PS10.04 Extending the Shelf Life of Fresh Ready-to-Cook Chicken Meals by using Lingonberry Marination and Low Oxygen Packaging 213.00

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***Abstract* — The aim of the study was to achieve a microbiological shelf life of at least 10 days at 4 ºC for a fresh ready-to-cook chicken meal. The meal consisted of raw chicken breast fillets, a mixture of raw cut vegetables of broccoli, cauliflower and carrots, pre-cooked rice and pasteurized sauce. Meals with marinated and non-marinated chicken meat were compared. Before packaging, the chicken meat was marinated in a lingonberry juice for 10 minutes to reduce surface bacteria. The meals were packaged in transparent one-compartment trays, and stored at 4 ºC. Microperforated top films were applied for sufficient penetration of O_2 for obtaining a gas equilibrium of appr. 5 % O_2 and 20 % CO_2 for much of the storage period. The marinated chicken meal had a shelf life of 12 days, as assessed by off-odour detection and a total plate count up to log 7. The shelf life of the non-marinated chicken meal was 7 days. In addition to the antimicrobiologial effect, the lingonberry juice marination improved colour stability, but increased drip loss during modified atmosphere storage. The extended shelf life of the chicken ready-to-cook meal obtained in this experiment facilitates a more widespread distribution in the market and reduced losses in food stores.**

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***Index Terms* — chicken meat, lingonberry juice marination, low oxygen packaging, microbiological shelf life, ready-to-cook meals.**

II. INTRODUCTION

The demand for ready-to-eat meals of high quality is growing world-wide. In Europe, complete chilled ready-to-cook meals consisting of raw cut vegetables, raw meat or fish, pre-cooked rice, potatoes or pasta, and sauce have been introduced. However, the sale of these meals is limited due to a microbiological shelf life of only 5 – 6 days and rapid quality deterioration. Ready-to-cook meals are cooked only once by the consumers. A valve for releasing steam during microwave heating is often placed in the top film of the packages. The EU funded project DoubleFresh is seeking to improve shelf life and quality of these meals by using selected pre-treatments of individual ingredients and suitable modified atmosphere packaging. Furthermore, the project aims at producing tasty, safe and healthy meals in a viable business concept.

Pre-treatment can include marination of raw meat with antimicrobiological berry juices. Lingonberries (*Vaccinium vitis-idaea*), found in Eurasia and North America, contain various acids, flavonoids and other antimicrobiologial compounds. The content of benzoic acid in juices of Finnish lingonberries was 0.72 g/l (1). The concentration of juices and contact time in the marinade must be balanced against effects on taste, drip loss and colour stability during storage.

Respiring vegetables and non-respiring foods like meat have different requirements for modified atmosphere packaging. In general, vegetables need access to oxygen (O_2) in levels of at least 2 – 3 % and below 15 – 20 % CO_2 during storage for maximizing shelf life and quality (2). Therefore, using laser-perforated films with a high O_2 penetration is a necessity. Vegetables differ greatly in their rate of respiration and need for supply of O_2. In contrast, the shelf life and quality of meat is best maintained under anaerobic storage and high concentrations of CO_2 (3,4). In the ready-to-cook meal concept with a microwaveable package with one compartment for all ingredients, it is a challenge to find suitable packaging materials and gas compositions.

As a part of the DoubleFresh project, we have worked on improving the shelf life and quality of a ready-to-cook chicken meal. The aim of the present experiment was to achieve a microbiological shelf life of this meal of a minimum of 10 days at 4 ºC by using a lingonberry juice marinade for the meat and suitable gas packaging with a low concentration of O_2.

III. MATERIALS AND METHODS

The meal consisted of raw chicken breast fillets (*M. pectoralis superficialis et profundus*) (Nortura, Hærland, Norway), raw cut vegetables (Spanish broccoli florets, Spanish cauliflower and Norwegian carrots slices), precooked white rice (Ardo Geer, Ardooie, Belgium) and pasteurized red bell pepper sauce (Fjordland, Oslo, Norway). Total weight of the meal was appr. 470 g.

