Sensory Attributes of Whey Protein Isolate and Candelilla Wax Emulsion Edible Films

S-J. Kim and Z. Ustunol

ABSTRACT: Whey protein isolate (5% w/v) films were plasticized with sorbitol or glycerol, and candelilla wax (0.8% w/v) was added to produce whey protein isolate and candelilla wax emulsion edible films. The films were cut into 7.62 cm × 2.54 cm strips and evaluated by a 15-member trained sensory panel for milk odor, transparency/opaqueness, sweetness, and adhesiveness using a structured 9-point intensity scale. The films had no distinctive milk odor; however, they were perceived to be slightly sweet and adhesive by the trained sensory panel. Whey protein isolate films without candelilla wax were clear and transparent, whereas candelilla wax containing films were opaque.

Keywords: whey protein, lipid, edible film, sensory

Introduction

USE OF EDIBLE FILMS AND COATINGS SUCH AS GELATIN CAPSULES, SAUSAGE CASINGS, OR CHOCOLATE COATINGS HAVE BEEN ARROUND FOR MANY YEARS (Debeaufort and others 1998; Cuq and others 1995; Guilbert 1986). However, interest in edible films has been renewed in recent years due to concerns about the environment and a need to reduce the amount of disposable packaging as well as demands by consumers for higher quality food products. Edible films can enhance food quality by acting as moisture, gas, aroma, and lipid barriers and providing protection to a food product after the primary package is opened. Antimicrobials and antioxidants may be incorporated into the films to provide further protective effects. Edible films and coatings could also serve to hold the food product intact and improve its handling characteristics. Thus, edible films provide the food processors with a number of new and unique opportunities for processing, handling, and product development (Krochta and DeMulder-Johnston 1997).

A number of plant and animal proteins such as corn zein, wheat gluten, soy and peanut protein, gelatin, collagen, casein, and whey proteins have been investigated for their ability to produce edible films, and the properties of these films have been reported (Gennadios and others 1994). McHugh and Krochta (1994a), Chen (1995), and Gennadios and others (1994) have reviewed the properties of milk protein-based edible films. Milk protein-based films have good mechanical strength and are excellent oxygen, lipid, and aroma barriers. But like other protein films, due to their hydrophilic nature, they are poor barriers to moisture (Chick and Ustunol 1998; Krochta and DeMulder-Johnston 1997; Miller and Krochta 1997, 1999; Shellhammer and Krochta 1997; McHugh and Krochta 1994b) to produce protein/lipid emulsion films. Thermal properties of whey protein isolate and lipid emulsion films have been reported, and their heat sealability also has been demonstrated (Kim and Ustunol 2000).

Over the years, various applications for milk protein-based edible films have been proposed, but none has been investigated extensively. Since an edible film becomes a part of the food product and is consumed with its contents, it is important that the edible film is compatible with the product that it contains, but also it is important that the edible film is fairly neutral from a sensory standpoint so that it is not detected during the consumption of the product. Morr and Ha (1993) stated that whey protein products are of limited use in other foods, due to the milk flavors associated with whey proteins and various other off-flavors that result during the drying of the powders. Although researchers have stated that whey protein-based films are bland in flavor and transparent (Chick and Ustunol 1998; Miller and Krochta 1997; McHugh and Krochta 1994b; Gennadios and others 1994), sensory data on milk protein-based edible films is still lacking. Sensory attributes are very important in that they often determine the acceptability of a food product. If an edible film is going to be consumed with its contents and if this film is going to be used commercially in the future, information on sensory attributes is of utmost importance. Therefore, the purpose of this research is to determine the sensory attributes of whey protein isolate/lipid emulsion films, using a trained sensory panel. Judges were trained to be sensitive to treatment difference so that they could detect small differences between samples (Stone and Sidel 1985; Pangborn 1984).

Materials and Methods

Materials

Whey protein isolate (WPI; ALACEN 895) was obtained from New Zealand Milk Products (North America) Inc., (Santa Rosa, Calif., U.S.A.). Candelilla wax was purchased from Strahl and Pitsch Inc. (West Babylon, N.Y., U.S.A.). D-sorbitol and glycerol were from Lonza Inc. (Fair Lawn, N.J., U.S.A.). NaOH was from Mallinckrodt Speciality Chemical Co. (Paris, Ky., U.S.A.). All materials were food grade.

