Acta Alimentaria, Vol. 31 (2), pp. 191–196 (2002)

PROLONGATION OF SHELF LIFE OF SPONGE CAKES USING MODIFIED ATMOSPHERE PACKAGING

M. V. RODRIGUEZ, L. M. MEDINA and R. JORDANO*

Department of Food Science and Technology, University of Córdoba,
Campus of Rabanales, Edificio C-1 Anexo. Ctra. NIV Km 396.A, E -14071Córdoba. Spain

(Received: 21 March 2001; accepted: 19 November 2001)

The effect of three different modified atmospheres on the shelf-life of sponge cake was studied. Three packaging atmospheres were tested: 50% CO_2: 50% N_2, 100% CO_2, and standard air as control. The samples were examined daily for visible mould growth and analysed periodically (after 2, 6, 13, 22 and 27 days) throughout storage (15–20 °C and 51–63% RH) for gaseous composition and microbial populations: mesophilic aerobic and anaerobic bacteria, lactic acid bacteria (LAB) and yeasts and moulds. The atmosphere CO_2:N_2 (50:50) extended the shelf-life of the sponge cakes by 2–3 days with respect to packaging in standard air.

Keywords: modified atmosphere packaging (MAP), sponge cake, shelf-life

Soft bakery products such as bread, rolls, and sponge cakes undergo a rapid loss in quality in which the prevalent deteriorating factors are loss of moisture, aging and the growth of moulds. The microbiological spoilage in these products is caused by fungal growth which mainly takes place on the surface (BRODY, 1995).

Most fresh baked products have only a few days' shelf-life at ambient temperature; microbial growth on the products is the major cause of economic loss in the bakery industry (OORAIKUL, 1991). Moulds are the most common types of spoilage organisms associated with baked products. However, bacteria and yeast are also implicated in the spoilage of some products where souring or fermentation occurs (KING, 1981).

In SEILER's (1996) opinion it is at present a well-known fact that packaging bakery products in CO_2 is an efficient conservation method, which protects all parts of the product, regardless of whether it is filled, covered or sliced. Moreover, it has no detrimental effects on the product's quality, either its smell or flavour, and permits very considerable increases in shelf-life.

In previous studies (RODRIGUEZ et al., 1999, 2000), the occurrence of mesophilic anaerobic bacteria, lactic acid bacteria (LAB), yeast and mould populations on sliced bread and pre-cooked pizza dough under modified atmosphere packaging (MAP) during storage has been studied.

* To whom correspondence should be addressed.
Tel.: + 34 957 212006; Fax + 34 957 212000; E-mail: bt1josar@uco.es

0139-3006/2002/$ 5.00

The objective of this study was to determine the influence of three atmospheres of packaging (50% CO_2:50% N_2, 100% CO_2, and standard air as control) on the shelf-life of sponge cake stored at 15–20 °C and 53–61% RH.

1. Material and methods

1.1. Sampling schedule

For the shelf-life study a total of 30 samples (3 batches ×10) of factory-made sponge cakes were studied during the entire experiment. The storage conditions and the atmospheres tested were 15–20 °C/53–61% RH and, 50% CO_2:50% N_2, 100% CO_2, and standard air as control, respectively. The samples were examined daily for visible mould growth, and analysed periodically (after 2, 6, 13, 22 and 27 days) for gaseous composition and microbial populations: mesophilic aerobic and anaerobic bacteria, LAB, and yeasts and moulds.

The baking dough was made up of the following formula: flour (2 kg), sugar (2 kg), salt (200 g) and eggs (6.6 kg).

