

Flavor Retention and Physical Properties of Rice Cakes Prepared from Coated Rice Grain

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ABSTRACT

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Flavored rice cakes are produced commercially by spraying a flavor coating on the cake surface. This study describes a method of making a flavored coating that is applied to individual rice grains before puffing and results in a more uniform flavor distribution. Rice was coated at 5% or 10% levels with coating materials made of jet-cooked (JC) starch or starch cooked in a water bath (WB), corn starch powder, salt, and a flavor compound. The viscosity of coating materials made with WB starch was twice that of coatings made of JC starch. Rice coated at 10% level had decreased specific density of rice cakes. Rice cakes made from coated

grain were similar in appearance to cakes made from uncoated rice but had higher flexural strength. Retention of flavor volatiles after puffing the coated grain was 82.8–56.8% for apple, 72.5–40.3% for anise, and 52.5–24.8% for onion flavor. The flavor volatiles measured in the rice cakes decreased during a three-month storage period to 49.3% for apple, 25.8% for anise, and 10.1% for onion flavor. Slightly higher retention of flavor volatiles was observed in cakes made with WB starch than in cakes made with JC starch. The difference in retention of flavor volatiles between starch slurry or starch-oil emulsion treatments was small.

The process for making puffed rice cakes is well known (Hayashi 1987; Yamaguchi 1988; Menzin 1996) and is utilized extensively in commercial snack food production. The process starts by loading rice grain with $\approx 17\%$ moisture content in the hopper of the puffing machine. The rice is metered into a cylindrical chamber, wherein a heated piston compresses and rapidly heats the grain to 190–250°C within several seconds. During this short time, pressure increases as the moisture within the rice becomes superheated. The piston is then opened quickly, causing expansion and fusion of the rice grain, forming a round cake. Specific density, textural strength, color, and flavor development in rice cakes are dependent on the type of rice grain used, grain moisture content, cooking temperature, and cooking time (Hsieh et al 1989, 1990a,b; Chandrasekhar and Chattopadhyay 1991; Huff et al 1992; Orts et al 2000).

Puffed rice cakes have a distinctive popcorn-like flavor that many enjoy. The rice cake market in the United States was estimated at \$250 million in 1995 (Woods 1997). A large component of rice cake consumers have been identified as those who prefer the health benefits of these whole grain, low calorie snacks. The share of the snack food market held by rice cake snacks has increased in recent years with the introduction of a variety of flavored products (Orts et al 2000). Current methods of preparing flavored rice cakes entail a spray process, wherein flavors are applied after the cakes have been puffed and cooked. The coating contributes to the appearance and physical strength of the flavored rice cake (*personal communication*, R. Bates and J. Neal, Lunberg Family Farms, Richvale, CA).

The superficial distribution of flavor compounds in a spray coating renders them susceptible to oxidation, resulting in some flavor loss. Additionally, spraying the surface with liquids containing flavors and seasoning may result in weight gain of the product (Lyon 1980). Flavors uniformly dispersed throughout the matrix of the rice cake might be better protected from oxidation and have greater consumer acceptance than rice cakes with only a thin flavor coating residing on the surface.

Achieving uniform flavor distribution in rice cakes is a difficult task. The flavor compounds may be added to the moistened rice

grain before puffing to achieve more uniform flavor distribution, but the flavor may be completely lost during the short puffing-cooking process. Such flavor loss due to extreme processing conditions has been reported in puffed and extruded products (Kollengode et al 1996; Kollengode and Hanna 1997a,b). One possible method of protecting flavor compounds during the puffing step is to use a flavor carrier. Buttery et al (1999) and Orts et al (2000) described a starch-based material that was puffed along with the rice grain to form a starch-rice composite cake with improved textural properties. Buttery et al (1999) suggested that a starch-based material may also be an effective flavor carrier for making flavored rice cakes.

A flavor carrier described by Knutson et al (1996) was made in which a starch-oil emulsion was prepared by a jet-cooking process. The flavor carrier was dried as a powder consisting of oil droplets encapsulated in a starch matrix. Qi and Xu (1999) indicated that flavor encapsulation in starch-based carriers may be an efficient method of controlled flavor delivery into cereal products. A dry powder or granulated starch could be used as a flavor carrier in rice cakes, but it would be difficult to distribute uniformly with rice grains before puffing. However, a slurry made of gelatinized starch and water or an emulsion of a starch slurry and oil could also be an effective flavor carrier and would be simple to apply to rice grains to achieve uniform distribution before puffing.

