SORPTION ISOTHERMS AND DIFFUSION COEFFICIENT OF WATER IN SALAMI

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BACKGROUND

Sorption isotherms are used in food science and technology for a number of purposes, the main fields of application being in drying, mixing, packaging and storage. Drying is one of the most important techniques for food preservation, the lowering of the water activity (aw) value is the main factor leading to the final keeping quality of fermented sausages (1).

To obtain comprehensive data on the water relation of a food, the aw levels corresponding to a range of water contents must be determined: these are plotted to provide a water sorption isotherm. This isotherm is useful not only in showing at what water contents certain desirable or undesirable levels of aw are achieved, but also in describing what significance any change in water content will have in terms of aw (2).

OBJECTIVES

The present study was undertaken to determine the sorption isotherm and the diffusion coefficient of water on two different kinds of Italian salami, Crespone-Milano (Ø 90 mm) and Turista Buonpiemonte (Ø 60 mm), processed at the Raspini S.p.a. factory at Scalenghe (Italy), and on one type of Spanish salami, Salchichon Cular Cosido (Ø 80 mm), processed at Embutidos Cordon, Cordoba (Spain).

MATERIAL AND METHODS

Determination of sorption isotherms

Six solutions with known aw values (0.529,0.577,0.708,0.753,0.843,0.903) were prepared as described in the literature (3). These solutions were placed in the lower portion of 12 sorption containers; in the upper portion of these container the 2 mm thick slices of the sausages under study were placed in triplicate.

The water sorption isotherms were determined for each kind of sausage both at the end of the drying stage and on the end product at two different temperatures (10°C and 20°C); on the whole, 12 water sorption isotherms were built.

From every sausage the two end portions of lenght equal to the diameter were cut off with the purpose to obtain a central cylinder for the slices preparation.

A sample (about 100 g) was drawn from each salami and was analysed for the determination of the pH-value and water, salt, fat and protein contents by the official AOAC methods.

The course of the weight loss was followed at regular time intervals until reaching 56 days for the Italian salami and 49 days for Spanish sausage.

The theoretical equilibrium weight value (We) was calculated by means of the regression Weight=f(t) expressed as: $W=A+B*\exp(-C*t)$ by determining the values of the parameters A, B and C by the least squares method; in this equation the value of A is equal to We and (A+B) represents the initial weight of the slice (Wo).

The water sorption isotherms were described by Xe=f(aw), where Xe is the mass ratio (water mass/dry mass) at the thermodinamic equilibrium; Xe was calculated by subtracting from the water content of each slice at the end of the experiment, obtained by chemical analyses, the difference between the last experimental weight and the theoretical equilibrium weight value (We).

The Oswin's model : $Xe=k*(aw/1-aw)^n$ was adopted for the description of the water sorption curves where k and n were calculated by means of the regression of the curve (4).

The choice of the Oswin model was made on the basis of the range of the aw-values chosen for the sorption experiment (i.e. Relative Humidity range usually covered in the drying and ripening procedures of fermented sausages).

Determination of diffusion coefficient of water

This study has been done by adopting the same experimental design for sorption isotherms. The diffusion coefficients were calculated by means of the equation of weight loss on long time (5): $\ln (Wt-We/Wo-We) = \ln (8/\pi^2) - (\pi^2*D*t)/4L^2$

where D=diffusion coefficient of water in slice [m^2/s], L=tickness of the slice [m], Wo=the weight of the slice at initial time [Kg], We=the weight of the slice at the thermodynamic equilibrium [Kg], Wt= weight at time t.

RESULTS AND DISCUSSION

Table 1 shows the results of the chemical analyses of the samples for the sorption experiment.

The weight loss rate of the sausage slices depends directly on the initial water content of the slices and is haigher at 20 °C and at the lower aw-values.

The equilibrium time was very large for some samples, depending on the aw-value maintained in the sorption containers; the calculation of the equilibrium weight We made by adopting the above referred mathematical model was very useful, especially in these cases, and gave in all cases very good estimates and excellent correlation.

The Oswin model gives the best correlation with the experimental points.

The calculated values of the Oswin parameters (Table 2) show that the sorption properties of the salami fall within a narrow range of variation.

Figures 1 and 2 show the sorption isotherm at the end of drying and ripening for the three different types of salami.

The diffusion coefficients of water, reported in Table 1 are very similar at the two temperature tested and at the two stage of processing.