1.2. Packaging

Products were factory-packed to avoid the risk of contamination during the transportation of samples. The sponge cakes (12×17 cm and 3.5 cm of thickness) were dispensed aseptically (one by one) into 21×30 cm Cryovac™ BB4L film bags (60 μm thick with permeability of O_2, CO_2, and steam of 35, 150 $cm^3/m^2/24$ h at 25 °C and 20 $g/m^2/24$ h at 23 °C, respectively). The packaging was done using a Sammic™ Mod. 320 packing device. Gases were produced by Carburos Metálicos™ (S.E. de Carburos Metálicos S.A., Spain). Once the samples had been packed, they were delivered to the laboratory for storage in chambers under room moisture and temperature conditions and protected from the light.

1.3. Microbial analysis

Ten grams of sample (extracted from the centre) were weighed and placed in sterile stomacher bags. Sterile 0.1% peptone water (90 ml) was added to the sample and the contents were homogenized for 2 min in a Seward™ 400 Stomacher. Serially diluted samples were deposited in duplicate by using the spread plate technique onto the following media: plate count agar (PCA, Difco) incubated at 35 °C for 48 h and incubated in anaerobic jars with H_2–CO_2 generators (Gas Generating Kit. Anaerobic system BR38, Oxoid) at 35 °C for 48 h to determine populations of mesophilic aerobic bacteria and mesophilic anaerobic bacteria (FOOD AND DRUG ADMINISTRATION, 1992), respectively. Agar MRS (Oxoid) acidified at pH 5.4 (DE MAN et al., 1960) and M_{17} agar (Oxoid) were prepared with a 10% lactose solution (5% v/v) according to TERZAGHI and SANDINE (1975) and incubated in anaerobic jars at 37 °C for 72 h and at 37 °C for 48–72 h, respectively, to determine populations of LAB. Potato dextrose agar

(PDA, Oxoid) was incubated at 25 °C for 5 days (MARSHALL, 1993) to determine populations of yeast and moulds. In all cases, the results of the counts were expressed as log CFU g^{-1}.

After two days of storage, samples were checked for the formation of mycelium. Where mycelium was detected, readings were taken at an earlier stage from any of the dishes used in the count. Moulds were identified by optical microscopy (FASSATIOVÁ, 1986; RAPER & THOM, 1949; RAPER & FENNELL, 1965).

1.4. Gas analysis

The changes in the gaseous composition within the modified atmosphere packs were monitored using an Abbis™ portable analyser, model Pak 12. Twenty ml of gaseous sample were extracted using an airtight syringe attached to the analyser.

1.5. Statistical analysis

Data were analysed by an analysis of co-variance. The statgraphics Statistical Graphics System (STSC, Inc. and Statistical Graphics corporation) program (version 5.0) was used.

2. Results and discussion

Table 1 shows the microbial populations (aerobic and anaerobic bacteria, LAB, yeast and moulds) in sponge cake (n = 32).

No statistically significant differences were detected ($P = 0.77$) between the mesophilic aerobic bacteria counts corresponding to the samples in the different packaging atmospheres. The counts evolved similarly, and irrespectively of the gaseous composition. Neither did the packaging atmosphere give significant differences ($P = 1.00$) between the mesophilic anaerobic bacteria. The counts evolved in an upward direction independently of the packaging conditions.

The differences between the LAB counts both in MRS and in M_{17} from the different packaging atmospheres were not significant ($P = 0.55$). The LAB counts did not have any correlation with the gaseous atmosphere, which was also reported by AHVENAINEN and co-workers (1990) in ham pizzas and tomato salad.

The yeast and mould counts obtained in the air-packaged samples were larger than those of the sponge cakes maintained in 50% CO_2: 50% N_2 and 100% N_2. However, the smaller counts belonged to the carbonic atmosphere-packaged product. At the half-way stage of storage, the difference between the three atmospheres tested, approximately one decimal logarithm, were not statistically significant ($P = 0.55$). The counts of the samples packaged in the modified atmosphere corresponded mainly to yeasts. BRÜMMER and co-workers (1980) attributed the end of the shelf-life of rice bread packaged in a carbonic atmosphere to the presence of yeasts. Only the air-packaged samples showed a predominance of moulds, with *Penicillium* spp. being isolated in 100% of the cases.