The purpose of this study was to use an analytical approach to evaluate the effectiveness of coatings made of a starch slurry or a starch slurry and oil emulsion as flavor carriers and texture modifiers for the production of flavored rice cakes.

MATERIALS AND METHODS

Materials

Short grain California brown rice was obtained from Lundberg Family Farms (Richvale, CA). Flavor compounds (apple: ethyl 2-methyl butyrate, anise: *trans*-anethole, and onion: propyl disulfide) were obtained from Aldrich Chemical Co., Milwaukee, WI. Unmodified dent corn starch (Melojel) was purchased from National Starch, Hackensack, NJ. Unmodified corn starch was selected based on a preliminary study in which puffed cakes made of corn starch adhered less to the platens of a rice cake machine during the puffing operation than other starches tested. Corn oil (Crisco brand, Cincinnati, OH) and salt (Morton salt, Chicago IL) were purchased at a local supermarket.

Sample Preparation

A flow chart of the steps taken to prepare rice samples for puffing is presented in Fig. 1. Corn starch was mixed with water to produce a suspension containing 8% (w/w) solids. The starch suspension was gelatinized by jet cooking (JC) at 125°C and 95 psi, or

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by heating under cover in a water bath (WB) to 90°C and maintaining the temperature for 10 min while mixing constantly. The gelatinized starch melts (JC and WB) were cooled to 30°C and either saved as a slurry (JCS, WBS) or mixed with corn oil for 1 min (5%, w/w) using a Waring blender to form an emulsion (JCE, WBE).

Coatings were made using 105 g of JCS, WBS, JCE, or WBE mixed with dry corn starch powder (45 g), NaCl (31.7 g), and 1.2 mL of flavor compound. The mixture was made by first blending the gelatinized starch material with the salt and dry starch powder for 30 sec in a Waring blender. Then the flavor oil was added and the mixture was blended an additional 30 sec. The coating mixture was sealed in a glass jar with a lid lined with aluminum foil and stored in a refrigerator at 4°C.

Rice grain was conditioned overnight with sufficient moisture to achieve 15% moisture content according to Approved Method 26-95 (AACC 2000). A sample of conditioned rice grain (180 g) and 10 g (5%) or 20 g (10%) of coating mixture was sealed in a 16-oz glass jar with a foil-lined lid. The jar was tumbled at 30 rpm for 1 hr to thoroughly coat each rice grain with the coating mixture. The jar was refrigerated overnight to allow the coated rice grain to equilibrate. The final moisture content of coated grain was adjusted to 18% by adding appropriate quantities of water and allowing the grain to equilibrate for at least 12 hr.

Viscosity of Coating Materials

Viscosity of coating materials was measured using a viscometer (model RheoCalcIII, Brookfield, Inc., Middleboro, MA) equipped with a 21 spindle. The measurements were taken at room temperature at two rotational speeds of 10 and 50 rpm.

Puffing Operation

Rice cakes were made from 20 g of coated grain that had equilibrated to 18% moisture content. Puffing was performed using a rice-popping machine (Airin, Co., Okazaki, Japan). The platen surface temperature was set at ≈200°C and cooking time was set at 12.3 sec (two cooking cycles 6 sec each separated by 0.3-sec gap for partial steam release). Each puffed cake was ≈10 cm in diameter with a thickness of 15–23 mm. Each cake was inserted in a polyethylene zip-lock bag (ITW Co., Sequin, TX) and stored at room temperature until the analysis was performed.

