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OBTAINING AND CHARACTERISATION OF STARCH-BASED EDIBLE FILMS INCORPORATING HONEY, PROPOLIS AND BEE BREAD

– Short communication –

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Abstract: This research investigates the physical-chemical, sensorial and mechanical characteristics of starch-based edible films incorporating three types of bee hive products: honey, propolis and bee bread, in concentrations varying from 1% to 3%, reported to starch. The results indicates an increasing of films moisture, water activity, ash content and acidity, in the order: honey<propolis<bee bread, all values increasing with the increasing of hive products percentage into the control film; a_w is remaining at very low values, under 0.4. Sensorial analysis indicated honey as the better suited for improving taste and flavour and bee bread for increasing colour intensity of the films; the sensorial characteristics are maintained during 30 days of films storage, in all cases. Compared with the control starch-based film (which is elastic, brittle and hard), the films containing 2% bee hive products are elasto-plastic and more resistant to penetration, the resistance increasing in the order: bee bread<propolis<honey.

Keywords: edible film, starch, honey, propolis, bee bread

INTRODUCTION

A great emphasis has been put nowadays on finding solutions for using biodegradable materials as food packaging, to replace conventional synthetic plastics (Wroblewska-Krepsztul et al., 2018; Vieira et al., 2011). Among them, starch is the most used biopolymer as bio-based food packaging material because of its ability in producing films (Moosavian et al., 2017; Shah et al., 2016) and its sustainability (Wroblewska-Krepsztul et al., 2018; Gadhave et al., 2018; Alvarez-Chavez et al., 2012).

Actual researches in the field of starch-based films are oriented in two main directions: improving the technology for starch-based packaging production (Shah et al., 2016) and making the packaging material active or responsive (Brockgreitens and Abbas, 2016; Yildirim et al., 2018). Essential oils or antioxidants are the most used compounds incorporated into the films. Essential oils show antibacterial, antifungal or both actions (Naiaretti et al., 2014; Oriani et al., 2014, Avila-Sosa et al., 2010). Antioxidants as grape juice or antocians are also used (Yıldırım-Yalçın et al., 2019; Lozano-Navarro et al., 2018). Such films are edible, too (Sadeghizadeh-Yazdi et al., 2019).

Honey and bee hive products as propolis, pollen, royal jelly or bee bread are valuable natural products containing bioactive compounds with anticancer, antimelanogenic, antibacterial, antioxidant action (Aumeeruddy et al., 2019; Pasupuleti et al., 2017). Honey has a very pleasant taste, too, given by the high content in sugars and odour molecules from plants (Deneulin et al., 2018). Propolis is pleasant, too (Wang, 2013). Bee bread taste is very much related with the taste of pollen, bee bread being composed on around 70% fermented pollen (Kieliszek et al., 2018).

This research aims to analyse the possibility to incorporate bee hive products into starch-based film. Three such products (honey, propolis and bee bread) are tested in three concentrations and physical-chemical, sensorial and mechanical characterisation of the resulted films is realised.

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MATERIALS AND METHODS

Materials

Corn starch was supplied by Amylon SA, Romania. Bee hive products were provided by ApiLife SRS Sibiu, Romania. Chemicals used: acetic acid (Sigma Aldrich), glycerol (Fisher Chemical) were of analytical degree.

Obtaining of starch-based films

The initial starch-based film was obtained in four steps: 1) mixing corn starch, acetic acid 1n and glycerol in the ratio starch:acetic acid:glycerol= 1:1:1 and then with water in the ratio mix:water=3;100; 2) boiling on water bath until the temperature of 95ºC; 3) pouring the resulted gel onto dry and clean dishes; 4) evaporating water at room temperature for 48h. The film containing hive products was obtained by following all the four steps; the bee hive products were added directly into the mix in the first step. Tree types of products were tested: acacia honey, propolis and bee bread, each in three concentrations: 1%, 2% and 3%, reported to the starch content.

Physical-chemical analysis of films

Prior physical-chemical analysis, films were cuted in very small pieces. Moisture, ash and acidity were determined by using the methods ISI 05, respectively ISI 02 and ISI 12 developed by the International Starch Institute (International Starch Institute, Science Park Aarhus, Denmark). The water activity of films was determined at 20°C (±0.5°C) using the device LabMaster-aw neo (Novasina, CH).