Table 1. Microbial populations (log CFU g^{-1})[a] in sponge cake (n = 30)

Atmosphere	Storage (days)	Microbial populations (log CFU g^{-1})				
		MAB	MANB	LAB (MRS)	LAB (M_{17})	Y + M
Air (control)	2	4.59	2.39	2.00	4.30	1.78
	6	**5.23**	ND	**4.26**	**4.74**	**4.02**
	13	**6.79**	**6.09**	**5.42**	**6.13**	**7.49**
	22	ND	**8.63**	**5.23**	**7.79**	**9.56**
	27	**6.85**	**7.00**	**6.48**	**6.18**	**6.75**
MA (50% CO_2: 50% N_2)	2	ND	ND	ND	ND	ND
	6	5.59	4.27	2.51	4.68	3.39
	13	6.91	6.40	4.45	5.86	4.45
	22	**7.19**	**6.04**	**5.72**	**6.65**	**7.51**
	27	**7.58**	**7.36**	**5.28**	**7.42**	**6.99**
MA (100% N_2)	2	ND	ND	ND	ND	ND
	6	5.43	4.29	5.17	4.67	3.40
	13	**6.54**	**6.41**	**5.76**	**6.38**	**6.65**
	22	ND	**7.03**	**6.20**	**7.22**	**7.18**
	27	**9.94**	**5.89**	**7.29**	**8.34**	**7.18**

[a] Average of two samples, each with duplicate plates. MA: modified atmosphere; MAB: mesophilic aerobic bacteria; MANB: mesophilic anaerobic bacteria; LAB: lactic acid bacteria; Y: yeasts; M: moulds; ND: not determined.
Boldface type indicates spoilage (visible sign of moulding)

The sponge cake being studied had a shelf-life of 3 days (with no preservatives and packaged in standard air). Hundred percent of the air-packaged samples became mouldy after six days of storage at 15–20 °C. In the case of the 100% N_2-packaged sponge cakes, no visible signs of moulding occurred up to 13 days. At day 20, 60% of the samples packaged in 50% CO_2:50% N_2 showed signs of moulding. However, in those control points mesophilic aerobic bacteria count was 5.43 log CFU g^{-1} for the products packed in 100% N_2 and 5.59 log CFU g^{-1} for those in 50% CO_2:50% N_2. Also, for yeasts and moulds the count was 3.39 log CFU g^{-1}. For this reason, we have to take into account not only the visible sign of moulding as criteria to prolong shelf life, but other microbial parameters as well. Taking into account all the aspects mentioned above, the 50% CO_2:50% N_2 atmosphere was the only one with justified advantages with respect to air atmosphere (shelf life of five days). In conclusion, the atmosphere CO_2:N_2 (50:50) extended the shelf-life of the sponge cakes by 2–3 days with respect to packaging in standard air.

For OORAIKUL (1991) cake doughnuts packaged in air and stored at ambient temperature developed moulds in about 3–5 days. DOERRY (1987) reported that neither CO_2 nor N_2 had any effect on the rate of staling bread, pound cake or sponge cake after 7 days of storage at 25 °C.

The microbial activity, especially that generated by the yeasts, exceeded any other factor altering the CO_2 concentration in the packaging atmosphere. Referring also to OORAIKUL (1991), the growth of yeasts was the element determining the changes in CO_2 in the head space of the sugar-sweetened products studied.

With regard to the O_2 concentration in the packaging atmosphere, in spite of having used compensated vacuum as the packaging technology, the residual O_2 concentrations were very high: 4.15% and 4.10% at day 6 of packaging in 100% N_2 and 50% CO_2–50% N_2, respectively. The porous nature of the product (able to absorb air) means that compensated vacuum is insufficient for the reduction of residual oxygen (SMITH et al., 1986; OORAIKUL, 1991).

