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EDIBLE COATINGS AS AN ALTERNATIVE TO SYNTHETIC FILMS

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Abstract: Edible films are defined as a thin, flexible layer of material used in food packaging which can be consumed with foods. Starch is a natural polymer widely used in food technology as component of edible films. The use of natural biopolimers in films preparing is restricted due to their poor mechanical properties and high brittleness. The addition of plasticizers (such as glycerol) and different thickness of edible films alters their functional properties. The aim of this work was to develop a methodology for the preparation of edible films base on starch polymers and to determine their physical properties. On the base of the results it was stated that the addition of glycerol to the starch film matrix increased the film thickness by 30-44%. Tensile strength (TS) and Elongation at break values (EL) were almost the same for films without glycerol, irrespective the film thickness, however addition of plasticizer influenced their mechanical properties. Addition of glycerol to the films increase their Elongation at break. The same effect was observed with increasing film thickness. Synthetic PE foil exhibited intermediate value of TS, however EL value was much greater than that for starch films with or without plasticizer. The lightness of the edible films is found to decrease with increasing thickness and L* value was lower than that of synthetic PE film. The decrease of b* (color movement from yellow towards blue) was observed with the addition of glycerol and with the increasing film thickness, however a* parameter was almost unchanged.
Keywords: starch, texture, edible film, color

INTRODUCTION

Packaging are used to ensure high quality and long shelf-life food products, but nowadays there is a pro-ecological trend to reducing use of synthetic materials. One of the problem-solving strategy is to replace the plastic packaging with new, biodegradable materials. Edible films and coatings seems to be a good alternative to the plastic foil. They are defined as a thin layer of material which can be consumed and provides a good barrier to moisture, oxygen and solute movement for the food **(Mokrejs et al., 2009).** Because edible films are considered a packaging as well as a food component, they should fulfill a number of requirements, such as: high barrier and mechanical efficiencies, biochemical, physico-chemical and microbial stability, they should be non-toxic, non-polluting and low cost **(Mokrejs et al., 2009).** Edible films are preparing from inexpensive natural biopolymers, such as polysaccharides (e.g. starch, cellulose, gums, chitosan) and proteins (e.g. collagen, casein, whey protein and total milk proteins) or from lipids (e.g. paraffin wax, carnauba wax, beeswax, candelilla wax) **(Bergo et al., 2010).**

Starch is a natural polymer widely used in food technology as a thickener, stabilizer, emulsifier and recently also as a component of edible films. The properties of foils based on starch depends on its botanical origin, concentration or type of modification. Starches are obtained from various botanical sources such as maize, wheat, rice and tapioca **(Park et al., 2009)**, however in Poland, the most popular starch source, is potatoe. The use of natural biopolimers in films preparing is restricted due to their poor mechanical properties and high

brittleness. Therefore modified starches are often used to replace their native counterparts and some additives (such as glycerol) must be added to the film composition to obtain the necessary properties **(Bergo et al., 2010; Chillo et al., 2008)**. On the other hand, functional properties of that foils can be modified by forming a films of different thickeness.

The aim of this work was to develop a methodology for the preparation of edible films base on starch polymers and to determine their physical properties.

MATERIAL AND METHODOLOGY

Modified potato starch (distarch phosphate - DP) was obtained from Wielkopolskie Przedsiębiorstwo Przemysłu Ziemniaczanego S.A. (Luboń, Poland), glycerol (Gly) was purchased from Chempur (Piekary Śląskie, Poland).

Films preparation: Starch/glycerol films were prepared according to following recipe **(Osés et al., 2009)**. Aqueous suspension of starch in concentration 2% (m/m) was preheated at 70ºC for 30 min under stirring speed 300 rpm in a water bath. After that time glycerol was added to the dispersion and was mixing for ten more minutes. The concentrations of plasticizer were 0 and 0.4 g/1g starch content. Then the edible film solutions were poured into a plastic Petri dishes (diameter 9 cm). To obtain films with different thickness, the following quantity of each film solution was poured: 10, 20 and 30 g of samples. The starch suspensions were dried under controlled conditions (60ºC and 60% RH for approx. 24 h) in an environmental chamber Climacell 222 (BMT, Krakow, Poland). Finally films were removed from the plates and were subjected to further analysis.

Film thickeness: Film thickness was measured with a hand-held micrometer (Falon Tech, Warsaw, Poland) having a precision of 0.01 mm at five random positions on the films and the mean was used in the calculations.

Tensile strength and elongation at break: Film Tensile strength (TS) and percentage Elongation at break (EL) were determined using TA. XT. Plus Texture Analyser (Stable Micro Systems, United Kingdom). Initial grip separation between holders was 50 mm, and velocity of assay was 50 mm/min. Stripes of 80 mm in length and 25 mm width were used. TS was calculated by dividing the maximum tensile force (N) by the cross-sectional area of the film (mm^2, original thickness * original width). EL was calculated as the percentage change of the initial gage length of the specimen (50 mm) at the point of the sample rupture.

