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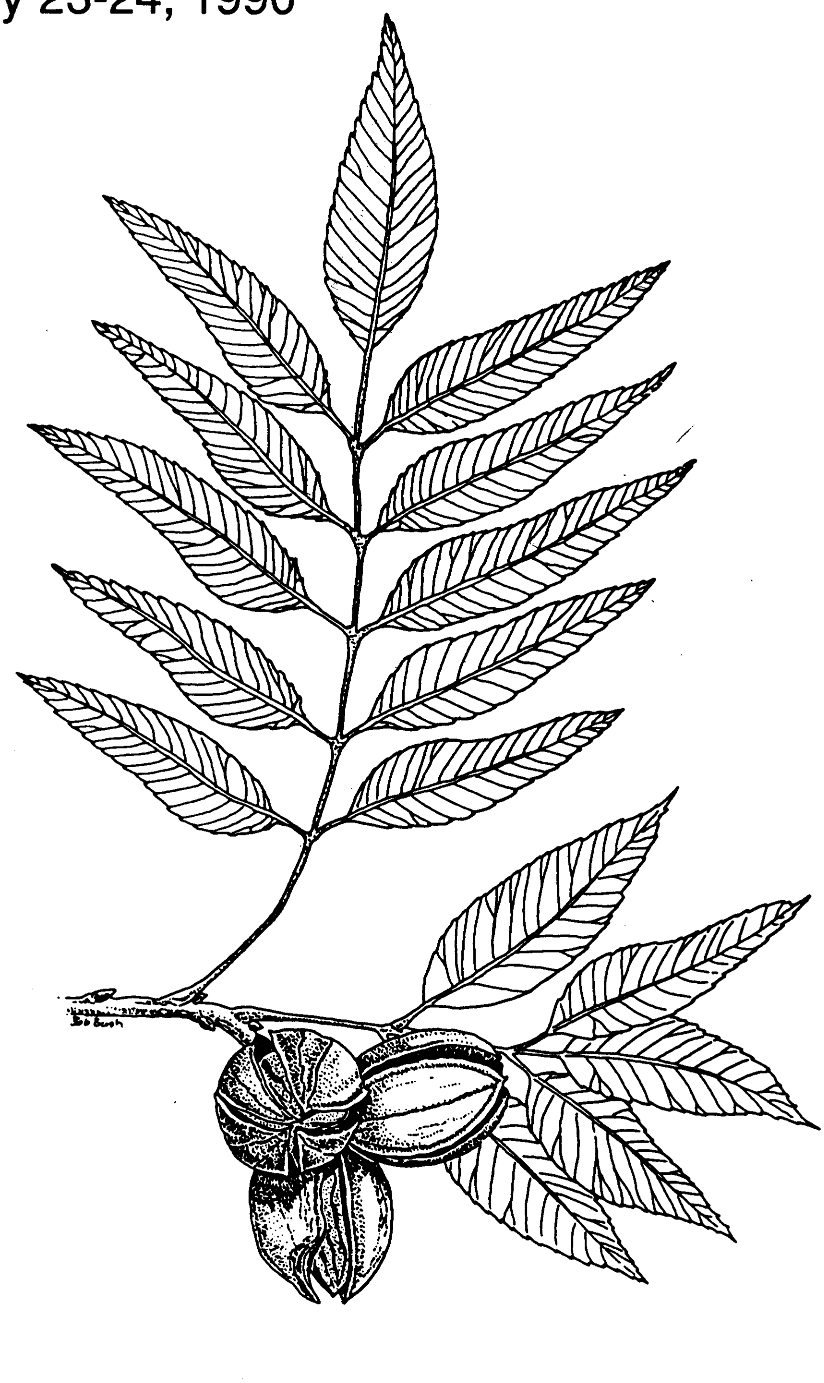

ALTERNATIVE PECAN PRODUCTS: PROBLEMS AND POTENTIAL

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ABSTRACT

A by-product of pecan chopping, pecan meal, was extruded using a twin-screw extruder in attempts to produce a remanufactured pecan piece which would possess enhanced value for secondary pecan processors, Milling of pecan meal with a colloidal mill rendered a light colored paste which combined with starch, soybean flour and water in the barrel of a twin-screw extruder to produce a pelletized pecan piece. Further development will be necessary to increase the pecan flavor, lighten the color, and remanufactured pecan pieces.