Marination of the chicken meat was performed two days post mortem with a pasteurized, filtered and unsweetened juice of lingonberries (Askim Frukt- og Bærpresseri, Askim, Norway) at a ratio of marinade: meat of 1:1, immersed for 10 minutes. The cut vegetables were washed in water and centrifuged to remove excess water. The ingredients were placed in trays starting in the bottom with sauce, followed by rice, vegetables and meat at the top. The packages were flushed with a gas mixture of 5% O_2/ 5 % CO_2/ 90 % N_2 (Yara Praxair, Porsgrunn, Norway) on a

Promens 511VG tray sealing machine (Promens, Kristiansand, Norway). The trays were of type transparent Færch polypropylene 1221-1G (Færch Plast, Holstebro, Denmark) containing 1150 cm^3. The top film was a microperforated polyethylene film type 52LD (Amcor Flexible, Ledbury, UK). The meals were stored at 4 º for up to 15 days. Analyses included composition of O_2 and CO_2 in headspace, total plate count of the meat surface on Plate Count Agar incubated at 30 ºC for 3 days (PCA), evaluation of off-odour using a 5 member trained panel, a* redness values of the meat surface (Minolta Chroma Meter CR-400 (Minolta Camera Co., Osaka, Japan) with 8 mm viewing port and illuminant D_{65}, weight loss and pH of the marinade. The analyses were performed in triplicate at all sampling times.

Statistical analysis and graphics were prepared by using Minitab v15 (Minitab Inc., State College, Pennsylvania, USA).

IV. RESULTS AND DISCUSSION

The concentration of O_2 in the packages is a good indicator of the condition and quality of the meal. Data in Figure 1, show that there was slight decrease from the appr. initial 7 to 5 % O_2 at day 9 of storage. At day 12, the concentration of O_2 in non-marinated meal packages was appr. 0.5 % compared to 2.5 % in the marinated meal packages ($p < 0.05$). Up to day 9, the vegetables, in particular broccoli, were mainly responsible for the consumption of O_2. At later storage, bacteria on the chicken meat were likely to contribute to additional O_2 depletion. The slower rate of O_2 depletion in the marinated meals indicated less bacterial growth on the meat, in agreement with microbiological data in Figure 2.

The concentration of CO_2 increased from initially 4 % to appr. 25 % at the end of storage for both meals (results not shown). The increase in CO_2 was more rapid at the later stage of storage in the non-marinated than the marinated meal.

Figure 2 demonstrates that the marinated chicken meat had nearly 1 log lower total plate counts than the non-marinated control at the time of packaging ($p < 0.05$). At 8 days of storage the difference in counts was log 3.5 ($p < 0.05$). Then the non-marinated meat had unacceptable high counts of log 7.8, and storage for these meals was discontinued. At day 12, the marinated chicken had counts of log 7.2.

Supporting the results of the total plate counts, data for off-odour in Figure 3 shows that the non-marinated meal was unacceptable with a score of 4 at 8 days storage, caused by off-odour from the chicken meat. In contrast, the marinated meal was still acceptable with a score of 2.5 at day 12.

Instrumental colour was affected by marination, as demonstrated in Figure 4. a* redness values were about 1 unit higher in marinated than non-marinated meat at the time of packaging ($p < 0.05$). While the a* values of marinated meat increased slightly from day 0 to days 9 and 12, the a* of non-marinated meat decreased from day 0 to 9, probably due to exposure to low concentrations of O_2, inducing formation of gray to brown metmyoglobin at the surface (4). Discoloration was effectively hindered by marination of the meat by making a red bluish colour of the surface.

The weight increase by the marination of chicken breast muscles was appr. 1 %, leading to an impact of the marinade only 1 – 2 mm into the surface, but not in the inner parts of the fillet. However, the drip loss averaged over the storage period was 5.8 % for the marinated meat compared to 2.4 % for the non-marinated meat ($p < 0.05$). Due to the low pH of the lingonberry marinade (2.9), we suggest that the increased drip loss is caused by partial protein denaturation at the meat surface, inducing release of liquid. Further studies are needed to explain the mechanisms for drip loss by lingonberry juice marination.

The vegetables chosen for this meal, that were broccoli, cauliflower and carrots, had no or minor decay at 12 days storage, probably a consequence of exposure to a favourable atmosphere of appr. 5 % O_2 and 20 % CO_2 for most of the storage period. Likewise, the rice and sauce both had a high quality and were unspoiled at 12 days storage. Therefore, the chicken meat was the ingredient that was limiting the shelf life of the meal. The headspace composition of the meal was not ideal for the meat fraction, but was a compromise to reduce decay and quality loss for the vegetables.

