THE EFFECT OF SODIUM CHLORIDE CONTENT AND TEMPERATURE ON PINTADO FISH (*PSEUDOPLATYSTOMA CORRUSCANS*) MEAT ISOTHERMS

Gabas, Ana L.[1]; Telis, Vânia R. N.[2]; Romanelli, Pedro F.[2]; Telis-Romero, Javier[2]
[1] Universidade de São Paulo – Faculdade de Zootecnia e Engenharia de Alimentos (FZEA), Pirassununga/SP/Brazil
[2] Universidade Estadual Paulista - Departamento de Engenharia e Tecnologia de Alimentos, São José do Rio Preto/SP/Brazil
Email: romaneli@eta.ibilce.unesp.br

Background

Pintado (*Pseudoplatystoma corruscans*) is a large-sized freshwater fish from Pantanal of Mato Grosso, Brazil, having high precocity and prolificacy. Stability and safety of such a species depends on water "availability". Water is the most important component in food systems, since it exercises a strong influence over process variables, product characteristics and stability attributes. Water mobility is considered as the key for product stability. Water availability indicates how freely water molecules can participate in reactions. A common approach in measuring water availability or water mobility in foods is that of water activity (A_W). An alternative to increase the shelf life of pintado meat could be the salting process. The use of sodium chloride in meat preservation precedes a lot the appearance of cooling. The process consists of promoting the removal of water from tissue, initially by changing the osmotic pressure with salt addition, and later, by drying. The objective is to reduce the water activity, inhibiting the microbial development and also reducing rates of undesirable reactions in the final product. The sorption isotherm is an equilibrium relationship that links the moisture content of a product with the temperature and relative humidity of the surrounding air, being of fundamental importance for processing and storage of dehydrated foods. The sorption characteristics of meat can be changed by different factors, such as temperature and dissolved solutes. In general, an increase in temperature decreases the water content at a given water activity, whereas differences between electrolytic and non-electrolytic solutions as well as the amount of positively and negatively charged ions play an important role in the sorption process (OKOS *et al.*, 1992). Empiric and semi-empiric equations have been used to correlate the experimental data of sorption isotherms, but although many authors have studied sorption isotherms of meat and meat products, only a few studies have investigated how NaCl affects the sorption process (COMAPOSADA *et al.*, 2000).

Objectives

The objective of this work was to determine sorption isotherms of salted and dehydrated pintado meat, as well as investigating the quality of adjustment of the main recommended isotherm models to experimental data.

Methods

Meat samples were taken from thigh muscle of pintado and submitted to the wet salting process in 30% (w/w) NaCl-water solutions for 16 hours. After salting, samples were dried in convection oven for 13 hours. Desorption isotherms were determined gravimetrically by exposing meat samples to several relative humidities provided by saturated salt solutions. Eight different relative humidities were obtained with saturated solutions of LiCl, $KC_2H_3O_2$, $MgCl_2$, K_2CO_3, $Mg(NO_3)_2$, $NaNO_2$, NaCl, and KCl. The temperature effect was studied by obtaining sorption data at 5, 10 and 15°C. Samples, in triplicate, were placed inside desiccators containing the saturated salt solutions in the bottom, stored in a chamber with controlled temperature, and weighted at regular time intervals until reach equilibrium, which was indicated by no detectable weight changes. The samples moisture content was then measured by the gravimetric method carried out in an oven at 105°C until constant weight.

The models fitting to sorption data were accomplished by non-linear regression using the software Origin v. 3.5 (Microcal Software, 1994). Evaluation of the best adjustment was made through analysis of the coefficient of determination of the adjustment (R^2) and of the root of the mean square of residues (RMS). The following isotherm models were considered to describe experimental data:

BET (BRUNAUER *et al.*, 1938): $X=X_m C\,a_w/[(1 - a_w) + (C - 1)(1 - a_w)a_w]$

Lewicki (LEWICKI, 2000): $X=[F/(1 - a_w)^G]-[F/(1+a_w^H)]$

Halsey Modified (HALSEY, 1948): $X=[k_H/\ln(C_H/a_w)]^{(1/r)}$

GAB (LABUZA et al., 1985): $X/X_m=(C_G k_G a_w)/[(1 - k_G a_w)(1 - k_G a_w + C_G k_G a_w)]$

In the above equations, $C, F, G, H, C_H, k_H, r, C_G$ and k_G are constants; a_w is the water activity (relative humidity of salt solutions); X is the moisture content in dry basis (kg water/kg dry matter) and X_m is the monolayer moisture content in dry basis (kg water/kg dry matter).

