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SHELF LIFE EXTENSION OF SLICED COOKED MEAT PRODUCTS BY MODIFIED ATMOSPHERE PACKAGING

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1 INTRODUCTION

Considerable changes have taken place in food production and distribution practices over the past 15 to 20 years, which have also had a major impact on requirements for food packaging in terms of both quality and quantity. Modified atmosphere packaging (MAP) is an internationally recognized, rapidly improving method that contributes to preserving the internal qualities of foods. It is widely used in the European Union, being the food packaging method of choice of the 1990's. MAP is mostly employed for packaging of sliced dry products by the Hungarian meat industry. MAP of traditional sliced cooked meat products is introduced in the Hungarian market nowadays.

MAP can be briefly defined as a method assuring the quality and extending the shelf life of foods, thereby reducing production and distribution costs.

MAP offers a wide range of new possibilities for producers, distributors, and consumers of sliced cooked meat products. The beneficial effects of MAP that cannot be always guaranteed with the use of vacuum packaging include: extended shelf life and improved color stability of products and easy separation of slices. In conclusion, by using MAP, consumers can be provided with high quality and esthetical sliced cooked meat products.

Food products are increasingly sold in self-service shops besides the regular distribution channels. This must also be taken into account when formulating packages.

As the popularity of sliced cooked meat products packed under modified atmospheres increases, new marketing tools become available for the manufacture of both wholesale and retail size packages.

The aim of this work was to evaluate the influence of MAP on shelf life of sliced cooked meat products under commercial conditions. The theoretical and practical applications of MAP and the conditions necessary for their implementation are also reviewed in this dissertation.

2 MATERIALS AND METHODS

2.1 Products tested

Three types of major commercial cooked meat products (i.e., Bologna sausage, Italian-type cooked sausage, and Kapuvár cooked ham) were tested in this study. The chemical composition of the products selected is shown in **Table 1**. Samples were taken from normal meat processing lines.

Table 1 Major chemical composition of the products tested

Product	Moisture	Fat	NaCl
	content (%)		
Bologna sausage	71.0	23.0	2.5
Italian-type cooked sausage	59.0	35.0	2.5
Kapuvár cooked ham	74.0	9.0	3.2

2.2 Packaging and storage

The outer layer of the samples was frozen, and then the products were sliced to 1.2 mm thickness and placed overlapped into polypropylene trays sealed with plastic films. Darfresh WEB films were used for vacuum packaging and Multibarrier 4 films for MAP. The headspace of modified atmosphere packaged cooked meat

products consisted of either 30% CO_2 and 70% N_2 or 60% CO_2 and 40% N_2. The samples thus produced were weighed, placed in cardboard boxes and stored protected from light exposure at 2 to 4 °C.

2.3. Sampling, analyses, and evaluation of results

Samples were taken after 1, 5, 11, 15, 20, 25, and 29 days of storage and microbiological, chemical, physical, and sensory analyses were carried out on two samples. The total experimental program was repeated twice.

2.3.1. Enumeration of microorganisms. The viable counts or presence/absence of the following microorganisms were determined according to Hungarian and German official methods: total plate count (MSZ 3640-3:1986), lactobacilli (DIN 10168:1991), *Salmonella* spp. (MSZ EN 12824:1999), *Staphylococcus aureus* (MSZ 3640-23:1985), enterococci (MSZ 3640-13:1976), *Escherichia coli* (MSZ 3640-12 MSZ 3640-12:1979), and mesophilic sulfite-reducing clostridia (MSZ 3640-16:1978).

2.3.2. Determination of nitrite content and pH value. The nitrite level of products was determined according to the official method of analysis used in Hungary (MSZ 6905:1981), and their pH was assessed by means of an ISFET 101 pH meter (Delta TRAK Inc., Pleasanton, CA, USA) and a LanceFET spear tip electrode on a homogenate consisting of 5 g of sample in 50 ml of distilled water.

2.3.3. Color measurement. The color of cooked meat products was measured using a Minolta CR-300 chromameter (with aperture diameter and viewing angle set at 8 mm and 0°, respectively) and described numerically by the CIELAB color space model. L* is a degree of lightness ranging from 0 (black) to 100 (white) along a gray scale. Positive a* values are red and negative a* values are green. Positive b* values are yellow and negative b* values are blue. Chroma is a measure of color saturation and hue is the color angle.

