Multi-layer films based on furcellaran containing active ingredients (curcumin extract, MMT, AgNPs and capsain) for storing pork loins

Ewelina Jamróz[1*], Piotr Kulawik[2], Joanna Tkaczewska[2], Nikola Nowak[1], Wiktoria Grzebieniarz[1], Eskindir Endalew Tadesse[2], Wondyfraw Tadele[2], Paulina Guzik[2], Rafał Szram[2]

[1] Institute of Chemistry, University of Agriculture, Balicka Street 122, PL-30-149 Cracow

[2] Department of Animal Products Processing, University of Agriculture, Balicka Street 122, PL-30-149 Cracow

*Corresponding author email: ewelina.jamroz@urk.edu.pl

I. INTRODUCTION

Food packaging plays an important role in ensuring food safety and protection, which in turn may lead to a reduction in food waste. Biopolymers such as proteins and polysaccharides are becoming interesting building blocks for packaging materials due to their environmental benefits. Furcellaran is a negatively charged polysaccharide obtained from the red alga *Furcellaria lumbricalis* and due to its gel-forming properties, it is an interesting candidate as a building compound for packaging materials. Moreover, it is non-toxic and biocompatible with other active ingredients, therefore it does not block their active action. Active packaging is gaining popularity because, due to the presence of an active additive, it can extend the shelf life of a food product. The aim of the work was to use two types of films previously characterized (1,2) as packaging materials for a meat product.

II. MATERIALS AND METHODS

2.1. Materials

All materials and reagents used in the experiment are presented (1,2). The procedure for obtaining gelatin hydrolysate was presented earlier (3). Fresh pork loin slices were obtained from local retail chain located in Kraków, Poland.

2.2. Methods

2.2.1. Preparation of active films

FILM A- The procedure for obtaining the FILM A is presented in the publication (1), and also schematically in Figure 1. **FILM B-**The methodology for obtaining FILM B was presented earlier (2) and in **Figure 1**.

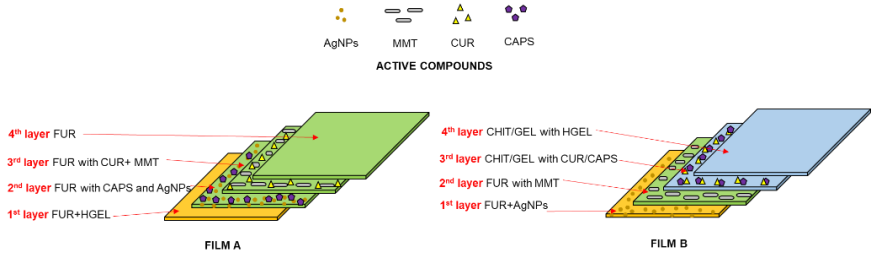

Figure 1. Scheme of obtaining two types of films used in an experimental study on a food product.

2.2.2. Evaluating the film influence on the quality of pork loins during cold storage

The pork loins slices were divided into 4 groups: wrapped in FILM A, FILM B and two controls: slices wrapped in LDPE film and not wrapped in any film. Samples were hermetically packed using tray sealer machine and stored at 4°C for 15 days. The samples were analyzed on days 0,4,7,11 and 15 for their microbiological contamination (total viable counts (TVC) and yeast and moulds (YM)), fat oxidation (TBARS) and sensory scores (color, aroma, texture and overall acceptability) according to (4). The experiment was carried out using three independent replications. Analysis included the two-way ANOVA with Tukey Post-hoc test with significance of difference established for $p<0.05$.

III. RESULTS AND DISCUSSION

The use of films caused the drying of the pork loin surface. This in turn resulted in inhibition of microbial growth, both TVC and YM. The TVC gradually increased from initial 1.8±0.1 log cfu/g on day 0 to 7.7±0.4 and 8.4±0.3 log cfu/g for control and LDPE control respectively on day 15. At the same time samples wrapped in films contained 3.5-5.1 log cfu/g of TVC, with the highest efficiency observed for FILM B. Similar trend was observed for YM, with control increasing from 0.8±1.4 to 6.8-7.8 log cfu/g vs 3.6-4.7 log cfu/g observed in samples wrapped in studied films (**Table 1**).

Table 1. Changes in (A) TVC (B) YM (C) TBARS.

	Days				
	0	**4**	**7**	**11**	**15**
TVC					
Control	1.77^{a}	1.94^{ab}	3.53^{bce}	5.77^{ef}	7.68^{g}
LDPE	1.77^{a}	2.22^{ab}	4.76^{def}	5.88^{f}	8.41^{g}
FILM A	1.77^{a}	2.28^{ab}	2.63^{abc}	4.13^{cde}	5.13^{def}
FILM B	1.77^{a}	1.87^{ab}	1.85^{a}	2.44^{ab}	3.53^{bce}
YM					
Control	0.81^{ab}	0.55^{a}	2.42^{abcde}	4.99^{ef}	6.81^{fg}
LDPE	0.81^{ab}	0.89^{ab}	3.52^{bcde}	4.83^{ef}	7.79^{g}
FILM A	0.81^{ab}	1.42^{abcd}	1.60^{abcde}	4.00^{de}	4.67^{ef}
FILM B	0.81^{ab}	1.11^{abc}	0.00^{a}	2.65^{abcde}	3.65^{cde}
TBARS					
Control	0.19^{ab}	0.17^{a}	0.21^{abc}	0.19^{a}	0.33^{abcd}
LDPE	0.19^{ab}	0.17^{a}	0.17^{a}	0.33^{abcd}	0.20^{ab}
FILM A	0.19^{ab}	0.33^{abcd}	0.39^{abcd}	0.46^{de}	0.42^{bcd}
FILM B	0.19^{ab}	0.28^{abcd}	0.25^{abcd}	0.43^{cd}	0.68^{bcd}