The effects of the lingonberry juice marination on reducing microbiological growth and extending shelf life were considerable. In this experiment, the targeted shelf life of 10 days would have been difficult to obtain without the lingonberry marinade. The causes for the high antimicrobiological effect of the marinade are not clear. In addition the low pH, the influence of bioactive compounds like benzoic and other acids, flavonoids etc. are possible causes (1). Lingonberry juice may have interesting applications for muscle foods beyond the use for chicken meat in fresh ready-to-cook meals.

V. CONCLUSION

A shelf life of 12 days at 4 ºC for the fresh ready-to-cook chicken meal was obtained by selecting high quality raw materials with low bacterial counts and marinating the chicken meat with a lingonberry juice, in addition to applying microperforated packaging materials yielding low O_2 atmospheres suitable for the vegetable fraction of the meal.

ACKNOWLEDGEMENT

The authors highly appreciate research funding from the European Union in the project DoubleFresh STREP FR6 PL 023182. The support from Fjordland and Nortura, both Oslo, Norway, in developing the meal is highly acknowledged. Drs. Gunnar Bengtsson and Nina Veflen Olsen at Nofima Mat are thanked for valuable advice on vegetable technology and meal composition.

REFERENCES

[1] Viljakainen, S., Visti, A., & Laakso, S. (2002). Concentrations of organic acids and soluble sugars in juices from Nordic berries. Acta Agriculturae Scandinavica Section B, Soil and Plant Science, 52 (2/3), 101 – 109.

[2] University of California, Davis. http://postharvest.ucdavis.edu (assessed on 14 May 2009).

[3] Rotabakk, B.T., Birkeland, S., Jeksrud, W., & Sivertsvik, M. (2006). Effect of modified atmosphere packaging and soluble gas stabilization on the shelf life of skinless chicken breast fillets. Journal of Food Science, 71, S124 – S131.

[4] McMillin, K.W. (2008). Where is MAP going? A review of future potential of modified atmosphere packaging for meat. Meat Science, 80, 43 – 65.

Fig. 1. Concentration of O_2 during storage of marinated and non-marinated chicken ready-to-cook meals at 4 ºC.
Symbols: ■ marinated with lingonberry juice, □ non-marinated.

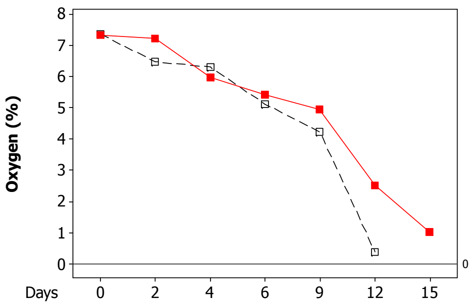

Fig. 2. Total plate counts on meat during storage of marinated and non-marinated chicken ready-to-cook meals at 4 ºC. Symbols as in Fig. 1.

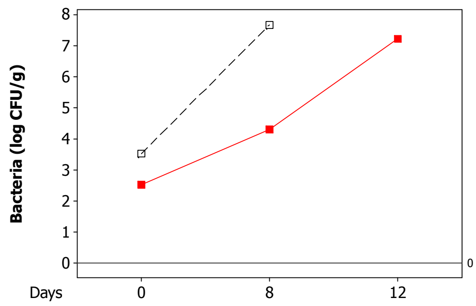

Fig. 3. Off-odour score during storage of marinated and non-marinated chicken ready-to-cook meals at 4 ºC. Scale: 1 = none, 3 = slight and 5 = extreme. Acceptable at scores < 3. Symbols as in Fig. 1.

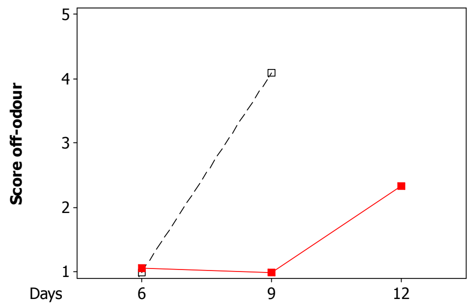

Fig. 4. a* redness values of meat during storage of marinated and non-marinated chicken ready-to-cook meals at 4 ºC. Symbols as in Fig. 1.