REFERENCES
1- L. Leistner in "Water Activity: Theory and Application to Food", p.295, edited by L.B. Rockland and L.R.Beuchat , Marcel Dekker Inc., New York and Basel, 1987
2- S.Gal in "Physical Properties of Foods", p.13, Applied Science Publishers, London and New York, 1983.
3- Commission of the European Communities, Community Bureau of Reference, Report EUR 12429, 1989.
4- Oswin, C.R. J.Chem.Ind. (London), 64, 419 (1946)
5- A.C.Janson and G.R.Peters, J.Phys. D:Appl.Phys., 6, 512,(1973)

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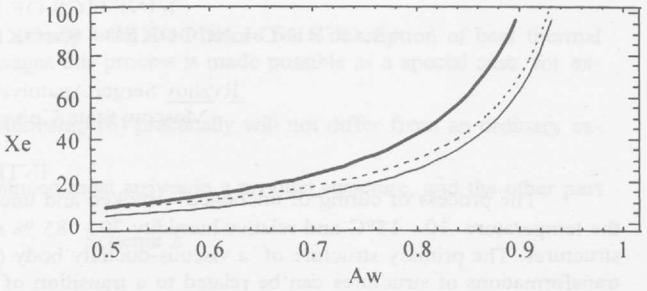

Fig. 1. Sorption isotherms 20°C) at the end of drying for Turist Buonpiemonte (—), Crespone Milano (---) and Salchichon Cula Cosido(—).

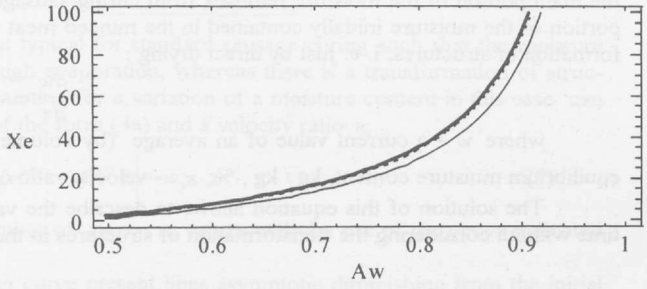

Fig. 2. Sorption isotherms (20°C) at the end of drying for Turist Buonpiemonte (—), Crespone Milano (---) and Salchichon Cula Cosido(—).

Chemical analyses (w/w %)	C.M. (end of drying)	C.M. (end of ripening)	T.B. (end of drying)	T.B. (end of ripening)	S.C.C. (end of drying)	S.C.C. (end of ripening)
moisture	43.53	40.42	45.85	43.77	44.16	44.96
salt	3.43	4.01	3.11	3.78	2.99	2.95
proteins	20.43	20.67	18.78	22.93	22.45	19.81
fat	31.00	33.46	30.15	27.49	28.79	31.28
pH	5.16	5.24	5.20	5.2	4.61	4.56

Table1. Chemical analyses of the salami samples used for the determination of the sorption isotherms. C.M.= Crespone Milano T.B.=Turista Buonpiemonte S.C.C.=Salchichon Cular Cosido

		End of drying		End of ripening	
S.i.	**T °C**	**K**	**n**	**K**	**n**
T.B.	20	6.9651	0.944	7.9982	0.934
T.B.	10	7.5842	0.857	9.3529	0.811
C.M.	20	6.5588	0.872	8.2012	0.854
C.M.	10	6.3273	0.973	9.1508	0.887
S.C.C.	20	9.2140	0.808	7.9840	0.807
S.C.C.	10	10.504	0.744	9.0630	0.814

Table 2 Oswin parameters for the different sausages.
S.i.=sample identification

salami Aw	Crespone Milano				Turista Buonpiemonte				Salchichon Cular Cosido			
	end of drying		end of ripening		end of drying		end of ripening		end of drying		end of ripening	
	10 °C	**20 °C**	**10 °C**	**20 °C**	**10 °C**	**20 °C**	**10 °C**	**20 °C**	**10 °C**	**20 °C**	**10 °C**	**20 °C**
0.903	6.00E-13	5.12E-13	8.29E-13	6.23E-13	1.71E-13	1.02E-13	3.30E-13	6.37E-13	3.02E-12	2.14E-12	3.68E-12	1.20E-12
0.843	3.21E-13	7.78E-12	4.74E-13	7.85E-13	7.97E-13	1.33E-13	4.96E-13	9.33E-13	1.39E-12	1.57E-12	7.29E-13	5.83E-13
0.753	6.82E-13	1.53E-12	6.11E-13	1.12E-12	8.96E-13	1.53E-12	6.80E-13	8.92E-13	1.30E-12	1.27E-12	2.70E-13	3.36E-13
0.708	6.70E-13	1.61E-12	8.66E-13	1.30E-12	9.66E-13	1.36E-12	6.57E-13	8.19E-13	8.36E-13	6.51E-13	4.15E-13	3.39E-13
0.577	1.22E-12	2.46E-12	1.65E-12	2.22E-12	1.43E-12	1.71E-12	1.39E-12	1.33E-12	5.31E-13	1.54E-12	8.28E-13	1.09E-12
0.529	1.61E-12	2.33E-12	1.46E-12	3.41E-12	2.16E-12	1.72E-12	1.57E-12	1.36E-12	1.59E-12	4.87E-13	8.28E-13	5.19E-13

Table 3. Effective diffusion coefficients of water (m^2/s) for "Crespone Milano", "Turista Buonpiemonte" and "Salchichon Cualr Cosido" salami.