a,b,c -.Different lettering in the same rows indicate significant differences ($P < 0.05$)

On the other hand as mentioned, the films caused drying of the meat surface dry matter increased from 29.0 on day 0 to 33.3-40.1% after 15 days of storage), which resulted in impaired sensory characteristics. Throughout the whole storage period, the control samples had higher sensory scores for all measured attributes than treated samples (**Table 2**).

Table 2. Sensory scores of pork loin samples stored at 4°C.

SMELL

	0	**4**	**7**	**11**	**15**
Control	5^{g}	4.6^{efg}	4.67^{efg}	3.76^{de}	2.98^{abcd}
LDPE	5^{g}	4.68^{fg}	4.71^{fg}	3.88^{def}	2.52^{ab}
FILM B	5^{g}	3.67^{d}	3.38^{bcd}	2.93^{abcd}	2.26^{a}
FILM A	5^{g}	3.48^{cd}	2.98^{abcd}	2.67^{abc}	2.21^{a}

MEAT COLOR

	0	**4**	**7**	**11**	**15**
Control	5^{h}	4.83^{h}	4.64^{gh}	3.86^{ef}	3.19^{de}
LDPE	5^{h}	4.83^{h}	4.43^{fgh}	3.93^{efg}	3.36^{de}
FILM B	5^{h}	2.70^{cd}	2.43^{bc}	2.26^{abc}	1.79^{ab}
FILM A	5^{h}	2.11^{abc}	2.07^{abc}	2.07^{abc}	1.60^{a}

TEXTURE

	0	**4**	**7**	**11**	**15**
Control	5^{i}	4.61^{hi}	4.29^{ght}	3.64^{efg}	2.79^{cde}
LDPE	5^{i}	4.53^{ghi}	4.43^{ght}	3.77^{fgh}	2.95^{cdef}
FILM B	5^{i}	2.97^{cdef}	2.57^{bcd}	2.24^{abc}	1.49^{a}
FILM A	5^{i}	3.28^{def}	2.50^{bcd}	2.24^{abc}	1.79^{ab}

OVERALL

	0	**4**	**7**	**11**	**15**
Control	9^{f}	7.7^{f}	7.74^{ef}	6.31^{de}	4.79^{c}
LDPE	9^{f}	7.66^{def}	7.89^{f}	6.30^{d}	4.19^{bc}
FILM B	9^{f}	4.22^{bc}	4.19^{bc}	3.93^{bc}	2.43^{a}
FILM A	9^{f}	3.45^{abc}	3.26^{ab}	2.98^{ab}	2.31^{a}

Moreover the samples wrapped in developed films were deemed unacceptable in terms of color and overall acceptability after just 4 days, in terms of texture after 7 days and in terms of aroma after 15 days. At the same time both control samples were considered acceptable until day 15 of storage. All studied films caused, aside from drying, the discoloration of meat, which took color characteristics of the active ingredient present in the films.

IV. CONCLUSION

The films successfully inhibited microbial growth, however they also caused deterioration of sensory properties and therefore cannot be used for high-water containing product Surprisingly, the films did not inhibit fat oxidation of the samples, measured through TBARS method. Moreover, the application of FILM A and FILM B seemed to promote the TBARS formation.

ACKNOWLEDGEMENTS

This work was supported by the National Center for Research and Development, Poland [Grant No.: LIDER/6/0016/L-11/19/NCBR/2020].

REFERENCES

1.Grzebieniarz, W., et al. (2023) Improving the quality of multi-layer films based on furcellaran by immobilising active ingredients and impact assessment of the use of a new packaging material. Food Chemistry 428:136759.
2.Nowak, N., et al. (2023) Active and Intelligent Four-Layer Films Based on Chitosan, Gelatin, Furcellaran and Active Ingredients—Preparation, Characterisation and Application on Salmon. Food and Bioprocess Technology
3.Tkaczewska, J., et al.(2019) Evaluation of the potential use of a carp (Cyprinus carpio) skin gelatine hydrolysate as an antioxidant component. Food Function, 10(2):1038-1048.
4.Kulawik, P., et al. (2024) Application of antimicrobial chitosan-Furcellaran-hydrolysate gelatin edible coatings enriched with bioactive peptides in shelf-life extension of pork loin stored at 4 and −20 °C. International Journal of Biological Macromolecules 254: 127865.