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Sensory Attributes of Freshly Roasted and Roasted Freeze Dried Chinese Chestnut (*Castanea mollissima*) Coated with Whey Protein Isolate-Pullulan Edible Coating

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Abstract: The objective of this study was to evaluate the influence of Whey Protein Isolate-Pullulan edible coatings on the sensory characteristics of chestnut fruit (*Castanea molissima*). Freshly roasted and roasted freeze dried chestnuts were dipped into a WPI-PUL coating solution for 30 min then drained, dried and stored for 24 h. Samples were evaluated by a 60 member sensory panel for sweetness, appearance and color, texture and crunchiness, flavor and acceptance using a structural 10 point intensity scale. WPI-PUL coated chestnut had no distinctive milk odor. However the coated chestnuts were perceived to be slightly sweet and adhesive by the sensory panel. The results suggested that WPI-PUL coatings greatly improved the sensory attributes of fresh and dried chestnuts as compared to the uncoated dried sample.

Key words: Chestnut, freeze drying, WPI, edible coatings, sensory evaluation

INTRODUCTION

The chestnut (*Castanea* Miller) belongs to the beech family (Fagaceae) including the beech (Fagus), the oak (Qercus) and Castanopsis. The 13 Castanea species are native to the temperate zone of the northern hemisphere, five in East Asia, seven in North America and one in Europe (Burnham *et al*., 1986) with four species of economic importance being distinguished as: *C. dentata* (North American), *C. mollissima* (Chinese), *C. sativa* (European) and *C. crenata* (Japanese).

Chestnuts are important plants whose nuts can be used for different purposes. The nuts are delicious and are harvested from huge, magnificent trees planted on large acres of land whose native habitat is the Northern Hemisphere, particularly in China, Korea, Japan and Southern Europe. The entire eastern half of the United States was once covered with native chestnut trees until a blight fungus introduced from Asia destroyed them in the early 1900s.

The Chinese chestnut, *Castanea mollissima*, is the smallest tree of all the species, growing to an average height of about 40 feet (12 m). It is native to northern and western China. The nuts are generally medium in size and of good eating quality. According to the FAO statistics (Bounous, 2002), it is evident that Asia ranks highest in the world production of chestnuts (44.3%) of which China produces 49.44%. The nuts are eaten as a traditional food in much of Asia and Europe, where they are consumed fresh, roasted, candied and as a source of flour for pastries. About one-third of the Chinese annual harvest is exported to Japan while the rest is mainly roasted and consumed locally. The fleshy nut is sweet with a starchy texture and has a low fat content, resembling a cereal grain.

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Chestnuts are characterized by a limited shelf-life because of their high water content (about 40% of moisture) and sugar content (Attanasio *et al*., 2004). Chinese producers are therefore confronted with a storage problem as product losses are very high.

The increased consumer demand for high quality, longer shelf-life and ready-to-eat foods has initiated the development of only mildly preserved products that keep their natural and fresh appearance as much as possible. Also, the need for further exploitation of natural resources and boosting of the economy in several shutters are of big concern.

Edible films and coatings may have that potential for application in the food industry. They should possess the appropriate protective properties and also retain these properties during the commercial marketing of food. Edible films and coatings are natural polymers obtained from agricultural products, such as, animal and vegetable protein, gums and lipids and are perfectly biodegradable and therefore safe for the environment (Khwaldia *et al*., 2004). A film can be made and then applied to a food at any time, much like a synthetic package, while a coating must be applied in liquid form to a food directly.

In a previous study, focus was on preparation and characterization of edible film from WPI and pullulan. The results indicated that WPI-PUL films were transparent enough to be selected and used as see-through coatings and/or packaging material and to prevent color deterioration (Gounga *et al*., 2007). The application of WPI-Pullulan coating in combination with freeze drying on roasted chestnuts was effective in the control of overgrowth of spoilage organisms and surface discoloration (unpublished results), hence showing a potential strategy to minimize the significant losses of harvested chestnut. A question of concern is the consumer acceptability of the roasted fresh and roasted freeze dried chestnut with WPI-PUL edible coating.

