ELSEVIER

PII: S0308-8146(97)00030-7

Food Chemistry, Vol. 60, No. 4, pp. 555–558, 1997

0308-8146/97 $17.00+0.00

Changes in the physicochemical properties and organoleptic quality of galician chorizos during curing and after vacuum-packing

E. Fenández-Fernández, J. Rozas-Barrero, M. A. Romero-Rodríguez & M. L. Vázquez-Odériz

Departamento de Química Analítica, Nutrición y Bromatología de la Universidad de Santiago de Compostela, Areas de Tecnología de Alimentos y de Nutrición y Bromatología, Campus de Lugo, 27002 Lugo, Spain

(Received 13 September 1996; revised version received 5 December 1996; accepted 5 December 1996)

Galician chorizo is a spicy smoked pork sausage made in northwest Spain. In the work reported here, physicochemical properties and organoleptic quality were evaluated (a) during manufacture and curing and (b) during storage of chorizos vacuum-packed after curing for 18 or 30 days. During curing, pH initially declined and then rose again; this pattern was reflected in an increase in acid flavour. Moisture content and water activity declined, while hardness increased, as reflected in the observed reduction in juiciness and the observed increase in subjectively-perceived hardness. Acidity index, peroxide index and proteolysis index increased only slightly over the curing period, and the tasters did not detect any organoleptic changes attributable to changes in these variables. During storage after vacuum-packing, no significant changes were observed in moisture content, water activity or hardness, but pH, acidity index, peroxide index and proteolysis index all increased gradually. During the last two weeks of storage of chorizos packed on day 30 of curing, tasters detected both rancid and strange flavours. © 1997 Published by Elsevier Science Ltd

INTRODUCTION

Galician chorizo is a spicy smoked pork sausage made in the region of Galicia in northwest Spain. It is prepared with chopped lean and fat at a ratio of about 7:3, together with salt (1.85%), garlic (0.25%), paprika (1.8%) and chilli pepper (0.25%). Neither sugar nor culture starters are used. The mix is stuffed into pig gut, which is twisted into a string of sausages, each weighing about 100 g, and separated by a small ball of mix that is characteristic of the product. The sausages are smoked for 6–12 h prior to drying/ripening, which takes 18–30 days.

During storage of products of this type, exposure to air may lead to problems, including contamination by yeasts or other fungi, decoloration, development of rancid flavours, or drying out (see Price & Schweigert, 1994). To reduce such problems, Galician chorizo is now often vacuum-packed. Despite such treatment, however, anaerobic and microaerophilic micro-organisms may continue to grow, leading to proteolysis and lipolysis, and in some cases causing the development of undesirable flavours and odours (see Roncalés, 1994).

There have been no previous studies of changes in the properties of Galician chorizo, or of any similar cured-pork product, during storage after vacuum-packing. Here, we report a study of the physicochemical and organoleptic properties of Galician chorizo at various stages in the manufacturing process, and after storage for up to 16 weeks following vacuum-packing on day 18 or 30 of ripening.

MATERIALS AND METHODS

Samples

The chorizos were prepared in a small-scale manufacturing plant in Lugo Province (Galicia, northwest Spain). At about 4°C, the meat was chopped and minced (12 mm openings), then mixed with the other ingredients, left for 24–36 h, then stuffed into pig gut. The sausage was then cold-smoked for 6–8 h, dried and ripened at 10–12°C and 70–80% relative humidity. After 18 or 30 days of ripening, the chorizos were vacuum-packed in 17×25 cm polyamide/polyethylene laminate food-storage bags (Cryovac Division from Grace) with the aid of a Vac-210 heat-sealing apparatus (Talleres Guasch). Subsequent storage was at about 20°C in the dark.

Samples were taken for physicochemical analysis and sensory evaluation from (i) lean meat, (ii) freshly prepared mix, (iii) recently stuffed chorizo, (iv) recently smoked chorizo, (v) two times per week during the

ripening period, and (vi) once every two weeks during the storage period (16 weeks). Two batches, manufactured on different days from different batches of meat, were studied.

Methods

pH was determined by a potentiometric method (ISO, 1974). Water activity was determined on the basis of dew-point measurement with an AquaLab CX-2 apparatus (Decagon Devices). Moisture content was determined by oven-drying at 102±2°C (ISO, 1973). Hardness was estimated on the basis of penetration resistance, with the aid of a Bertuzzi 327 penetrometer. Proteolysis index (non-protein nitrogen as a percentage of total nitrogen) was estimated following determination of both fractions by the Kjeldahl method (Carreri *et al.*, 1993). The acidity index (% free fatty acids expressed as % oleic acid) was determined in accordance with ISO 1740 (ISO, 1980) after extraction of lipids by means of an automated Soxhlet procedure. The peroxide index was likewise determined after extraction of lipids, in accordance with ISO 3960 (ISO, 1977). All of the above variables were determined in duplicate.