For each determination, three replicates were obtained and the average reported.

Sensorial analysis

Three characteristics were sensory evaluated: taste, flavour, colour intensity. A 7-point hedonic scale was used, where 7 meant extremely desirable characteristic and 0 meant extremely undesirable sensorial characteristic. The sensorial analysis was made by a panel of ten, male and female, semi-trained researchers, from the Department of Agricultural Sciences and Food Engineering at University Lucian Blaga from Sibiu, Romania. Sensory evaluation was conducted at day 0 and after 10 and 30 days of films storage at room temperature in a dark place. Before analysis, all samples were blinded by individually labeled random numbers and were served all at the same time.

Mechanical properties measurements

Tests on mechanical resistance of films (penetrometry) were carried out using TA.XTplusC Texture Analyser (Stable Micro Systems, Godalming, UK), equipped with 5000g load cell and flat cylindrical tip. Films with quadratic form 10x10 cm were fixed in a frame developed by us. Each sample was compressed with speed 250 $mm \cdot min^{-1}$ until the rupture of the film occured. Exponent Conenct Lite software was used to determine the textural profile of each sample.

10 tests were made for each sample and only the similar profiles were considered for analysis (minimal five similar profiles for each sample).

Prior textural analysis, films thickness was measured by microscopy (using three points for each measurement) and only films with thickness of 400 μm to maximal 420 μm were used for the textural measurements.

Statistical analysis

Microsoft Excel version 2013 software (Microsoft Corporation, Redmond, WA, USA) was used for statistical analysis. All data were expressed as mean ± SD (standard deviation) of three replicate samples.

RESULTS AND DISCUSSION

Figure 1 shows the water content (moisture), water activity, ash content and acidity values for starch films with additions of hive products, namely propolis, bee bread and honey, at different concentrations. Compared to the original film, the addition of honey does not lead to a significant increase in the film humidity, even honey is hygroscopic (Zamora et al., 2006). The bee bread determines the best water retention into the film, followed by propolis and honey (Figure 1a). Increasing the proportion of each addition leads to increased moisture in the film. An explanation of the better water entrapment into the films having bee bread and propolis could be their content in

waxes, which is absent or present as traces in honey. An ordering of the samples can be made, depending on the humidity, as follows: bee bread > propolis> honey; this order is respected for all concentrations analyzed.

As shown in Figure 1b, the water activity for all analyzed films is very small, varying in the range 0.355 - 0.373. Under these conditions, it is not possible to develop any type of microorganism (Lopez-Malo and Alzamora, 2015). All additions lead to an increase in water activity. In all samples, the order identified at the variation of a_w isthose identified at the variation of water content, the order being respected to all tested concentrations. This result is in accordance with researches showing a very good correlation between water activity and moisture in honey (Zamora et al., 2006).

The ash content is much increasing at the addition of hive products in the control film, this increase being higher in the case of using bee bread in higher concentrations (2% to 3%) (Figure 1c). As literature indicates, all products incorporated here into the film are very in minerals and salts ((Pasupuleti et al., 2017; Kieliszek et al., 2018). They increase the ash content in

The addition of bee hive products increases the films acidity, too, as Figure 1d shows. Propolis has the highest influence, followed by bee bread, whereas honey influences slightly the film acidity. This result is due to the high content in acids in propolis and bee bread (Pasupuleti et al., 2017; Kieliszek et al., 2018). The small increase of acidity at the addition of honey could be due to a small acidity of the honey type used in this research.

Figure 2 presents the results obtained at the sensorial analysis. All panelists gave 0 points to the initial starch-based film, which is colourless and an unpleasant taste and flavour of vinegar, from the acetic acid used at the film obtaining. Honey is giving the most pleasants taste and flavour (Figures 2a and 2b) to the edible film, no differences in these characteristics being identified at the increase of honey concentration from 2% to 3%. The increase of honey content to 3% gives a film which is adherent to the surface and very difficult to manipulate.