Over the years, various applications of whey protein based edible films have been proposed on various fruits (Cisneros-Zevallos and Krochta, 2003; Lee *et al*., 2002; Pérez-Gago *et al*., 2005). 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. It is also 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 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 (Gounga *et al*., 2007; Miller and Krochta, 1997), sensory data on milk protein-based edible films and/or coatings 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 consumer studies and sensory attributes is of utmost importance and an appropriate tool for determining a food product's sensory acceptability. However, there are no studies reporting the use of consumer data to determine the acceptability of roasted chestnut coated fresh or dried. Therefore, the purpose of this study was to determine the sensory attributes of WPI-PUL-coated roasted chestnut, using a trained sensory panel. Panelists were trained to be sensitive to treatment difference so that they could detect small differences between samples.

MATERIALS AND METHODS

Materials

Whey protein isolate (WPI, ca. 86.98% Kjeldahl N×6.38) was obtained from New Zealand Milk Products (Fonterra Ltd., Auckland, New Zealand). Pullulan (PUL) was purchased from Food Ingredients Hayashibara Shoji, Inc. (Okayama, Japan). Glycerol (Merck) was used as the plasticizer. All other chemicals were obtained from the chemical reagent Co. (China) and were of food grade quality.

Chestnut Samples

Freshly roasted Chinese chestnuts (*Castanea molissima*) were purchased from a local chestnut shop (Jin Li Wang, Wuxi, China). The fruits were peeled and frozen at -20°C for 72 h. Samples were then dried for 72 h using a freeze-drier (LABCONCO CORPORATION, Kansas, USA). After freeze drying, the samples were transferred into a tightly closed plastic bag and kept in a desiccator containing silica gel until further use.

Coating Formulation and Sample Preparation

WPI (6.36 g), pullulan (0.64 g) and glycerol (3.6:1 ratio of WPI:Gly) were mixed in distilled water and the pH adjusted to 7 with 1 N NaOH. The film solution was prepared according to the method described by Gounga *et al.* (2007).

Selected samples (fresh-roasted chestnut [FRC] and roasted-freeze-dried chestnuts [RFDC]) of uniform size and color were separately dipped into the coating solution for 30 sec. Residual solutions were drained off and the coated fruits were dried at ambient temperature using a fan for 30 min and then stored in a box covered with synthetic film at ambient temperature for 24 h before analysis. Control samples of FRC and RFDC were also prepared.

Sensory Evaluation

Sensory evaluation of all treated chestnuts (FRC and RFDC) and controls was conducted using a taste panel consisting of 60 students, both female (35) and male (25) of different study class categories of Jiangnan University. The panelists familiar with chestnut taste were selected according to their ability to distinguish the tested food attributes in the sensory evaluation laboratory of the university. They had been involved in sensory work with chestnut and other new products during the whole year when experiments were carried out in the laboratory. Samples of four treated chestnuts were placed in a plate and evaluated by the panelists using a structural 10 point intensity scale, where 10 indicated the highest and 1 the lowest intensity of the attribute being assessed. Half scores could also be indicated. Attributes were (1) sweetness, (2) appearance and color, (3) body and texture/crunchiness/mouth feel, (4) flavor and (5) acceptance. Each attribute was rated accordingly (Fig. 1). The panelists rinsed their mouth with water before tasting another sample. This study was conducted in May 2007.

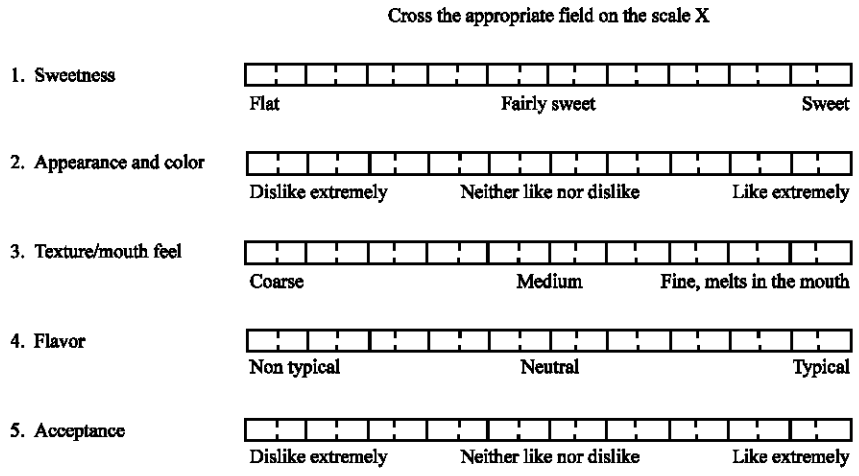

Fig. 1: Questionnaire for sensory evaluation

For additional demographic questions, panelists were also asked whether they would prefer a ready to eat to a non peeled chestnut; which form would they prefer (fresh fruits or dried?) and whether or not they would prefer chestnuts with a milk taste.