Sensory analyses were performed by groups of 20 tasters trained over the preceding six months. In each session, each taster evaluated a whole chorizo. The properties rated were perceived hardness, juiciness, acid flavour, rancid odour, strange odour (presence/absence), and overall quality.

Between-variable relationships were investigated by Pearson product-moment correlation analysis as performed by the statistical package SPSS (version 2.01).

RESULTS AND DISCUSSION

Changes during manufacture

The results of physicochemical determinations over the pre-curing and curing period are listed in Table 1.

pH declined gradually between the fresh-meat stage and the first ten days of curing; this is attributable to lactic acid build-up. pH then increased until the end of the curing process, which is attributable to the production of ammonia and amines (Astiasarán *et al.*, 1990). The maximum pH values reached were higher than has been reported previously for similar products (Bello *et al.*, 1974; Astiasarán *et al.*, 1990; Santamarina *et al.*, 1992), probably because sugars are not included in the mix. Domínguez *et al.* (1988) found similar maximum pH values in a study of farmhouse chorizos from León Province.

Both water activity and moisture content declined gradually over the pre-curing and curing period. As expected given the reduction in moisture content, hardness likewise declined, and these two variables were closely correlated ($r = -0.9622$).

The proteolysis index peaked between days 11 and 18 of curing. Acidity and peroxide content showed slight increases over the pre-curing and curing period: more marked increases have been reported in previous studies of similar products (Astiasarán *et al.*, 1990; Santamarina *et al.*, 1992), but our results are similar to those of Domínguez *et al.* (1988) for León chorizo, which is likewise made without starters.

The results of sensory analysis indicate a slight reduction in acid flavour over the final part of the curing period (days 22–30), and acid flavour was strongly correlated with pH ($r = -0.9020$). Perceived hardness likewise increased over the pre-curing and curing period, while juiciness decreased. Both changes can be attributed to the drying out of the product: perceived hardness and moisture content were correlated with $r = -0.9909$, and juiciness and moisture content with $r = 0.8936$. Note that both increased perceived hardness and reduced juiciness are desirable changes in a cured product destined for consumption raw.

Neither strange nor rancid odours were detected at any stage. The lack of rancid odours is as expected given that there was only a small increase in peroxide index. In general, overall quality as rated by tasters increased

Table 1. Physicochemical properties of Galician chorizos as determined during manufacture and curing. Values shown are means for two batches (two determinations per batch)

Day	pH	aw	Moisture (%)	Hardness (kg)	Proteolysis index	Acidity index (% oleic acid)	Peroxide index (meq O_2/kg lipid)
*	6.00	0.998	61.00		0.0538	2.41	2.21
**	5.71	0.976	55.67	3.40	0.0713	2.44	2.17
1	5.31	0.967	54.44	3.26	0.135	2.92	1.69
4	5.19	0.950	46.60	3.83	0.771	2.71	1.64
8	5.02	0.945	42.88	7.08	2.01	2.66	1.82
11	4.88	0.917	36.75	7.70	2.34	2.90	2.36
15	5.08	0.901	32.56	7.52	2.21	3.20	2.21
18	5.14	0.880	29.21	9.90	2.20	3.49	2.18
22	5.18	0.842	25.05	11.08	0.160	3.82	4.80
30	5.26	0.810	22.07	13.00	0.0075	4.19	4.84

* raw mix.
** inmediately after stuffing.

over the pre-curing and curing period. Overall quality was closely correlated with perceived hardness ($r = 0.9943$), juiciness (−0.9225) and acid flavour (−0.9322).

Changes during storage

The results of physicochemical determinations during storage are listed in Tables 2 and 3. pH increased slightly over the 19-week storage period (by 0.58 in chorizos packed on day 18 of curing, and by 0.40 in chorizos packed on day 30 of curing). The correlation between pH and time-of-storage (weeks) was stronger for chorizos packed on day 18 ($r = 0.9649$) than for chorizos packed on day 30 ($r = 0.7253$), as expected given the more consistent increase in pH in chorizos packed on day 18.

Water activity, hardness and moisture content remained practically constant during storage, and the post-storage differences in these parameters, between chorizos packed on day 18 and on day 30, were basically the same as the pre-storage differences. Acidity index increased steadily throughout the storage period, the correlation between this variable and time-of-storage being $r = 0.9873$ for chorizos packed on day 18 and $r = 0.9943$ for chorizos packed on day 30. The maximum value reached was higher for chorizos packed on day 18 (14.5%) than for chorizos packed on day 30 (10.8%). Peroxide index gradually increased in both samples until about week 11–12 of storage. This increase is probably attributable to the presence of oxygen inside the chorizo, since the manufacturers do not use vacuum stuffing equipment. Week-11 peroxide content was higher in chorizos packed on day 30 (23.54 meq O_2 per kg of lipid) than in chorizos packed on day 18 (12.40 meq O_2 per kg of lipid), which may explain the observed differences in acidity. Towards the end of the storage period (weeks 13–14 onwards), peroxide index dropped slightly.