Results and Discussion

The experimental equilibrium moisture contents obtained at different values of water activity and temperature are shown in **Table 1**, whereas **Table 2** shows the calculated parameters for the tested models and the resultant values of R^2 and RMS. Taking into account the results of the statistical parameters R^2 and mainly RMS, the Halsey Modified model provided the best fitting to sorption data.

The obtained isotherms could be considered as being of type III, according the classification of BRUNAUER *et al.* (1940). This type of sorption curve has been obtained for other salted meat products and its shape is attributed to the presence of NaCl. This salt bounds a small amount of water at a_w below 0.75, which corresponds to its saturated solution relative humidity. On the other hand, when water activity increases above this value, there is a large increase in water sorption even for small increases in a_w. The NaCl solution crystallizes below water activity of 0.75, therefore the crystallized salt adsorbs little or no water, and the reduction in a_w is due to adsorption by non-solutes, such as proteins; above its saturation point a solution is produced and the sorption is determined by the presence of dissolved NaCl as well as proteins (DELGADO & SUN, 2002).

Experimental data have also shown that decreasing temperature leaded to a small increase in equilibrium moisture content at the same water activity.

Conclusions

1) The Halsey Modified model showed the best fitting to sorption isotherms of salted and dehydrated pintado meat.

2) Sorption isotherms behaved as type III isotherms, with little water adsorption at a_w lower than 0.75 and sudden increase in equilibrium moisture content above this a_w value. This behavior could be attributed to the NaCl presence.

3) Decreasing temperature leaded to a small increase in equilibrium moisture content at the same water activity.

Table 1. Equilibrium moisture contents (dry basis) of salted and dehydrated pintado meat and corresponding values of water activity at different temperatures.

5°C		10°C		15°C	
a_w	X (d. b.)	a_w	X (d. b.)	a_w	X (d. b.)
0.113	0.387	0.113	0.394	0.112	0.393
0.247	0.725	0.248	0.739	0.245	0.737
0.333	0.885	0.335	0.902	0.331	0.899
0.448	1.161	0.451	1.183	0.446	1.180
0.550	1.996	0.553	1.704	0.547	1.480
0.658	2.445	0.663	2.124	0.655	1.782
0.758	3.088	0.763	2.635	0.753	2.293
0.857	3.941	0.862	3.359	0.852	2.929

Table 2. Parameters of GAB, Halsey Modified, BET and Lewicki models for salted and dehydrated pintado meat at different temperatures.

Model	T (°C)	Parameter			RMS	R^2
		X_m	C_G	k_G		
GAB	5	3.696	1.010	0.601	92	0.991
	10	1.436	2.927	0.744	23	0.997
	15	0.996	5.692	0.804	3	0.999
		k_H	C_H	r		
Halsey Modified	5	2.195	3.163	0.378	80	0.993
	10	1.781	2.163	0.547	15	0.998
	15	1.394	1.543	0.799	10	0.998
		X_m	C			
BET	5	0.654	36.094		1233	0.889
	10	No convergence				
	15	No convergence				
		F	G	H		
Lewicki	5	0.742	0.852	-1.947	804	0.927
	10	0.702	0.772	-1.831	428	0.941
	15	0.638	0.770	-1.642	202	0.960

References

BRUNAUER, S., DEMING, L. S., DEMING, W. E. & TELLER, E. (1940). On a theory of the Van der Waals adsorption of gases. Journal of the American Chemical Society, 62, 1723-1732.

BRUNAUER, S., EMMETT, P. H. & TELLER, E. (1938). Adsorption of gases in multimolecular layer. Journal of the American Chemical Society, 60, 309-319.

COMAPOSADA, J., GOU, P. & ARNAU, J. (2000). The effect of sodium chloride content and temperature on pork meat isotherms. Meat Science, 55, 291-295.

DELGADO, A. E. & SUN, D.-W. (2002). Desorption isotherms for cooked and cured beef and pork. Journal of Food Engineering, 51, 163-170.

HALSEY, G. (1948). Physical adsorption on non-uniform surfaces. Journal of Chemical Physics, 16, 931-937.

LABUZA, T. P., LOMAURO, C. J. & BASKSHI, A. S. (1985). Evaluation of food moisture sorption isotherm equations. Part I: Fruit, vegetable and meat products. Lebensmittel-Wissenschaft Und-Technologie, 18, 111-117.

LEWICKI, P. P. (2000). Raoul´s law based food water sorption isotherm. Journal of Food Engineering, 43, 31-40.

OKOS, M. R., NARSIMHAN, G., SING, R. K. & WEITNAUER, A. C. (1992). Food dehydration. In D. R. HELDMAN & D. B. LUND. *Handbook of Food Engineering*, 440 p. Marcel Dekker, New York.

Acknowledgements

Authors thank to Fapesp for financial support.