Statistical Analysis

In order to evaluate the panelists' performance, a two-way analysis of variance (ANOVA) using SAS Software (SAS System for window V8, SAS Inc., Cary, NC, USA) was performed on the sensory data separately for each attribute and significant differences between treatment means were determined by Duncan's Multiple Range Test (DMRT) at a probability level of 5%.

RESULTS AND DISCUSSION

Sensory evaluation of controls and WPI-PUL-coated FRC and RFDC was carried out. The results showed that, except for appearance and color, coated FRC had the highest scores in all attributes, followed by uncoated FRC and coated RFDC, respectively (Table 1).

The freeze dried chestnuts, whether coated or uncoated, was judged to be fairly sweet, as indicated by a mean score of 5.19 ($p<0.05$). This is an indication that roasted chestnut should exhibit a sweet taste (Kunsch *et al*., 2001). However, no differences ($p>0.05$) were identified in sweetness when coated and uncoated samples were compared.

Color is one of the most important attributes of foods, being perceived as a quality and acceptance indicator. It plays a major role in the assessment of external quality in food industries and in food engineering research. The coated RFDC had the highest score for appearance and color of 7.1, followed by coated FRC. More so, the ANOVA showed a significance difference in color and appearance ($p<0.05$) between the controls and coated samples. These results confirmed that the coated chestnuts maintained a fresh like appearance whereas an obvious whiteness developed in the uncoated dried chestnuts as found in a previous study (unpublished results).

The coating improved the texture and mouth feel of both fresh and dried chestnuts. The texture of uncoated RFDC was rather floury and coarse, as indicated by a lower score of 3.2. The unsatisfactory texture could be a consequence of the drying process, from which foods undergo volume changes, either by shrinkage due to moisture loss, or by expansion due to gas generation or pore formation. The open pore volume fraction plays an important role in determining the structural properties of a product (Attanasio *et al*., 2004). The crunchiness of dried chestnuts was improved by the coating as showed by a score of 4.4. This is a consequence of fruit rehydration during dipping into the film solution, thus restoring the raw material's properties when it comes into contact with water.

Table 1: Treatment means and DMRT for all attributes[A]

Samples codes[B]	Sweetness	Appearance and color	Texture/ mouth feel	Flavor	Acceptance
FRCC	6.7±0.9a	6.9±0.6a	7.7±0.3a	7.3±0.5a	7.9±0.1a
FRUC	6.2±0.6ab	4.8±0.2b	6.9±0.4b	6.7±0.1a	6.5±0.5b
RFDCC	5.4±0.8ab	7.1±0.2a	4.4±0.5c	5.3±0.2b	5.1±0.1c
RFDUC	5.0±0.9b	4.3±0.2b	3.2±0.3d	4.2±0.4c	3.8±0.4d

[A]: Each value represents the mean value and (standard deviation) of sixty determinations (n = 60), Sweetness: 1 = Flat; 10 = Sweet. Appearance and color: 1 = Bad; 10 = Excellent. Texture/Mouth feel: 1 = Floury, coarse; 10 = Fine, melts in the mouth. Flavor: 1 = Non typical; 10 typical. Acceptance: 1 = Bad; 10 = Excellent.

[B]: FRCC: Freshly Roasted Coated Chestnut; FRUC: Freshly Roasted Uncoated Chestnut; RFDCC: Roasted Freeze Dried Coated Chestnut; RFDUC: Roasted Freeze Dried Uncoated Chestnut. Any two means in the same column followed by the same letter(s) are not significantly different ($p>0.05$)

The flavor of a food product consists of the volatile compounds that are perceived by the olfactory system. Panelists liked the flavor of fresh chestnuts (mean, 6.98) significantly more than dried chestnut (mean, 4.75). Also the flavor score of coated chestnuts (mean, 6.30) was higher than that of the uncoated ones (5.44). The result indicated that coating affected the flavor of both fresh and freeze dried chestnuts. However, the coating did not have the specific milk odor; but it was perceived to be slightly sweet by the panelists (Table 1). This is in agreement with the findings of Kim and Ustunol (2001) who reported that WPI-based edible films had no distinctive milk odor.