Film preparation

WPI (5% w/v) and sorbitol (5.0 or 4.2% w/v) or glycerol (3.5 or 2.7% w/v) were mixed in distilled water and the pH adjusted to 8 with 2N NaOH. Solutions were heated to 90±2 °C while being stirred continuously. Candelilla wax (CW; 0.8% w/v) was added during heating and allowed to melt into the solutions to provide a solids content of 10% w/v for sorbitol
and 8.5% w/v for glycerol-plasticized film-forming solutions. The solutions were homogenized for 2 min using a Polytron PT 10/35 homogenizer with a PTA 20 TS homogenizing head (Tekmar Co., Cincinnati, Ohio, U.S.A.). The solutions were filtered through a layer of cheesecloth, vacuum degassed for 30 min, and then cast on 18.5 cm circular Teflon surfaces. The films were dried at room temperature 23 ± 2 °C and 30 ± 5% RH for 18 ± 3 h. Dried films were peeled and stored at 23 ± 2 °C and 50 ± 5% RH until sensory evaluation.

Sensory evaluation

Sensory evaluation of the films was conducted using a 15-member trained sensory panel consisting of faculty and graduate students (8 female and 7 male) at Michigan State Univ., ages 20 to 55. The panelists were selected through a screening process for their ability and reliability to distinguish the tested films’ attributes. The panelists participated in two 3-h orientation and training sessions. They were trained to discriminate and score the films consistently for the attributes being tested—transparency/opaqueness, milk odor, sweetness, and adhesiveness. The training involved tasting or sniffing the samples of varying intensities for each attribute being investigated. Samples used for the training sessions were commercial products purchased at the local grocery stores or samples prepared in the laboratory that varied in sensory attributes being tested. Panelists also practiced using the structured scale to quantify tested attributes, and were provided with feedback on their ratings. Data collection sessions were held once a day for 3 consecutive days. All testing and training sessions were conducted in a climate-controlled, sensory analysis laboratory equipped with individual testing booths. Panelists were provided with water at room temperature (~23 °C) for rinsing between samples.

Films were cut into 7.62 cm × 2.54 cm strips. Two strips of each film were presented in a randomized group of four to the trained panel. The panelists were instructed to evaluate the films for transparency/opaqueness, milk odor, sweetness, and adhesiveness. For determination of transparency/opaqueness, the panelists were asked to visually inspect the samples and score. To determine milk odor, the panelists were asked to sniff the samples. For determination of sweetness, they were asked to take the entire sample in their mouths, chew it a few times and swirl it around in their mouths, and then score. To determine adhesiveness, panelists were asked to place the sample between their molars, chew five times, and evaluate the force required to remove the sample from the teeth after mastication. Panelists evaluated each characteristic using a structured 9-point intensity scale, where 9 indicated the highest and 1 the lowest intensity of an attribute. Each attribute was rated on a separate ballot. The sensory scores were averaged for 15 judges for each of the four treatments (whey protein isolate film, plasticized with sorbitol or glycerol with or without candelilla wax) for all 3 replicates and attributes tested. A new film-forming solution and new set of films were prepared for each replicate. Statistical analysis was conducted using Sigma Stat 2.0 (Jandel Corp., San Rafael, Calif., U.S.A.) to determine statistical differences. Treatment means were compared using Student-Newman-Keuls comparison. Differences were considered significant at P < 0.05.

Results and Discussion

WHEY PROTEIN ISOLATE CONTAINED 93.5% PROTEIN AND <1% fat and lactose (data provided by New Zealand Milk Products [N. America] Inc.). Composition of WPI was confirmed using AOAC (1990) procedures.

Table 1—Sensory attributes of whey protein isolate and candelilla wax emulsion edible films as determined by a trained sensory panel

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Transparancy/opaqueness</th>
<th>Milk Odor</th>
<th>Sweetness</th>
<th>Adhesiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPI-S</td>
<td>2.02 ± 0.79a</td>
<td>1.38 ± 0.67a</td>
<td>4.60 ± 1.66a</td>
<td>3.96 ± 1.44a</td>
</tr>
<tr>
<td>WPI-G</td>
<td>2.07 ± 0.99a</td>
<td>1.64 ± 1.01a</td>
<td>5.58 ± 2.10a</td>
<td>2.42 ± 1.19a</td>
</tr>
<tr>
<td>WPI-S-CW</td>
<td>8.42 ± 0.57a</td>
<td>1.64 ± 0.67a</td>
<td>3.78 ± 1.60a</td>
<td>3.40 ± 1.68a</td>
</tr>
<tr>
<td>WPI-G-CW</td>
<td>8.64 ± 0.56a</td>
<td>2.00 ± 1.27a</td>
<td>3.93 ± 1.85a</td>
<td>1.76 ± 0.80a</td>
</tr>
</tbody>
</table>

*a,bMeans with the same superscript are not significantly different (P < 0.05).