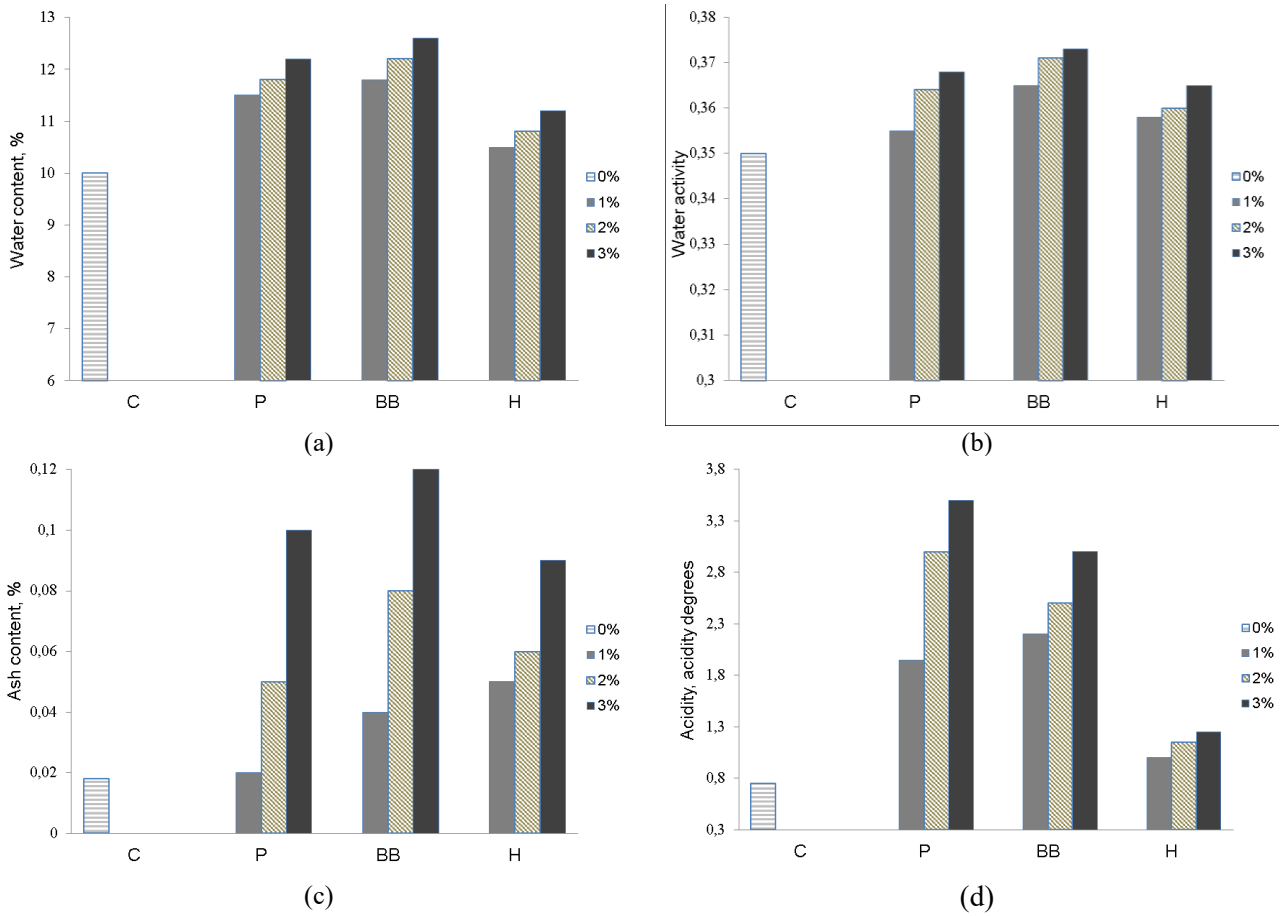

Figure 1. Influence of the addition of bee hive products on physical-chemical characteristics of the starch-base dfilms. a) water content; b) water activity; c) ash; d) acidity. C – control (starch-based film without any addition); P – control film with added propolis; BB – control film with added bee bread; H – control film with added honey.