*

This work was supported in part by the Comisión Interministerial de Ciencia y Tecnología (CICYT), Ministerio de Educación y Cultura, Madrid (Spain), through Project ALI94-1409-E.

References

AHVENAINEN, R., SKYTTÄ, E. & KIVIKATAJA, R. L. (1990): The influence of modified atmosphere packaging on the quality of selected ready-to-eat foods. *Lebensm. Wiss. Technol.*, *23*, 139–148.

BRODY, A. L. (1995): El mercado. (The market.) -in: PARRY, R. T. (Ed) *Envasado de los alimentos en atmósfera modificada*. (Modified atmosphere packaging of foods.) A. Madrid Vicente Ediciones, Madrid, pp. 32–55.

BRÜMMER, J. H., STEPHAN, H. & MORGENSTERN, G. (1980): Maßnahmen zur Schimmelbekämfung der Brot. 2 Mitt: Atmosphärenaustausch mit Kohlendioxid. *Getreide Mehl Brot*, *34*, 164–168.

DE MAN, J. C., ROGOSA, M. & SHARPE, M. E. (1960): A medium for the cultivation of lactobacilli. *Appl. Bacteriol.*, *23*, 130–135.

DOERRY, W. T. (1987): Packaging bakery foods in controlled atmospheres. CAP '87. *Proceedings of the Third International Conference on Controlled/Modified Atmosphere/Vacuum Packaging*. Scotland Business Research, Inc. Princeton, NJ., pp. 203–233.

FASSATIOVÁ, O. (1986): Moulds and filamentous fungi in technical microbiology: progress in industrial microbiology. Vol. 2. Elsevier, Amsterdam.

FOOD AND DRUG ADMINISTRATION (1992): *Bacteriological analytical manual*, 7th ed. A.O.A.C. International, Arlington, pp. 17–26.

KING, B. D. (1981): Microbial inhibition in bakery products – a review. *Bakers Digest*, *55*, 8–12.

MARSHALL, R. T. (Ed) (1993): *Standard methods for the examination of dairy products*. 16th ed. American Public Health Association, Washington, D.C., pp. 281–283.

OORAIKUL, B. (1991): Modified atmosphere packaging of bakery products. -in: OORAIKUL, B. & STILES, M. E. (Eds) *Modified atmosphere packaging of food*. Ellis Horwood Limited, London, pp. 49–117.

RAPER, K. B. & FENNELL., D. I. (1965): *The genus* Aspergillus. Williams & Wilkins, Baltimore, Maryland.

RAPER, K. B. & THOM, C. (1949): *A manual of the penicillia*. Williams & Wilkins, Baltimore, Maryland.

RODRIGUEZ, V., MEDINA, L. M. & JORDANO, R. (1999): Incidence of mesophilic anaerobic bacteria and lactic acid bacteria on sliced bread under modified atmosphere packaging during storage. *J. Fd Quality*, *22*, 701–710.

RODRIGUEZ, V., MEDINA, L. M. & JORDANO, R. (2000): Effect of modified atmosphere packaging (MAP) on the shelf-life of sliced wheat flour bread. *Nahrung*, *44*, 247–252.

SEILER, D. A. L. (1996): Envasado en atmósferas modificadas de los productos de panadería. (Modified atmospheres packaging for bakery products.) -in: BRODY, A. L. (Ed) *Envasado de alimentos en atmósferas controladas, modificadas y a vacío*. (Controlled /modified atmosphere/ vacuum packaging of foods.) Acribia, Zaragoza, pp. 141–156.

SMITH, J. P. OORAIKUL, B., KOERSEN, W. J, JACKSON, E. D. & LAWRENCE, R. A. (1986): Novel approach to oxygen control in modified atmosphere packaging of bakery products. *Fd. Microbiol.*, *3*, 315–320.

TERZAGHI, B. E. & SANDINE, W. E. (1975): Improved medium for the lactic streptococci and their bacteriophages. *Appl. Microbiol.*, *29*, 807–813.