Table 1 summarizes the results of the trained sensory panel. Transparency is the property of a material that allows one to see through it. Conversely, opaqueness is the property that blocks the passage of light. Overall, WPI films without candelilla wax were perceived to be clear and transparent, whereas candelilla wax-containing films were opaque. Transparency of WPI films plasticized with sorbitol and glycerol, without any candelilla wax added, were similar. They were scored 2.02 and 2.07, respectively, by the panelists. LDPE film, which was used for the training of the panelists, was assigned a score of 1. Both WPI films plasticized with sorbitol and glycerol containing candelilla wax were significantly more opaque (P < 0.05) compared to films without candelilla wax, and were given scores of 8.42 and 8.64, respectively, by the panelists. These scores were close to the opaqueness of wax paper, which was used in the training of the judges and was assigned a score of 9. The scores in this study was consistent with Kim (2000), who reported increased opacity upon incorporation of candelilla wax into sorbitol-plasticized WPI films as determined by HunterLab color scale L-value. Increased opacity in soy-protein-based films upon addition of fatty acids (lauric acid, palmitic acid, stearic acid, oleic acid) was also reported by Rhim and others (1999), also as measured by HunterLab colorimeter L-value. According to Hernandez (1997), the transparency or opacity of a polymer is due to its morphology rather than the chemical structure or molecular mass of the material. Morphological homogeneity of the film due to the presence of candelilla wax particles probably caused visible light to scatter through the film, causing its opaqueness.

Odor of a food product consists of the volatiles that are perceived by the olfactory system (Meilgaard and others 1999). The sensory panel did not detect any specific milk odor from any of the films. All films tested were scored to have similar odor. WPI films plasticized with sorbitol and glycerol were scored 1.38 and 1.64, respectively. WPI films plasticized with sorbitol and glycerol containing candelilla wax were scored 1.64 and 2.00, respectively, by the panelists. These scores were close to that of deionized water which was used during the training and was assigned a score of 1. Thus, we do not anticipate milk odor of the films will be a limitation for their future use. Whey powder solutions of 4 and 8% w/v were also used during the training of the panel for detection of milk odor, and were assigned scores of 5 and 9 respectively. In our preliminary experiments, these levels provided for moderate and distinct milk odor, respectively.

All films were perceived to be slightly sweet. Although WPI films without candelilla wax were perceived to be slightly sweeter than candelilla-wax-containing films, the differ-
ences were not statistically significant. Sweetness scores of the films ranged from 3.93 to 5.58. During training sessions, the panelists were provided with deionized water, which was assigned a score of 1; a 2.5% w/v sucrose solution, which was assigned a score of 5; and a 5% w/v sucrose solution, which was assigned a score of 9. Again, these sugar levels were selected for training based on our preliminary results. Polyhydric alcohols such as glycerol and sorbitol are structurally similar to sugars, except that they contain hydroxyl groups as their functional groups. Polyhydric alcohols are sweet, but generally less than sucrose (Lindsay 1996), which contributed to the slight sweetness of our films. Contribution of lactose (in the whey powder) to the sweetness of the films is probably insignificant, since lactose was present <1% in the whey powder. Also lactose is significantly less sweet than polyhydric alcohols.

Adhesiveness of a food product is the property that causes it to adhere to a surface. For adhesiveness, the sensory panel evaluated the force required to remove the films from their teeth after chewing. Overall, sorbitol-plasticized films were more adhesive ($P<0.05$) than glycerol- plasticized films. Although not statistically significant, candelilla-wax-containing films were perceived to be less adhesive by the panel. WPI films plasticized with sorbitol without candelilla wax were scored 3.96, and candelilla-wax-containing films were scored 3.40. WPI films plasticized with glycerol without candelilla wax were scored 2.42 and candelilla wax containing films were scored 1.76 for adhesiveness by the panelists. For the training of the judges, caramel was provided as the most adhesive product and was assigned a score of 9, jelly beans were assigned a score of 6, while gummy bears were the least adhesive and were given a score of 1. Again, this scale was determined based on our preliminary studies. Initially, we speculated that the differences in adhesiveness of the films may be due to the differences in their moisture content since glycerol-plasticized films had higher moisture contents than sorbitol plasticized films (data not shown). One may expect the higher moisture films to be more adhesive. This was not the case, however. Differences in the adhesiveness of the different films are probably due to the differences in the properties of the plasticizers.

**Conclusion**

WPI FILMS AND FILMS CONTAINING CANDELILLA WAX were perceived to be fairly neutral in their sensory attributes. They had no distinctive milk odor; however, they were perceived to be slightly sweet and adhesive by the trained sensory panel. Whey protein isolate films without candelilla wax were clear and transparent, whereas candelilla wax containing films were opaque. Further studies are needed on the sensory attributes and overall consumer acceptance of products that are contained in these films, to determine whether these films interfere with the food products taste, aroma, and texture.

**References**


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