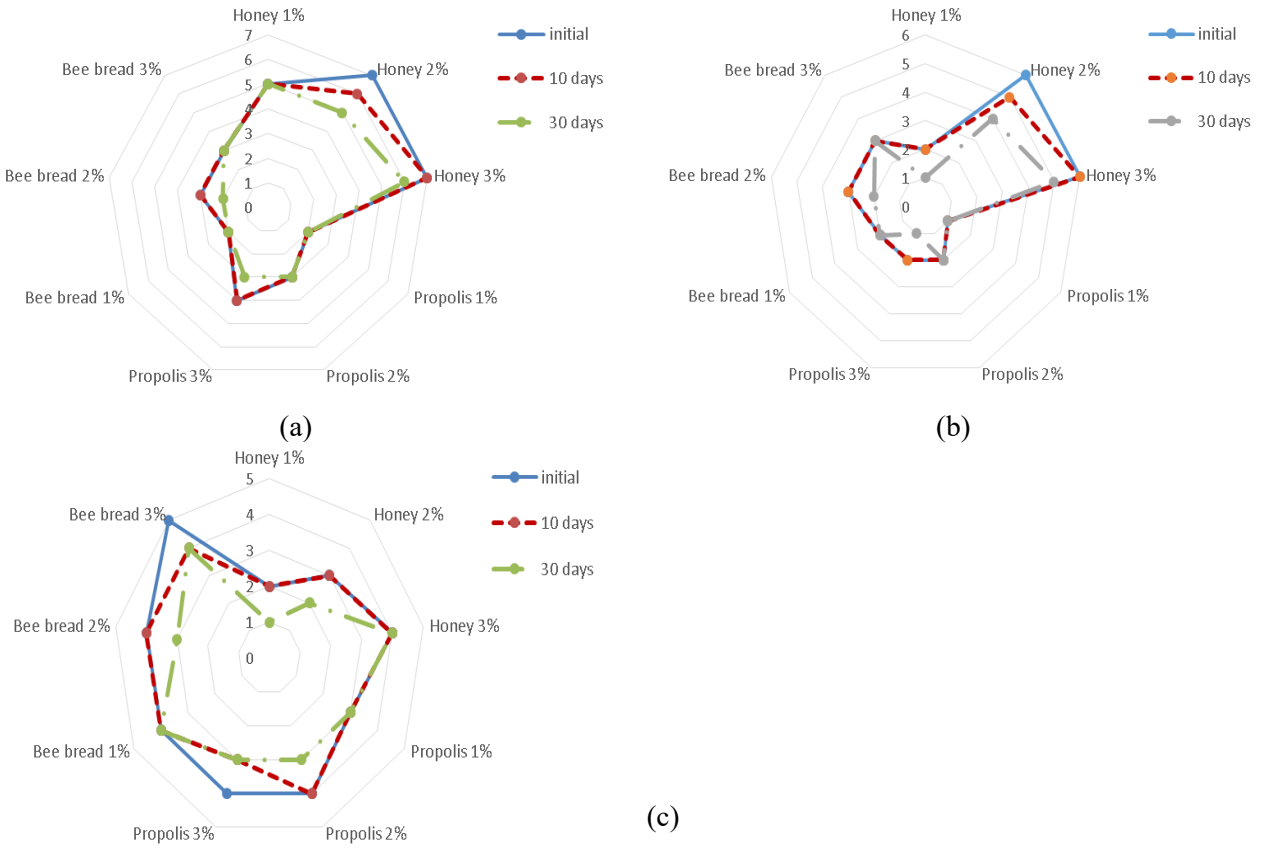

Figure 2. Sensorial analysis of films containing honey, propolis and bee bread in three concentrations: 1%, 2% and 3%, determined immediately after film obtaining and after maintaining for 10, respectively 30 days. (a) taste; (b) flavour; (c) colour intensity.

Bee bread and propolis in all concentrations tested don't influence significantly the taste and flavour (Figures 2a and 2b), but they offer a more attractive colour to the starchy film, compared with honey (Figure 2c). The most coloured film is those obtained with 3% bee bread.

After 10 days and 30 days of films storage, no significant differences in the sensorial characteristics analysed are identified.