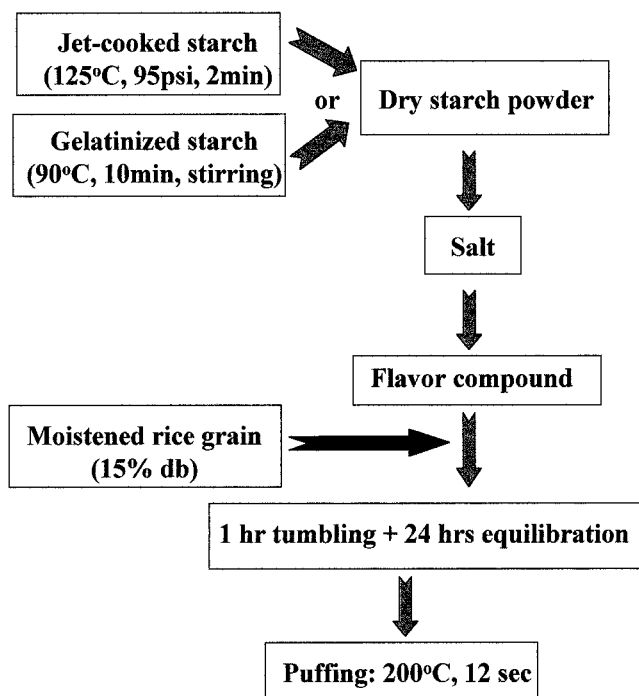


Fig. 1. Flow chart of rice grain coating and puffing procedures.

Physical Properties of a Puffed Cake

A 2.5-cm wide strip was cut from the center of each rice cake. The strip was weighed and volume was determined by a displacement method using 2-mm glass beads. Density measurements were determined on eight replicate samples. Mechanical measurements of compressive and flexural properties were done at room temperature using a universal testing machine (model 4500, Instron, Canton, MA). The flexural test was a three-point bending method based on the ASTM method D790m-89. The flexural beams measured 2.5 cm wide and 10 cm long and the span distance was 5 cm. The sampling rate was 10 mm/min. Measurements were terminated at full failure, giving an indication of the flexural breaking strength (S_f) of the puffed cakes. The modulus (M_f) was calculated as a ratio of stress to the corresponding strain below the proportional limit of the force-deformation curve. Flexural Yield (Y_f) was measured as percent of deformation. Toughness (T_f) was measured as the area under the stress-strain curve.

Isolation of Volatiles

Flavor analyses were performed according to Buttery and Ling (1998). Rice cakes (20 g) were disintegrated in Waring blender for 60 sec with 250 g of water, 58 g of NaCl, and 2.5 mL of internal standard (2-pentanone, 6-methyl 5-hepten-2-one). The rice cake slurry was poured into a 2-L round-bottom flask and stirred for 1 hr. The volatiles from the dynamic headspace were collected in a large (≈10 g) Tenax trap. The trap and the flask were connected to a Teflon diaphragm pump that recirculated purified air around the closed loop at 3–6 L/min for 1 hr. The Tenax trap was removed from the loop at the end of isolation, and the volatiles were extracted with 50 mL of distilled ether. The ether extract was concentrated to ≈50 μL using a water bath kept at 60°C and a micro-Vigreux distillation column.

Identification of Volatiles

Volatiles were analyzed using an HP5890 gas chromatography instrument coupled to an HP5971 quadrupole mass spectrometer. Fused silica capillary columns (60 m long and 0.25 mm, i.d.) that were coated with DB-Wax or DB-1 were used. The injector used a 1/20 split and was kept at 170°C. The DB-Wax column was kept at 30°C for the first 4 min after injection and then heated at 2°C/min to 170°C and held an additional 60 min. The DB-1 column was held at 30°C for the first 25 min after injection and then heated at 4°C/min to 200°C and held an additional 30 min.

Experimental Design

All measurements were taken at least in duplicate and analyzed using analysis of variance (ANOVA). The F tests were used to determine to which effects inferences should be directed. Means and 95% confidence intervals were calculated.