Parameters of color L, a* and b** were determined in CIELAB system ($10^o/D_{65}$ color spaces, gap 10mm) in transmission by using spectrophotometer X – Rite Color i5. The color parameters of the films were expressed as L* (lightness; from 0=black, to 100=white), a* (+a=redness, -a=greenness) and b* (+b=yellowness, -b=blueness).

RESULTS AND DISCUSSION

Table 1 shows the results of thickness measurement and mechanical properties of the analysed films. The thickness of films increased with increasing quantity of polymer suspension poured into Petri dishes. Furthermore the addition of glycerol to the starch film matrix increased the film thickness by 30-44% comparing to respective films without plasticizer. Synthetic PE foil had the least thickness among the samples. Tensile Strength and Elongation at break values were almost the same for films without glycerol, irrespective the film thickness, however addition of plasticizer influenced the mechanical properties of analysed wraps. TS values were over twice lower for films with glycerol (for DP-6 even five times) compared to respective films without glycerol, and those values decreased with increasing film thickness. Addition of Gly to the films increase their Elongation at break (EL). The same effect was observed with increasing film thickness. Synthetic PE foil exhibited intermediate value of TS, however EL value (63.2%) was much greater than that for starch films with or without plasticizer. Effects of plasticizer on EL and TS is known

from the literature. Mechanical properties of starch films are comparable to the literature data. **Kim et al. (2002)** reported that films prepared using highly corboxymethylated starch exhibited better EL and lower TS values with increasing glycerol content. Similar results were obtained by other authors for starch films (**Osés et al., 2009; Ryu et al., 2002**).

Table 1. Thickness and mechanical properties of distarch phosphate (DP) films with different thickness and glycerol content

Film	Glycerol content [%]	Thickness [µm]	Tensile Strength [MPa]	Elongation at break [%]
DP-1	0	24.8 ± 1.7	41.0 ± 4.4	6.1 ± 1.4
DP-2	0	52.8 ± 2.2	38.9 ± 9.4	4.6 ± 0.8
DP-3	0	83.8 ± 3.4	42.2 ± 8.4	4.7 ± 0.8
DP-4	40	33.5 ± 2.6	18.9 ± 0.8	5.0 ± 0.9
DP-5	40	76.0 ± 2.2	15.2 ± 3.8	11.2 ± 2.9
DP-6	40	108.8 ± 3.2	8.3 ± 1.9	14.5 ± 2.5
PE	-	10.0 ± 0.0	27.4 ± 0.7	63.2 ± 2.6

Edible films used for food wrapping should be thin, colorless and transparent to simulate the appearance of synthetic nonbiodegradable films [Rhim et al., 2002]. In order to compare the color parameters and differences between synthetic film and those prepared using modified starch preparations with different thickness and glycerol content, L*, a* and b* were measured spectrophotometrically. The lightness (L*) of the films is found to decrease with increasing thickness, but there were no difference between the films with or without plasticizer (Table 2). The decrease of b* (color movement from yellow towards blue) was observed with the addition of glycerol and with the increasing film thickness, however a* parameter was almost unchanged.

Table 2. L*, a* and b* color parameters of distarch phosphate (DP) films with different thickness and glycerol content

Film	Glycerol content [%]	L*	a*	b*
DP-1	0	93.2 ± 0.9	-0.05 ± 0.03	0.37 ± 0.03
DP-2	0	91.7 ± 0.5	0.04 ± 0.03	0.35 ± 0.08
DP-3	0	90.8 ± 0.0	-0.06 ± 0.03	-0.03 ± 0.04
DP-1	40	92.1 ± 0.2	-0.07 ± 0.02	0.35 ± 0.03
DP-2	40	91.0 ± 0.1	-0.02 ± 0.07	0.14 ± 0.09
DP-3	40	90.8 ± 0.7	-0.04 ± 0.08	-0.32 ± 0.21
PE	-	96.5 ± 0.1	0.02 ± 0.01	0.38 ± 0.03

DP films analyzed in this paper were lighter (L* parameter from 90.8 to 93.2) than other authors observed for starch films, e.g. **Galus et al. (2012)** found that soy protein isolate (SPI)+acetylated distach phosphate, and SPI+starch acetate have L* value about 82. Silimar results obtained **Flores et al. (2007),** for tapioca-starch edible films with or without sorbate (L* values were 82-85). The lightness of the PE films analyzed in this paper was slightly higher (L* = 96.5) than that of edible films. However a* and b* values were almost the same as for films without glycerol and with the smallest thickness.

CONCLUSIONS

1. Addition of glycerol to the starch film matrix increased the film thickness by 30-44%.
2. Tensile Strength and Elongation at break values were almost the same for films without glycerol, irrespective the film thickness, however addition of plasticizer influenced their mechanical properties.
3. Addition of glycerol to the films increase their Elongation at break. The same effect was observed with increasing film thickness.
4. Synthetic PE foil exhibited intermediate value of TS, however EL value was much greater than that for starch films with or without plasticizer.
5. The lightness of the edible films is found to decrease with increasing thickness and L* value was lower than that of synthetic PE film. The decrease of b* (color movement from yellow towards blue) was observed with the addition of glycerol and with the increasing film thickness, however a* parameter was almost unchanged.

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