Figure 3 shows the results obtained at the analysis of the films mechanical characteristics at penetrometry tests. The initial control film (without any addition of hive products) was compared only with the films obtained with 2% of honey, propolis and bee bread. The films obtained with 3% additions were not used for this analysis because of the difficulty to obtain them (too sticky); the films obtained with 1% additions were not considered because of the reduced influence on the sensorial characteristics.

The control film shows elastic behaviour, with a breaking force of 1438 g after a deformation of 14.2 mm; this material is brittle. Samples containing 2% of each propolis, bee bread or honey show both elastic and plastic behaviour; they are ductil materials, with the elastic limit lower as the breaking force for the control sample. The film with propolis has a well-defined zone with plastic behaviour, compared with the film with bee bread (where the plastic behaviour is not very clear). The clearest plastic behaviour is visible for the film produced with 2% honey; this material presents a resistance increase in the last section, indicating a structure re-organisation before breaking. The films produced with hive products can be ordered, in the order of increasing resistance, as follows: film with 2% bee bread < film with 2% propolis < film with 2% honey. The control film is the hardest. The film with 2% honey is the most suitable for stretching.

Some applications could be found for the products obtained and characterised here, especially for those containing honey in concentration of 2%, as edible film for sweet foods or foods where the sweet taste is desired, even the product is not swet. Tests on packaging condiments as cinnamon or nutmeg powder were made, with very good results. The film is suited as packaging material for liquid chocolate or even honey.

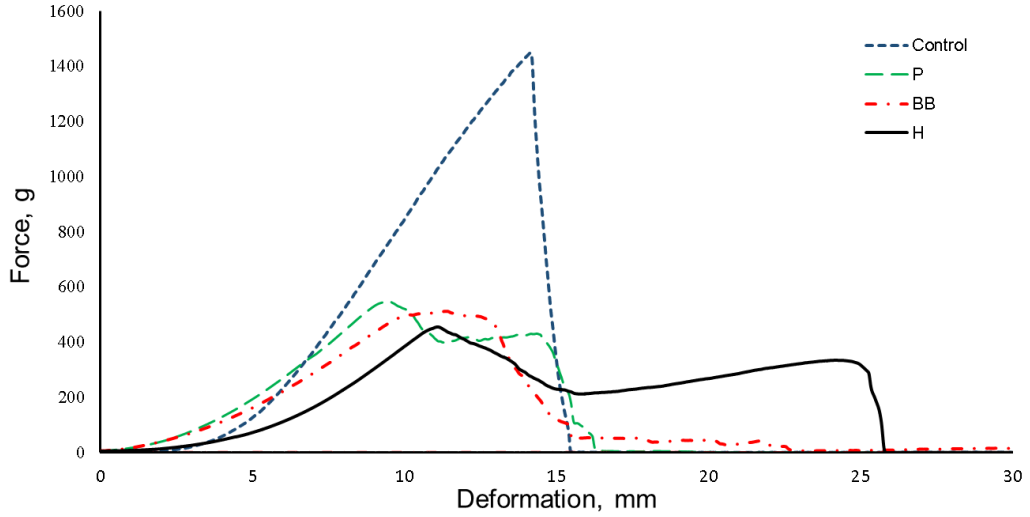

Figure 3. Relation force/deformation at penetration in starch-based films with added bee hive products. C – control (starch-based film without any addition); P – control film with 2% propolis added; BB – control film with 2% bee bread added; H – control film with 2% honey added.

CONCLUSIONS

A starch-based film was obtained in this research, in four-steps, and three hive products, namely honey, propolis and bee bread were successfully incorporated into the film in three concentrations: 1%, 2% and 3%. All films were physical-chemical characterised; the results allows ordering the films moisture, a_w, ash and acidity in two ways:

- depending on the hive product added, as follows: bee bread > propolis> honey;
- depending on the concentration used, as follows: 3%>2%>1%.

The sensorial analysis indicates honey as the most adequate for taste and flavour improvement of the initial film , whereas bee bread is most suitable for colouring the films.

The penetrometry tests on the films with 2% additives evidenced the elasto-plastic character of the films. Compared with the initial starch-based film, which is hard and brittle, the addition of small amounts of bee hive products (2%) increase the films resistants. Honey makes the films stretchy, applications as small bag for condiments powder, liquid chocolate or even honey being possible.

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