Viscosity of coating materials was evaluated using a 2² factorial design, where cooking method and starch-oil emulsion and slurry were compared. Physical strength and density of rice cakes were evalu-

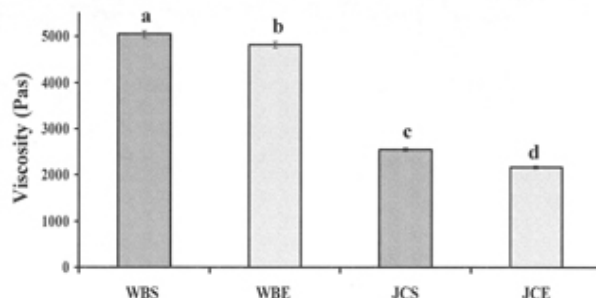


Fig. 2. Viscosity of coating materials: water bath slurry (WBS); water bath emulsion (WBE); jet cooked slurry (JCS); jet cooked emulsion (JCE). Bars with the same letter are not significantly different ($P \leq 0.05$).

ated using analysis of variance for 2³ factorial design (cooking method, emulsion vs. slurry, and 5 vs. 10%). Retention in flavor volatiles was analyzed using a 2³ × 3 factorial design (cooking method, emulsion vs. slurry, 5 vs. 10%, and storage time) for each flavor. For textural analyses, the controls were made of rice cakes puffed from rice grain without any coating added. Controls for flavor retention experiment were made of rice grain without any coating but with the same amount of flavor oil as experimental treatments.

RESULTS AND DISCUSSION

Properties of Coating Materials

The viscosity of coating materials was strongly affected by the method used for starch cooking (Fig. 2). The coating material produced from JC starch had half the viscosity of coating materials prepared from WB starch. Also, coating materials prepared from JC starch had smaller torque and lower shear stress values than coatings prepared from WB starch (*not shown*). The coatings prepared from emulsions had lower viscosity than coatings prepared from starch slurries. However, this difference was not as profound as that between JC starch and WB starches. Lower viscosity of coatings made from JC starch may be explained by a high shear generated during the jet-cooking process. High shear could disrupt granular structure of swollen starch and subsequently result in lower viscosity of coating materials.

Appearance

Orts et al (2000) reported that starch introduced to rice cakes in the form of beads created inclusions that were lighter in color than surrounding puffed rice. Such inclusions were visible on the cake surface and could make these cakes less attractive to some consumers.

In the present study, rice cakes made with coated rice grain had an appearance similar to those made from uncoated grain. Cakes containing 10% coating materials had a thin crust of puffed coating visible on the lower surface. However, the upper surface and sides of cakes made from coated rice were identical to the cakes made from uncoated grain.

Density

The density values presented in this study are in agreement with those reported by Hsieh et al (1989, 1990b) and Huff et al (1992), who used a sand displacement method to evaluate specific density. Rice cakes puffed from coated rice had a specific density that was comparable or lower than the density of rice cakes prepared from uncoated grain (Table I). Coating the rice grain with mixtures made of WB starch decreased the specific density of rice cakes even more. The lowest specific density was obtained in rice cakes coated with 10% WBE. Orts et al (2000) reported that cakes made from a mixture of rice and starch beads had a higher specific density than cakes made from only rice. They reasoned that differences in density may be caused by air trapped between particles of puffed rice in rice cakes, whereas cakes made of wheat starch beads had no such cavities.

Flexural Strength

Cakes made from coated grain appeared less brittle and less prone to fracture than those made from uncoated rice. Rice cakes puffed from coated grain had higher *Tf* values at break point than cakes produced from uncoated rice, even though *Yf* values were similar for all treatments. The *Mf* values were not affected in cakes made from rice grain coated with 5% JCS, JCE, WBS, or WBS coating materials. However, lower *Mf* values were detected in cakes containing 10% coating materials made of WBE and WBS.

The data show that the coating material generally increased the flexural strength of rice cakes. The possible mechanism for the increased flexural strength in cakes produced from coated grain was an increase in adhesion between rice particles. Orts et al (2000) suggested that the wheat starch in rice cakes made of a mixture of rice and wheat starch beads formed a matrix that held the puffed rice particles together. They also showed that rice cakes made with ≥20% starch beads had greater *Sf*, lower *Mf* values, and were less brittle than cakes puffed without starch beads. Results of the present study showed that by using starch-based coating materials, less starch was needed (5–10%) to significantly improve mechanical properties compared with rice cakes made with a mixture of rice