INTRODUCTION

Pecans are sold as a premium tree nut and have many uses as a component in the formulations of baked goods, confections, ice creams, and snack foods. Unfortunately, pecan sales have not kept pace with sales of other tree nuts such as walnuts or almonds as a result of inadequate marketing strategies (Karst 1989, Mizelle 1989) and variable product quality (Hubbard et al. 1988). Developing a strategy whereby pecan by-products are processed into value-added, alternative pecan products may increase the value of pecans. For this strategy to be successful, a niche for the new product or product-line must be determined followed by product development, test-marketing, product refinement and promotion. The whole process must be precisely coordinated through all phases of development.

Economic losses occur during the chopping of pecans to produce pieces for further food manufacturing. A by-product of the chopping operation, pecan meal, is produced at a rate of 3-6% depending upon the type of equipment used, the condition of the pecans, and the rate of chopping (Santerre 1989). Pecan meal has a value which is less than one forth the value of pecan pieces. This low value of meal is significant when considering the fact that an estimated 13-27,000 kg/week are produced in the southeastern U.S. Unfortunately, there is not an adequate market for meal and this by-product is often discarded.

An option for utilization of pecan meal is to press the meal to produce oil, however, pecan oil is expensive and does not compete economically with the less expensive oils. Attempts should be directed at converting pecan meal into a value-added product, such as a remanufactured pecan piece which will offer several advantages over pecan pieces. The secondary processor (i.e., baker, confectioner, ice cream maker, etc.) of pecan pieces often finds objectionable quality due to off-flavors (as a result of mold or rancid flavor development), darkening, presence of shell and interstitial shell, and the presence of pecan weevil larvae. The production of a remanufactured pecan piece could provide a pecan piece with enhanced quality for secondary processors. Some of the advantages of a remanufactured pecan piece produced from pecan meal include: 1) a consistent size and shape; 2) elimination of harmful shell fragments; 3) extended shelf life following addition of stabilizers and preservatives to the formulation; 4) low cost of raw product (i.e., meal); 5) elimination of pecan weevil larvae; and 6) reduced off-flavors which are found occasionally in pecan halves.

A remanufactured pecan piece must meet several quality requirements before it would be considered useful as a food ingredient. First, the final product must have a nut-like texture with good integrity when added to high moisture environments (i.e., greater than 40% moisture as in a cookie batter or bread dough). Second, it must have a characteristic pecan flavor and mouthfeel. Third, the piece must have an appearance (including size, shape and color) which is similar to pecan kernels and desirable to consumers. Fourth, the cost of producing the remanufactured pecan piece must be feasible in relation to it's final value.

In order to develop a remanufactured pecan piece, the composition of pecans must first be explored. Pecans are composed of 68% lipid, of which 92% is unsaturated (McCarthy and Matthews 1984). Pecans

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are generally dried to between 3.5% and 5.0% moisture and contain approximately 7.7% protein (Tables 1 & 2). The formulation to produce a piece, will require a binder(s) such as starch and/or soy bean flour which will also reduce the lipid content of the final product and incorporate a nut-like texture. Several steps will be required during preparation of the piece in order to gelatinize the starch, eliminate the raw flavor in the soybean flour, mix the pecan meal with the other components and compress all of the ingredients into a pelletized form. A flexible piece of equipment which can handle all of these requirements is the co-rotating, twin-screw extruder. With an extruder of this type, the starch, soybean flour and pecan meal can be wetted, mixed, sheared, cooked, cooled and compressed into a final form in a single operation.

The objectives of this research have been divided into 2 phases as follows:

Phase I

A) To determine the upper limit of lipid concentration in the extrusion of mixtures of soybean flour, starch, pecan meal, pecan paste, water and pecan oil to produce a remanufactured pecan piece from pecan by-products.

