Influence of Packaging and Storage Temperature on Cured Pork Blood Sausages Shelf-Life

Roseiro, L.C.; Santos, C.; Almeida, J.; Vieira, J.A.
Instituto Nacional de Engenharia e Tecnologia Industrial
Instituto de Biotecnologia, Química Fina e Tecnologias Alimentares - Departamento de Tecnologia das Indústrias Alimentares.
Estrada do Paço do Lumiar, 1699 Lisboa Codex, PORTUGAL.

Introduction

The consumption of blood pork sausages is quite popular in many south european countries. Differing from region to region on the addition of spices and on processing methodology, these products usually show a short shelf-life, due basically to their intrinsic raw material sensitivity to microbial spoilage and chemical deterioration.

It is generally accepted that haematic complexes are important catalysts of lipid oxidation in meat and meat products, namely the ferric forms (Greene, 1969). Moreover, cooking increases product susceptibility to oxidation, due to the denaturation of haem proteins, the source of a significant increase in the amount of non-haem iron (Igene *et al.*, 1979). This, rather than haem iron, is actively involved in the oxidation process (Sato & Hegarty, 1971; Love & Pearson, 1974; Apte & Morrissey, 1987). In addition, cooking also disintegrates the cellular membranes which facilitate the oxidation of highly unsatured fatty acids in the phospholipids (Renerre, 1990). The author also states that haem catalysis occurs only at low haem concentrations, and that, contrarily, an inhibition process takes place at high haem concentrations. The target of the present study was to evaluate the microbial and rancidity evolution of a typical portuguese blood sausage along a storage period of 3 months, held under different package and temperature conditions, in order to determine their proximate shelf-life.

Methods

Product characterization - "Morcela de Assar" basic raw materials consist of fatty trimmings and blood, including as most important seasonings and spices, cummin, garlic, vinegar, and Sodium Chloride. Nitrate/Nitrite salt is also used as an additive in the industrial production. Raw sausages are first cooked in boiling water or steam, till an internal temperature of 85°C, and then submitted to a short smoking period (40°-50°C), during which external colour and peculiar taste are transmitted and a slight aw reduction is achieved.

Preparation of samples - Samples collected from an industrial processing plant were held at 20°±2°C and 4°C, unpacked, packed under vacuum and MAP (50%N_2+50%CO_2), until used for analysis at day 0, 30, 60 and 90 of storage.

Chemical analysis - Total and non-haem iron were measured by the method described by Wang and Lin (1994). TBA (Thyobarbituric acid) was evaluated by the modified method of Tarladgis *et al.*, (1960) as described by Rhee (1978). Residual nitrite/nitrate and chloride were determined by the methods described in AOAC (1984). Peroxide index was determined by the method described by Pearson (1973) and expressed as miliequivalent of oxygen per Kg of fat.

Microbial analysis - Total aerobic plate counts (30°C) (ISO 4833-1991) and detection of coliforms (ISO 4831-1991), *E. coli* (ISO 3811-1979), *Staphylococcus aureus* (NF.V/08-014) and Spores of Clostridia SH_2^+ (NP-2262-1986) were performed.

Sensory analysis - Sensory evaluation of rancid odour in the product was carried out by 4 trained panelists on finely comminuted samples held in closed containers, according a four point scale (1-no rancid odour; 2-slight rancid odour; 3-moderate rancid odour; 4-extreme rancid odour).

Statistics - TBA number and peroxide values were analyzed using a Factorial model analysis of variance based on a completely randomized block experimental design (Norman and Bailey, 1981). Multiple range analysis of means was performed by the Ducan test.

Results and Discussion

General - Same batch and freshly processed blood sausage mean proximate compositions are depicted in Table 1. Differences in major parameters between samples probably reflect poor homogeneity in distribution of raw materials in casings and different time/temperature relationship during smoking/drying operation. Otherwise, the addition to the formulation of fatty trimmings with distinct fatty acid profiles and chilling storage times (different initial fat oxidation conditions) could also be the source of the apparent lack of consistency in trend of chemical parameter results with some factors under study.