TABLE I
Physical Characteristics^a of Rice Cakes Made from Coated Grain

Sample ^b	<i>Yf</i> (%)	<i>Sf</i> (MPa)	<i>Mf</i> (MPa)	<i>Tf</i> (N/mm)	Density (g/cm ³)
Control	9.54ab ^c	0.1252c	2.310a	6.5b	0.179a
JCE 5%	11.48a	0.2048a	2.894a	13.5a	0.184a
JCE 10%	9.84ab	0.1634b	1.887ab	14.2a	0.156b
JCS 5%	8.31b	0.2375a	3.174a	15.0a	0.167ab
JCS 10%	9.34ab	0.1599b	2.207ab	17.2a	0.147c
WBE 5%	8.95ab	0.1777b	2.341a	16.8a	0.140c
WBE 10%	10.16a	0.1208c	1.370b	16.5a	0.135c
WBS 5%	9.93ab	0.2011a	2.292ab	17.9a	0.137c
WBS 10%	11.40a	0.1618b	1.245b	18.0a	0.116d

^a *Yf* = yield to break; *Sf* = flexural strength; *Mf* = modulus; *Tf* = toughness.

^b JCE = jet cooked emulsion; JCS = jet cooked slurry; WBE = water bath emulsion; WBS = water bath slurry.

^c Means in columns followed by the same letter are not significantly different ($P \leq 0.05$).

TABLE II
Retention of Apple Flavor Volatiles (ppm) in Rice Cakes Made from Coated Grain

Sample ^a	0 Days	1 Day	30 Days	60 Days	90 Days
Control apple	329.8a ^b	85.1b	nd ^c	nd	53.5d
JCE 5%	103.5c	60.5c	59.0c	57.0c	53.2d
JCE 10%	185.5b	132.0a	133.0a	125.0a	91.5b
JCS 5%	91.5d	52.0c	53.1c	49.1c	50.1d
JCS 10%	177.5b	133.0a	136.1a	120.1a	97.0b
WBE 5%	102.1c	77.5b	75.1b	76.0b	78.5c
WBE 10%	185.0b	129.5a	129.2a	127.0a	124.5a
WBS 5%	76.0d	50.0c	54.0c	59.1c	61.1d
WBS 10%	154.5bc	128.0a	127.0a	128.0a	123.5a

^a JCE = jet cooked emulsion; JCS = jet cooked slurry; WBE = water bath emulsion; WBS = water bath slurry.

^b Means in columns followed by the same letter are not significantly different ($P \leq 0.05$).

^c Not determined.

and starch beads. For the potential producer, this technology may offer better handling properties and smaller breakage loss during packaging. For the consumer, it offers a less crumbly product.

Flavor Retention

Results of this study indicate that JC and WB starches worked well as flavor carriers. Coating the rice grain allowed the flavor compounds and seasonings to be evenly distributed throughout the rice cake and retain a significant amount of flavor volatiles over a three-month storage period. The grain coating method may eliminate the need for postpuffing spray applications of flavor and seasonings in rice cakes. This would reduce the capital cost for the equipment and maintenance in terms of floor space requirements and decreased cost of installation and operation of a spraying system.

Rice grain coated by JCE absorbed more flavor volatiles than grain coated with JCS (Tables II, III, and IV). The greater absorption in JCE coated rice seemed reasonable because it contained oil, and all three flavors tested were oil-soluble. After the puffing process, there was no difference in flavor content in rice cakes that had been previously coated with either JCE or JCS (Tables II–IV). This result indicated that greater flavor loss must have occurred in puffed rice previously coated with JCE than in rice coated with JCS. The greater loss of flavor volatiles in puffed rice previously coated with JCE versus JCS may be due to a slightly higher puffing temperature or a faster heat transfer in coatings containing oil.

The initial loss in flavor that occurred within the first 24-hr period, as stated previously, most likely occurred during the cooking-puffing process because flavor retention was relatively stable during storage. Loss of flavor volatiles during cooking-puffing most likely occurred by steam distillation during the sudden pressure drop that occurs at the end of the puffing step. A similar loss of flavor compounds in extruded products had been attributed to a steam distillation event that accompanies a sudden pressure drop as the extruded product exits through the extruder orifice (Kollengode et al 1996; Kollengode and Hanna 1997a,b).