The proteolysis index likewise increased slightly during the storage period: the percentage increase reached by the end of the storage period was 6.41% for chorizos packed on day 18 and 5.62% for chorizos packed on day 30. The relatively rapid increase over the last few weeks of storage may be related to the reduction in peroxide index observed over this same period, since fermentative micro-organisms break down peroxides and form carbonyl compounds (Lizárraga *et al.*, 1989).

The results of sensory analysis indicate that neither perceived hardness, juiciness nor acid flavour was appreciably affected by storage. Strange odours and rancid odours were, however, detected during the last few weeks of storage of chorizos packed on day 30. This is attributable to the increase in peroxides to levels in excess of 20 meq O_2 per kg of lipid, which can be considered to indicate rancidity (Santamarina *et al.*, 1992). Overall quality was better for chorizos packed on day 18 than for chorizos packed on day 30 throughout the storage period; in chorizos packed on day 18, unlike those packed on day 30, none of the sensory descriptors showed significant declines during storage.

Table 2. Physicochemical properties of Galician chorizos as determined during storage (at 20°C in the dark) after vacuum-packing on day 18 of curing. Values shown are means for two batches (two determinations per batch)

Week	pH	Proteolysis index	Acidity index (% oleic acid)	Peroxide index (meq O_2 kg^{-1} lipid)
0	5.14	2.19	3.49	2.03
1	5.10	3.86	4.38	2.70
2	5.26	3.88	5.53	2.94
4	5.25	4.69	7.11	3.06
6	5.39	4.75	8.94	6.00
8	5.41	5.84	11.0	7.55
10	5.39	5.11	10.63	11.50
12	5.52	5.27	12.7	12.4
14	5.55	6.62	13.67	3.10
16	5.72	6.41	14.52	2.10

Table 3. Physicochemical properties of Galician chorizos as determined during storage (at 20°C in the dark) after vacuum-packing on day 30 of curing. Values shown are means for two batches (two determinations per batch)

Week	pH	Proteolysis index	Acidity index (% oleic acid)	Peroxide index (meq O_2 kg^{-1} lipid)
0	5.26	0.0075	4.19	4.84
1	5.33	0.0238	4.93	9.50
3	5.48	0.0238	6.15	11.14
5	5.53	0.0513	7.00	14.2
7	5.42	0.4238	7.82	15.3
9	5.58	0.7750	8.40	20.2
11	5.61	1.3925	9.28	23.5
13	5.41	3.7275	10.5	3.26
15	5.66	5.6250	10.8	3.39

ACKNOWLEDGEMENTS

We thank Dr Luis Ramil Novo and Dr Jose María Alonso Meijide, of the Department of Statistics and Operations Research of the University of Santiago, for their assistance with data analysis.

REFERENCES

Astiasarán, I., Villanueva, R. & Bello, J. (1990). Analysis of proteolysis and protein insolubility during the manufacture of some varieties of dry sausage. *Meat Sci.*, **28**, 111–117.

Bello, J., Larralde, J. & Sáenz de Buruaga, I. (1974). Estudio de las modificaciones proteicas que tienen lugar durante la elaboración de algunos derivados cárnicos. Curación del chorizo de Pamplona. *Anal. Bromat.*, **XXVI**, 195–210.

Carreri, M., Mangia, A., Barbieri, G., Bolzoni, L., Virgili, L. & Parolari, G. (1993). Sensory properties relationships to chemical data of italian-type dry-cured ham. *J. Food Sci.*, **58**, 968–972.

Dominguez, M. C. , Ferré, C. & Zumalacarregui, J. M. (1988). Aportaciones a la caracterización del chorizo elaborado en la provincia de León: parámetros químicos y físico-químicos. *Alimentaria*, **198**, 19–23 .

ISO (1973). International Standard meat and meat products. Determination of moisture content. ISO-1442-1973.

ISO (1974). International Standard meat and meat products. Determination of the pH. ISO-2917-1974.

ISO (1977). International Standard meat and meat products. Determination of peroxide content. ISO-3970-1977.

ISO (1973). International Standard meat and meat products. Determination of moisture content. ISO-1442-1973.

ISO (1980). International Standard animal and vegetable oils and fats. Determination of the acid value of the fat. ISO-1740–1980.

Price, J. F. & Schweigert, B. S. (1994). Ciencia de la carne y de los productos cárnicos. Ed. Acribia, Zaragoza.

Roncalés, P. (1994). Tecnología, cambios bioquímicos y calidad sensorial de los embutidos curados. Jornadas Técnicas Expocarne-94, Valencia.

Santamarina, I., Lizárrga, T., Astiasarán, I. & Bello, J. (1992). Contribución a la Tipificación del chorizo de Pamplona. Estudio físico-químico y sensorial. *Rev. Esp. C. Tecnol. Alim.*, **32**, 431–435.