B) To determine the optimal ratio of each component in an extrudate to be used for producing a pecan piece which has nut-like characteristics.

Phase II

A) To mill pecan meal into a paste which maintains a pecan-like color and flavor and can be incorporated into an extruder to produce a light colored pecan piece.

B) To determine an approach which will reduce the time-temperature exposure of the pecan paste while maintaining the texturization of starch and the cooked flavor of the soybean flour during extrusion of a remanufactured pecan piece.

C) To assess progress in the formulation of a remanufactured pecan piece and develop further strategies in it's successful development.

MATERIALS AND METHODS

Phase I

Extrusion was used to process 14 pecan formulations. The formulations were as follows:

1. 100% soybean flour
2. 50% soybean flour; 50% raw pecan meal
3. 50% soybean flour; 50% raw pecan meal
4. 50% soybean flour; 50% raw pecan meal
5. 5% soybean flour; 55% raw pecan meal
6. 40% soybean flour; 50% raw pecan meal; 10% corn starch
7. 60% soybean flour; 40% raw pecan meal
8. 50% soybean flour; 40% roasted pecan meal; 10% corn starch (>water)
9. 50% soybean flour; 40% roasted pecan meal; 10% corn starch (<water)
10. 50% soybean flour; 40% roasted pecan paste; 10% corn starch
11. 40% soybean flour; 50% roasted pecan paste; 10% corn starch
12. 50% soybean flour; 50% corn starch
13. 25% soybean flour; 50% roasted pecan meal; 25% corn starch
14. 30% soybean flour; 40% roasted pecan oil; 30% corn starch

Each exudate was prepared using a Clextral BC45 co-rotating, twin-screw extruder (Clextral, Inc., Odessa, FL) configured as shown in Table 3. The operating parameter wre: 3 dies of 4mm diameter; die face cutter with blade 4 CLX; air gap, 3 mm. Other conditions are given Tables 4 & 5. Extrudates were partially dried using a 80°C convection oven. Following drying, extrudates were analyzed for color, moisture and texture.

'Roasted and raw pecan pastes' were prepared from pecan meal which was obtained from commercial suppliers, then roasted at 176°C for 30-40 min. or maintained raw, ground to a paste using a Morehouse Stone Mill, Model M-MS-3 (Fullerton, CA) with a 0.254 in. stone clearance. 'Pecan oil' was obtained by pressing 'roasted pecan meal' in a Carver Hydraulic Press, Model C (Menomonee Falls, WI) at 2400 psi for 10-15 min. Defatted soy flour (Soyafluff 200W; Central Soya, Inc., Fort Wayne, IN) and/or corn starch (BakaSnak; National Starch and Chemical Co., Bridgewater, NJ) was added to produce a product with a nut meat texture and to reduce the lipid concentration from 65% for raw meal.

Phase II

Extrusion was conducted using a Baker Perkins MPF-50D (APV Baker, Grand Rapids, MI) co-rotating, twin-screw extruder with the screw configuration (L/D 25) given in Table 6. The operating parameters were: water feed setting, 4 (83.3 mL/min.); dry ingredient feed setting, 65 (348 g/min.); pecan paste feed setting, 1.5 (100 g/min.); screw speed, 200-220 RPM; Torque, 50%; die diameter, 3 mm; die pressure, 240 psi (single die); die length, 5.0 cm.

The dry ingredients (starch and soybean flour) were added through the first port of the extruder barrel, whereas, pecan paste was pumped through a port which was 2/3rds down the barrel using a Moyno pump. Starch and soybean flour were mixed in a 1:3 ratio in three 22.7 kg portions in a tumble cone mixer for 10 min. and the portions were then combined.

'Pecan paste' was prepared by grinding frozen, raw pecan meal using a Colloid, Toothed Mill, Type MZ-110/A (Fryma, Inc., Edison, NJ) which was set at 1/2 turn open from fully closed. Product temperature following milling was between 45.7°C and 51.3°C and maintained a dark brown color. Pecan paste was immediately place at 32°C and stored for 2 months until further processing.