A slight secondary decrease in flavor content occurred after 60 days of storage, although it is unclear whether this decrease was real

because it was not significant in all treatments. Some loss of flavor compounds by oxidation may be expected during storage because the coating material contained unsaturated fatty acids (corn oil) and sodium, a metal catalyst. Numerous investigators (Blanchfield and Ovenden 1974; Artz and Rao 1994; Kollengode et al 1996; Kollengode and Hanna 1997a; Qi and Xu 1999) have shown that many commercial flavors exhibit considerable sensitivity to oxygen, light, metal catalysts, and heat, and may be quickly lost during processing and storage. Interestingly, there seemed to be no correlation between the volatility of the flavor compounds and their retention in rice cakes. The apple flavor compound had a lower boiling and flash point than anise and onion, yet the percent retention was similar or higher in apple than in anise and onion (Tables II–IV). Similarly, no correlation between boiling point and volatile retention in extruded snacks was reported by Kollengode and Hanna (1997b). They suggested, however, that the addition of chemicals with a lower boiling point than flavor volatiles may help in retention of the flavor volatiles in puffed snacks.

Flavor retention in cakes made from rice coated with WB starch was similar or slightly higher than in those made from JC starch (Tables II, III and IV). A small difference in flavor retention was observed in cakes prepared from grain coated with emulsion or starch slurry in both JC and WB coatings, although in both cases the data were not consistent.

Coatings that contained oil (JCE and WBE) did not lead to greater flavor retention in stored rice cakes than rice cakes made with coatings containing WBS or JCS. However, rice cakes made of coatings containing oil were more easily removed from the platens after puffing.

In this study, an analytical approach was employed to analyze the retention of flavor volatiles in puffed products. One could only suspect that the presented data would correspond with actual human preferences. Thus, additional study is required to correlate these results with a panel acceptance. Such work should also include study of formation of odors and off flavors that may be generated during cake puffing. Similarly, the mechanical properties of rice cakes presented here may be correlated with textural and sensory panel studies.

TABLE III
Retention of Onion Flavor Volatiles (ppm) in Rice Cakes Made from Coated Grain

Sample ^a	0 Days	1 Day	30 Days	60 Days	90 Days
Control onion	74.8b ^b	8.8c	nd ^c	nd	4.3d
JCE 5%	61.5c	16.5b	17.1b	13.0b	6.9d
JCE 10%	108.0a	30.5a	28.0a	26.2a	17.5b
JCS 5%	56.5d	14.0b	13.5b	11.2b	5.7d
JCS 10%	78.0b	34.5a	30.1a	24.9a	17.5b
WBE 5%	40.0e	21.0b	19.0b	18.1ab	10.6c
WBE 10%	106.5a	35.5a	33.2a	29.9a	28.5a
WBS 5%	37.5e	18.0b	16.0b	15.1b	10.2c
WBS 10%	63.5c	26.0ab	25.0a	25.3a	26.5a

^a JCE = jet cooked emulsion; JCS = jet cooked slurry; WBE = water bath emulsion; WBS = water bath slurry.

^b Means in columns followed by the same letter are not significantly different ($P \leq 0.05$).

^c Not determined.

TABLE IV
Retention of Anise Flavor Volatiles (ppm) in Rice Cakes Made from Coated Grain

Sample ^a	0 Days	1 Day	30 Days	60 Days	90 Days
Control anise	242.6a ^b	37.7d	nd ^c	nd	22.0c
JCE 5%	98.0e	64.5c	62.5b	58.6b	25.1c
JCE 10%	182.5b	73.5b	74.1a	68.6a	47.0b
JCS 5%	71.0f	64.5c	63.5b	55.1b	27.5c
JCS 10%	117.5d	82.0a	78.2a	72.3a	50.5b
WBE 5%	69.5f	38.5d	38.1c	35.6c	32.0c
WBE 10%	144.5c	72.0b	73.2a	71.2a	83.8a
WBS 5%	56.5f	39.5d	36.8c	35.4c	29.5c
WBS 10%	135.5c	71.0b	75.2a	75.9a	83.0a

^a JCE = jet cooked emulsion; JCS = jet cooked slurry; WBE = water bath emulsion; WBS = water bath slurry.