All samples received different hedonic ratings in acceptance. Coated FRC were highly appreciated (7.9) followed by the uncoated ones whereas the uncoated RFDC were considered unacceptable (rating <5.0).

All in all, the sensory characteristics improved by the use of WPI edible coatings are appearance and color, plus overall acceptance of the dried sample (Table 1), which, in the case of texture and mouth feel, showed the lowest values. This is in disagreement with the general comment from the panelists who appreciated its crunchiness that occurred from the dipping (results not shown). The dried uncoated chestnuts were below the limit of acceptability in all attributes except for sweetness.

As of yet, no consumer acceptance tests or other sensory studies have been published on foods with WPI-PUL coatings. However, sensory studies have been conducted on related food products such as fresh/dried fruit, nuts or lightly processed fruits coated with WPI-based edible films. For instance, Pérez-Gago *et al.* (2003) evaluated the sensory properties of WPI-Beeswax-coated fresh-cut apples containing different concentrations of Beeswax (BW). They reported that WPI-BW coating had a pleasant visual appearance with an appropriate concentration of BW, while maintaining the actual color of the fruit and this was in agreement with present results.

Table 2 presents a combined ANOVA of all sensory attributes in all treatments. Treatment 1 (drying) was significant for all attributes except for appearance and color and treatment 2 (coating) was significant for all attributes except for sweetness. This indicates that all attributes were dependent separately on drying factor and coating factor except appearance and color for the former and sweetness for the latter. The interaction $T_1 \times T_2$ showed no significance difference in sensory attributes ($p>0.05$).

When the panelists were asked to provide any general comments on the samples, more attention was given the dried coated chestnut. The panelists mostly appreciated the general appearance of coated RFDC with a suggestion of improving their sweetness and crunchiness.

Coating showed an additional benefit on sensory quality in terms of crunchiness as indicated by panelists' general comments.

In response to whether the panelists would prefer ready to eat to non peeled fruits, 72.88% of panelists responded favorably (Table 3). More than 93% of the participants would prefer fresh chestnut as compared to the dried state. Hence, there is a significant market demand for fresh processed chestnuts with longer shelf-life and enhanced health benefits.

Table 2: Analysis of variance of WPI-PUL-coated fresh and dried chestnuts

		Mean squares				
Source of variation	df	Sweetness	Appearance and color	Texture/ mouth feel	Flavor	Acceptance
Treatment 1	1	4.9820*	0.1200**	36.7822*	15.0248*	22.8506*
Treatment 2	1	0.5712**	18.0075*	2.8300*	2.1887*	4.8819*
$T_1 \times T_2$	1	0.0333**	0.3675**	0.0889**	0.2472**	0.0062**
Errors	236	0.6936	0.1279	0.1534	0.1323	0.1136
R-square	-	0.5020	0.9470	0.9700	0.9430	0.9680

T_1, fresh/dry; T_2, control/coated; df: Degree of freedom; Significance: *: $p<0.05$; **: $p>0.05$

Table 3: Demographic questions and distribution percentage of the answers

Demographic questions	Answer and distribution percentage		
Q1: Would you prefer a ready to eat fruit to a non peeled fruit?	Yes	No	Not sure
	72.88	27.12	0
Q2: In general, which fruit would you prefer?	Fresh fruit	Dried fruit	
	93.22	6.78	0
Q3: Would you prefer a fruit with a milk taste?	Yes	No	
	71.19	28.81	0

CONCLUSION

The present study showed that WPI-PUL coating had positive effect on the sensory attributes of both roasted fresh and freeze dried chestnuts. The coated chestnuts had no distinctive milk odor; but, they were perceived to be slightly sweet and more adhesive by the sensory panel. The results also showed that the coated dried chestnuts were more attractive as compared to the uncoated samples which were below the limit of acceptability in most attributes. This was a result worth noting, considering the application of WPI-PUL edible films to dried chestnut for commercial uses, hence providing an alternative strategy to minimize the significant losses in harvested chestnut. Further investigation in dried chestnut coatings to improve crunchiness and sweetness as recommended by the panelists is worth doing.

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