2.3.4. Sensory evaluation. Samples from each formulation were randomly assigned for sensory evaluation to a 5-member panel, 2 min after the vacuum or modified atmosphere packages were opened. Properties were assessed using a 5-point rating scale ranging from 0 to 4. A score of 0 from an individual panelist indicated unacceptability for consumption in terms of the organoleptic characteristic tested. The following sensory properties of the cooked meat products were assessed: drip formation, intensity and freshness of odor and flavor, slime formation, stickiness and cohesiveness of slices.

2.3.5. Curve fitting. Gompertz curves were fitted to time series that changed from an initial to a final value during any period of storage. The initial value, the initial and final points in time of the fast change, and the final value were determined on the basis of the curve fitted (**Figure 1**). Proper polynoms were also fitted to the other time series and the characteristic values were determined based on these polynoms.

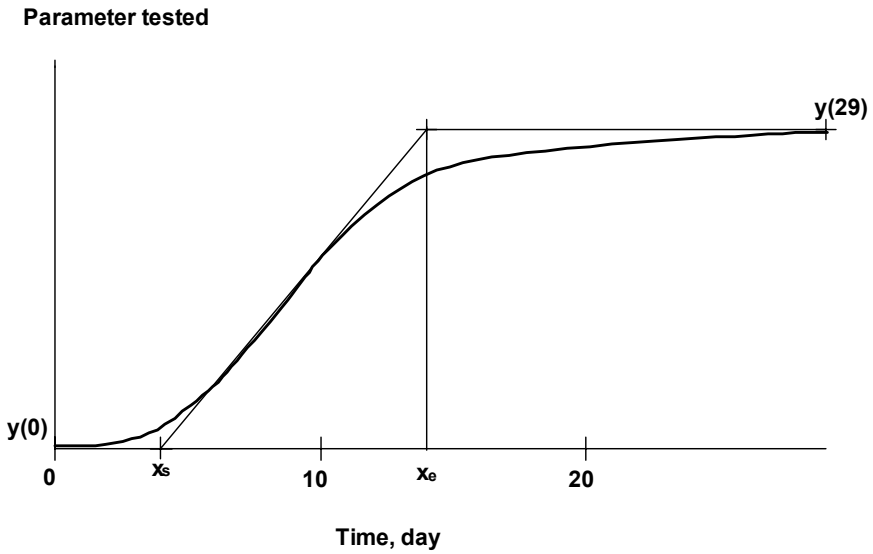

Figure 1 Characteristic points of curve fitting

y(0): Value of parameter tested on day 0; y(29): value of parameter tested on day 29; x_s: start of change; x_e: end of change

3 RESULTS

3.1 The modified atmospheres containing 30% or 60% CO_2 were found to be capable of extending the shelf life of the sliced cooked meat products tested.

3.2 Packaging method had a major influence on the survival and growth of mesophilic aerobic and anaerobic microorganisms and those of lactic acid bacteria (LAB).

3.3 As opposed to packaging system, product properties did affect nitrite levels during refrigerated storage.

3.4 The presence of CO_2 in the headspace of packages provided some degree of protection against decline in odor freshness. The sausages and cooked ham started to develop unpleasant odors after 25 and 11 days of storage, respectively under a headspace CO_2 content of 30%. A gas atmosphere containing 60% CO_2 contributed to retained odor freshness for 20 and 25 days in Bologna sausage and Italian-type cooked sausage, respectively. Under identical conditions, the spoilage of coked ham was put off until day 24.

3.5 A headspace CO_2 content of 30% resulted in off-odor only in Kapuvár cooked ham between days 1 and 15. However, the presence of 60% CO_2 in the packaging atmosphere led to unpleasant off-odors in all three products tested as follows: between days 11 and 15 in the sausages and between days 1 and 20 in cooked ham.

3.6 The characteristic odor of vacuum packed cooked meat products started to decline on day 5. As for MAP, 30% CO_2 retained

the characteristic odor of Kapuvár cooked ham, Bologna sausage, and Italian-type cooked sausage for 2, 25, and 29 days, respectively. In Bologna sausage, Italian-type cooked sausage, and Kapuvár cooked ham packed under modified atmosphere containing 60% CO_2 this sensory attribute deteriorated after 25, 20, and 25 days of storage, respectively.

3.7 MAP had a beneficial effect on the characteristic flavor properties of sausages from the beginning of the storage period. The products retained their characteristic flavor for 20 to 25 days of storage.

