45:1301-1304.

OCKERMAN, H.W., and KWIATEK, K. 1985. Distribution and rate of migration of curing ingredients (nitrite, salt, glucose) in pork tissue as affected by electrical stimulation. *J. Food Sci.* 50:492-494.

PASIN, G., O'MAHONY, M., YORK, G., WEITZEL, B., GABRIEL, L., and ZEIDLER, G. 1989. Replacement of sodium chloride by modified potassium chloride (cocrystalized disodium-5'-inosinate and disodium-5'-guanylate with potassium chloride) in fresh pork sausages: acceptability testing using signal detection measures. *J. Food Sci.* 54:553-555.

TERRELL, R.N. 1983. Reducing the sodium content of processed meats. *Food Tech.* 37(7):66.

WIRTH, F. 1990. Reducción de Sal Común en los Productos Cárnicos. Posibilidades y limitaciones. *Fleischwirtsch. español.* 1:46.

Table 1. Apparent diffusion coefficient (Da) for sodium, potassium and chloride ions (10^6 cm^2/sec).

MIXTURE	SODIUM	POTASSIUM	CHLORIDE
M1	3.06±0.104		2.57±0.967
M2	2.56±0.388	3.02±0.418	2.49±0.189
M3	2.41±1.061	1.97±0.128	2.83±0.678
M4	2.95±0.198	3.26±0.352	2.48±0.310
M5	1.04±0.215	2.47±0.675	2.49±0.048
M6		1.752±0.604	2.32±0.148