Rancidity - The variance ratios (F values) for TBA and peroxide values are represented in Table 2. The storage duration, the packaging conditions and the storage temperature affected significantly both parameters. In relation to TBA, the packaging conditions showed the highest influence, being that induced by the duration of storage intermediate. Differently, the most expressive effect on peroxide is caused by storage temperature followed, by decreasing order, by the storage duration and packaging condition. Factors also interacted greatly in their influence on these quality parameters, with SDxPC and SDxST showing the most significant effects. PCxST only slightly interacted for peroxide value.

Both vacuum and MAP conditions, despite the general increase in TBA and peroxide values with storage time at 4°C or 20°C (Table 3), restricted the oxidative spoilage of samples. Although significantly higher ($P<0.05$) than the results obtained in controls, they represent a minor practical interest, failing the panelists to detect the presence of rancid odour (Table 4). As expected, the oxidation of fat is speed up by the storage temperature.

Blood sausage in air at 4°C after 90 days of storage, presented a slight but perceivable rancid odour, while such sensory deterioration appeared early at 20°C (60 days). It must be noted that samples stored in air at both temperatures also lost their textural characteristics due to excessive dehydration after 60 days, decreasing the aw value from 0.94-0.95 to 0.75 (4°C) - 0.67 (20°C).

Microbiology - The referred evolution in a_W values of samples stored in air explains the microbial results found out on these experimental conditions (Table 4), namely the expressive reduction in total counts observed between 60 and 90 days of storage at 4°C and the stability of the population along all the storage period at 20°C. The higher degree of contamination in MAP than in vacuum packaged samples after 30 days, irrespective of the storage temperature, is not clear. Nevertheless, microbial development assumed a great importance on the definition of shelf-life in both conditions. To achieve good commercial stability, the severity of cooking/smoking treatments should be reanalysed in parallel with the possible influence of these operations in the lipid oxidative process.

Conclusions

Vacuum and MAP technologies proved to be efficient in the prevention of lipid oxidation up to 3 months of storage at 4°C or 20°C. However, the retail case life is, in such cases, damaged by microbial development.

Samples stored at 4°C in air showed good retail characteristics up two months, but presented evident signs of rancidity at 20°C. Both samples were considered too hard in texture after 2 months of storage, due to dehydration.

References

AOAC 1984. Official Methods of the Association of Official Analitycal Chemists, Fourteenth Edition, Virginia, Inc. Arlington.

Apte & Morrissey, 1987. Effect of Water soluble Hem and non-haem Iron complexes on lipid oxidation of heated muscles systems. Food Chem. 26, 213:222.

Greene, B.E. 1969. Lipid oxidation and Pigment changes in raw beef. J. Food Sci. 34, 110:113.

Igene, J.O.; King, J.A.; Pearson, A.M.; Gray, J.I. 1979. Influence of pigments, nitrite, and non-haem iron on development of warmed-over flavor (WOF) in cooked meat. J. Agric. Food Chem., 27(4), 838:842.

Love, J.D.; Pearson, A.M. 1974. Metmyoglobin and non-haem iron as prooxidants in cooked meat. J. Agric. Food Chem. 22, 1032:1034.

Norman, T.J. e Bailey, M.A. 1981. Statistical Methods in Biology. (2ªed) Ed. Hodder and Stoughton.

Pearson, D. 1973. Laboratory Techniques in Food Analysis, Butterworths & Co, London.

Renerre, M. 1990. Review: Factors involved in the discoloration of beef meat. Int. J. of Food Sci. and Technol., 25(6), 613:630.

Rhee, K.S. 1978. Minimization of further lipid peroxidation in the distillation 2-thiobarbituric acid test of fish and meat. J. Food Sci. 43 (6), 1776:1778.

Sato, I.; Hegarty, G.R. 1971. Warmed-over flavor in cooked meats. J. Food Sci. 36, 1098.