^b Means in columns followed by the same letter are not significantly different ($P \leq 0.05$).

^c Not determined.

CONCLUSIONS

The rice coating procedure used in the present study was effective in uniformly distributing flavor and seasoning throughout puffed rice cakes and in preserving flavor compounds during puffing and storage. In addition, rice cakes made from coated grain had lower density, better mechanical properties, and were similar in appearance to cakes made from uncoated rice. The rice coating procedure negates the need for postprocessing steps for adding flavors and seasonings.

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LITERATURE CITED

- American Association of Cereal Chemists. 2000. Approved Methods of the AACC, 10th ed. Method 26-95. The Association: St. Paul, MN.
- Artz, W. E., and Rao, S. K. 1994. Lipid oxidation in extruded products. Pages 296-314 in: ACS Symp. 543. Am. Chem. Soc.: Washington, DC.
- ASTM. 1992. Method D790m-89. Annual Book of ASTM Standards. American Society for Testing and Materials, West Conshohocken, PA.
- Blanchfield, J. R., and Ovenden, C. 1974. Problems in flavoring extruded snack foods. *Food Manuf.* 49:27-29,51.
- Buttery, R. G., and Ling, L. C. 1998. Additional studies on flavor components of corn tortilla chips. *J. Agric. Food Chem.* 46:2764-2769.
- Buttery, R., Orts, W. J., Takeoka, G. R., and Nam, Y. 1999. Volatile flavor components of rice cakes. *J. Agric. Food Chem.* 47:4353-4356.
- Chandrasekhar, P. R., and Chattopadhyay, P. K. 1991. Rice puffing in relation to its varietal characteristics and processing conditions. *J. Food Proc. Eng.* 14:261-277.
- Hayashi, Y. 1987. Method for producing crackers and apparatus for carrying out the same. U.S. patent 4667588.
- Hsieh, F., Huff, H. E., Peng, I. C., and Marek, S. W. 1989. Puffing of rice cakes as influenced by tempering and heating conditions. *J. Food Sci.* 54:1310-1312.
- Hsieh, F., Hu, L., Peng, I. C., and Huff, H. E. 1990a. Pretreating dent corn grits for puffing in rice cake machine. *J. Food Sci.* 55:1345-1348.
- Hsieh, F., Hu, L., Huff, H. E., and Peng, I. C. 1990b. Effects of water activity on textural characteristics of puffed rice cakes. *Lebensm. Wiss. Technol.* 23:471-473.
- Huff, H. E., Hsieh, F., and Peng, I. C. 1992. Rice cake production using long-grain and medium-grain brown rice. *J. Food Sci.* 57:1164-1167.
- Kollengode, A. N. R., Hanna, M. A., and Cuppet, S. 1996. Volatiles retention as influenced by method of addition during extrusion cooking. *J. Food Sci.* 61:985-989, 1079.
- Kollengode, A. N. R., and Hanna, M. A. 1997a. Cyclodextrin complexed flavors retention in extruded starches. *J. Food Sci.* 62:1057-1060.
- Kollengode, A. N. R., and Hanna, M. A. 1997b. Effect of low boiling point liquids on volatile retentions in starch extrudates. *Lebensm. Wiss. Technol.* 30:814-818.
- Knutson, C. A., Eskins, K., and Fanta, G. F. 1996. Composition and oil-retaining capacity of jet-cooked starch-oil composites. *Cereal Chem.* 73:185-188.
- Lyon, L. 1980. Popularity of extrusion processing places added demand on flavorings. *Food Prod. Dev.* 14:58-61.
- Menzin, M. 1996. Popcorn cake machine. U.S. patent 5755152.
- Orts, W. J., Glenn, G. M., Nobes, G. A. R., and Wood, D. F. 2000. Wheat starch effects on textural characteristics of puffed brown rice cakes. *Cereal Chem.* 77:18-23.
- Qi, Z. H., and Xu, A. 1999. Starch-based ingredients for flavor encapsulation. *Cereal Foods World* 44:460-465.
- Yamaguchi, N. 1988. Food material for puffing. U.S. patent 4734289.
- Woods, M. 1997. Let us eat tastier rice cakes. *Agric. Res.* 45(9):23.

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