3.8 The initial decline in flavor freshness of Bologna sausage was independent of packaging system. The spoilage of modified atmosphere packed Italian-type cooked sausage and that of Kapuvár cooked ham were observed after 20 and 25 days of storage, respectively. The flavor freshness of Bologna sausage declined after day 5. Italian-type cooked sausage retained its flavor freshness for 5 and 25 days in vacuum packaging and in MAP containing 30% CO_2, respectively. Kapuvár cooked ham was found to have outstanding flavor freshness regardless of sampling time and composition of the packaging atmosphere.

3.9 Off-flavor was only experienced on day 29 in Kapuvár cooked ham packed under modified atmosphere containing 60% CO_2.

3.10 No correlation was found between packaging system and salty flavor.

3.11 Sweet flavor as a sensory attribute was monitored during storage because of the initial sweetness of Kapuvár cooked ham which, however, disappeared after day 11.

3.12 The slices showed signs of slime formation after day 25. The degree of slime production was the highest in Kapuvár cooked ham, it was less pronounced in Bologna sausage, whereas only slight slime formation was observed in Italian-type cooked sausage. MAP had a beneficial effect on this sensory attribute tested. The presence of 60% CO_2 in the headspace of packages provided complete protection for Italian-type cooked sausage against slime formation.

3.13 The cohesiveness of Bologna sausage slices declined after 20 days in vacuum packaging and after 26 days in MAP. The vacuum packed Italian-type cooked sausage slices were sticky throughout the storage period, whereas their modified atmosphere packaged counterparts were found to be excellent in this respect. The cohesiveness of cooked ham slices packed under modified atmospheres was scored 4.0 for 3 weeks and then a decline in scores was observed.

3.14 Drip formation was experienced in the vacuum packed Bologna sausage and cooked ham from the beginning to the end of storage, whereas the Italian-type cooked sausage samples showed no sign of dripping over the entire storage period. MAP provided some degree of protection against this quality defect until day 25. Drip formation only occurred at the end of storage in the modified atmosphere packed Kapuvár cooked ham and Bologna sausage samples.

3.15 Both vacuum packaging and MAP had a lowering effect on the pH of products. The pH value of Bologna sausage decreased gradually until day 10 and then remained practically unchanged for the rest of storage. As for the Italian-type cooked sausage and cooked ham, pH fell for approximately 2 weeks and increased afterward, reaching the initial value by the end of the storage period.

3.16 On the basis of b*/a* values, the surface redness of cooked ham was significantly higher than that of the other two products tested. The hue values of Bologna sausage and Italian-type cooked sausage did not change, being close to each other throughout the storage period. The redness of Kapuvár cooked ham declined in vacuum packaging and in MAP containing 30% CO_2, whereas it remained practically unchanged in MAP consisting of 60% CO_2 and 40% N_2.

3.17 No change was observed in the lightness of sausages during the storage period. In contrast, the L* value of Kapuvár cooked ham increased both in vacuum packaging and in MAP containing 30% CO_2; however, a headspace CO_2 concentration of 60% resulted in no change in the lightness of this product during storage.

3.18 The color saturation of vacuum packed Italian-type cooked sausage and Kapuvár cooked ham slightly declined as storage progressed. This sensory attribute showed no changes in any other formulation at any sampling time.

4 NEW FINDINGS

4.1 Modified atmospheres containing 30% or 60% CO_2 are capable of reducing the numbers of mesophilic microorganisms, thereby extending the shelf life of products. The growth of LAB in modified atmosphere packed sliced cooked meat products is slower and, therefore, their viable counts are lower than those of mesophilic microbes. The packaging system applied has a major influence on the growth of LAB, with headspace CO_2 concentrations reducing the growth rate of these microorganisms.

4.2 Headspace CO_2 levels result in unpleasant off-odors only in certain products. With increasing CO_2 concentrations, the slime formation of sliced cooked meat products is reduced. The start of decline in odor freshness is delayed in modified atmosphere packed products compared to their vacuum packaged counterparts.

4.3 MAP was found to slightly improve the red-yellow hue of sausages and considerably improve the red-pink hue of Kapuvár cooked ham. The color of sausages becomes paler and lighter in the presence of CO_2 regardless of its concentration in the headspace of packages. In contrast, the lightness of cooked ham decreases under such conditions, thus increasing the color intensity of this product.

4.4 The flavor changes during refrigerated storage of modified atmosphere packed sliced cooked meat products are attributable to ageing processes which are yet to be clarified.