Wang, F.S; Lin, C.W. 1994 The effects of heating and chemical treatment on the hem and non-haem iron content of heat-induced porcine blood curd. J. Sci. Food Agric. 65, 209:213

Table 1 - Chemical characterization of blood sausage.

	Protein (%)	Moisture (%)	Fat (%)	Chloride (%)	Nitrite (ppm)	Nitrate (ppm)	Total Iron mg/Kg	Non Haem Iron (mg/Kg)
Sample 1	28.1	37.4	30.2	3.2	2.2	27.1	143	20.5
Sample 2	24.9	45.3	25.2	3.4	2.5	26.0	152	28.1

Table 2 - *F*-values for TBA and Peroxide values.

	F values (Main Effects)			*F values* (Interactions)		
	Storage day (*SD*)	Packaging (*PC*)	Storage temp. (*ST*)	*SD x PC*	*SD x ST*	*PCx ST*
TBA	55.0***	167.3***	11.4**	37.9***	10.0***	0.6ns
Peroxide Value	61.9***	41.5***	75.2***	45.1***	60.4***	7.6**

, * = significant at 1%, 0.1% levels, respectively.

Table 3 - TBA and Peroxide mean values for blood sausage after various intervals of storage at different temperatures and packaging conditions.

Storage temp. (°C)	Storage time (days)	TBA			Peroxide Value		
		Air	Vacuum	MAP	Air	Vacuum	MAP
	0	${}^{x}0.30^{a}$	${}^{x}0.30^{a}$	${}^{x}0.30^{a}$	${}^{x}29.00^{c}$	${}^{x}29.00^{c}$	${}^{x}29.00^{c}$
4	30	${}^{x}1.26^{b}$	${}^{y}0.43^{c}$	${}^{z}0.31^{a}$	${}^{x}34.98^{d}$	${}^{y}29.49^{c}$	${}^{z}26.90^{b}$
	60	${}^{x}1.94^{e}$	${}^{y}0.42^{c}$	${}^{z}0.57^{d}$	${}^{x}15.17^{b}$	${}^{y}30.86^{c}$	${}^{z}41.00^{f}$
	90	${}^{x}2.36^{f}$	${}^{y}0.48^{d}$	${}^{y}0.49^{c}$	${}^{x}16.27^{b}$	${}^{y}28.91^{e}$	${}^{y}33.62^{d}$
20	30	${}^{x}1.63^{d}$	${}^{y}1.24^{f}$	${}^{z}0.85^{e}$	${}^{x}37.27^{e}$	${}^{y}23.75^{b}$	${}^{z}26.60^{b}$
	60	${}^{x}1.38^{c}$	${}^{y}0.38^{b}$	${}^{z}0.55^{d}$	${}^{x}4.65^{a}$	${}^{y}9.53^{a}$	${}^{z}14.38^{d}$
	90	${}^{x}3.52^{g}$	${}^{y}0.60^{e}$	${}^{z}0,39^{b}$	${}^{x}16.22^{b}$	${}^{y}25.00^{b}$	${}^{z}36.31^{b}$

(a-g) Means in the same column bearing a common letter to the right of the number do not differ significantly (P>0.05).

(x-z) Means in the same row bearing a common letter to the left of the number do not differ significantly (P>0.05).

Table 4 - Total plate counts and odour acceptability score mean values after various intervals at different temperatures and packaging conditions.

Storage temperature (°C)	Storage time (days)	Total Counts (log cfu g-1)			Sensory score		
		Air	Vacuum	MAP	Air	Vacuum	MAP
	0	4.1	4.1	4.1	1.0	1.0	1.0
4	30	6.0	6.5	8.0	1.0	1.0	1.0
	60	7.6	8.1	8.5	1.2	1.0	1.0
	90	5.2	7.3	8.5	2.0	1.0	1.0
20	30	6.5	6.7	7.6	1.0	1.0	1.2
	60	5.8	7.5	8.5	1.8	1.0	1.0
	90	6.6	6.7	6.3	2.7	1.0	1.0