5 SCIENTIFIC PUBLICATIONS AND ORAL PRESENTATIONS ON THE TOPIC OF THE PH.D. DISSERTATION

1 ORAL PRESENTATIONS DELIVERED AT SYMPOSIA

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1.1.2 **SZALAI, M.** (1998) Húsipari termékek csomagolásának EU követelményei. *Gyöngyöspack Élelmiszer- és Csomagolás-technikai Kiállítás és Vásár*. Előadás, Gyöngyös, 1998. szeptember 3.

2 PAPERS PUBLISHED IN POPULAR MAGAZINES

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2.1.2 **SZALAI, M.**, MOLNÁR, E., TANNINEN, T., MÁRK, I. & MÁRK, E. (2000) Nyers húsok védőgázos csomagolása. *A Hús* **10** (2), 105–109.

2.1.3 **SZALAI, M.**, & MOLNÁR, E. (2001) Új csomagolási módok: az aktív és az intelligens csomagolás. *A Hús* **11** (1), 32–37.

3 PAPERS PUBLISHED IN PROCEEDINGS

3.1 In Hungarian

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3.1.2 SAARISTO, E. & **SZALAI, M.** (1996) A csomagolás szerepe az élelmiszerek minőségmegőrzésében. *XXVI. Óvári Tudományos Napok*. "Új kihívások és stratégiák az agrártermelésben." Az előadások teljes terjedelemben megjelent anyagai, II. kötet,

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3.1.3 SAARISTO, E., **SZALAI, M.** & FARKAS, L. (1996) Élelmiszerek csomagolása. *XXVI. Óvári Tudományos Napok*. "Új kihívások és stratégiák az agrártermelésben." Az előadások teljes terjedelemben megjelent anyagai, II. kötet, Élelmiszer-minőség Szekció, Mosonmagyaróvár, 444–447.

3.1.4 **SZALAI, M.** & TANNINEN, T. (1998) Élelmiszerek csomagolása módosított légterű, ún. védőgázos eljárással. *XXVII. Óvári Tudományos Napok*. "Új kihívások a mezőgazdaság számára az EU-csatlakozás tükrében." Az előadások teljes terjedelemben megjelent anyagai, IV. kötet, Minőségi Élelmiszer-előállítás Szekció, Mosonmagyaróvár, 883–886.

3.1.5 **SZALAI, M.**, TANNINEN, T. & FARKAS, L. (1998) Élelmiszerek módosított légterű, ún. védőgázos csomagolására alkalmas fóliák és azok előállítása. *XXVII. Óvári Tudományos Napok*. "Új kihívások a mezőgazdaság számára az EU-csatlakozás tükrében." Az előadások teljes terjedelemben megjelent anyagai, IV. kötet, Minőségi Élelmiszer-előállítás Szekció, Mosonmagyaróvár, 887–889.

3.1.6 **SZALAI, M.** (2002) Újdonságok a csomagolásban és a környezetvédelem. *13. Húsipari Továbbképző Napok*. Az előadások teljes terjedelemben megjelent anyagai, Budapest, 101–106.

4 PAPERS PUBLISHED IN SCIENTIFIC JOURNALS

4.1 In Hungarian

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4.1.2 **SZALAI, M.**, MÁK, E., RÉTI, A., SZIGETI, J., FARKAS, L. & VARGA, L. (2003) Védőgázos csomagolású marinádozott csirkehús vizsgálata, különös tekintettel az érzékszervi tulajdonságokra

(Evaluation of modified atmosphere packaged marinated chicken meat with special reference to sensory properties). *Acta Agronomica Óváriensis* **45** (1), 69-76.

4.1.3 **SZALAI, M.**, MÁRK, I., RÉTI, A., SZIGETI, J., FARKAS, L. & VARGA, L. (2003) Szeletelt, hőkezelt húskészítmények színstabilitásának vizsgálata vákuumos és különböző gázösszetételű védőgázos csomagolási módoknál (Color stability of sliced cooked meat products packaged under vacuum or modified atmospheres). *Acta Agronomica Óváriensis* **45** (közlésre elfogadva).

4.2 In English

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4.2.2 **SZALAI, M.**, SZIGETI, J., FARKAS, L., VARGA, L., RÉTI, A. & ZUKÁL, E. (2003) Effect of headspace CO_2 concentration on shelf life of cooked meat products. *Acta Alimentaria* **32** (közlésre benyújtva).