Tristimulus color of the samples was measured on the Gardner Color Analyzer. A yellow standard tile was used (standard tile; L=78.46, a=-2.20, b=23.40). The sample cell was filled with pecan pieces and the cell was covered to prevent stray light.

Texture was measured on the Instron Universal Testing Instrument (Model No. 1122) by measuring the amount of force required to compress 1.5 g of pecan pieces down to 2 mm with a compression anvil. A 500 kg load cell was used with the full scale set at 200 kg full scale for samples 1 to 7 and at 50 which equals 500 kg for samples 8 to 14. Crosshead speed was set to 10 mm/min. Chart speed was 50 mm/min. For sample #12, only 1.0 g sample was tested due to it's puffed size. Texture measurements were reported as N/g pecan pieces.

Moisture was measured using CEM Automatic Volatility Computer. The microwave settings were as follows: mode=1; power=60%; time=10 min. Each sample was ground in the 8 oz. cup with the Oster blender and a 3.3 g sample was analyzed.

Oil Content was measured using the Goldfisch Method (Gould 1976) with a sample size of 5.0 g an extraction time of 17 hr using 50 mL of peteoleum ether.

RESULTS & DISCUSSION

Phase I

The color of all of the extrudates was unacceptably dark due to the high temperatures during the extrusion and/or milling process(es). The pecan paste used in this phase was unacceptably darkened during the milling process. The paste also had a less intense pecan flavor than the roasted pecan meal. Color measurements for the various extrudates are given in Table 7. L-value readings are indicative of the lightness of the samples. The range of L-values is 1 to 100 with a reading of 1 being black and a reading of 100 being white. The L-value of an extruded pecan piece should be greater than 50 if the product is to resemble pecan piece.

Due to the problems associated with extruding high fat products (i.e., difficulty in conveying through the barrel and loss of product consistency), the maximum level of pecan meal which could feasibly be extruded was 40% (db). Therefore, a formulation which includes 40% pecan meal containing 65% lipid, appears to be most desirable in terms of final texture. The extrudate from this formulation would have a final lipid content of 26% (db). In this study, the formulations which were composed of less than 40% pecan meal or paste possessed a suprisingly good texture. Formulations which incorporated corn starch with the soybean flour appeared to provide a better final texture than soybean flour alone. Instron compression forces for the 14 extrudates are given in Table 8. Extrudates composed of 50% soybean flour plus 40% roasted pecan meal or pecan paste plus 10% corn starch gave the best compression readings and were subjectively found to have a better nutmeat mouthfeel.

This study indicates that using a pecan paste to produce a pecan piece may offer a couple advantages. First, using pecan paste instead of pecan meal would improve consistency of the extrudate. Second, the use of a ground pecan paste instead of a pecan meal would eliminate the problems associated with shell pieces in the final produce. Unfortunately, grinding of shell and interstitial shell pieces which are present in the meal, may also increase the astringency of the final paste. A strategy may be employed where the pecan paste would be injected into the previously mixed, heated and cooled (texturized) corn starch plus soybean flour mixture at a later stage of the extrusion process (possibly at the die). This would reduce the time-temperature exposure of the pecan paste and reduce the color darkening which we observed as well as reduce the loss of pecan flavor volatiles which occurred during Phase I. By reducing the loss of pecan flavor volatiles during processing the intensity of the pecan flavor in the final pecan piece would increase. For this strategy to be successful, the pecan paste would need to be produced at a lower temperature to incur less darkening.

Phase II

Grinding of pecan meal using a cooloidal mill produced a pecan paste at a low enough temperature to produce a paste with desirable color and flavor. In addition, the milling procedure also allowed enough of the pecan lipid to remain bound in fat globules, thereby reducing separation of the oil. An additional benefit was noted by the reduction of shell pieces during grinding. Shell fragments which were added to the mill were reduced to a grit-like substance which would be more of an annoyance to consumers than a health risk.

The extruded pecan piece produced in this phase had a final composition of 44.4% soybean flour; 21.5% pecan paste; 19.3% water and 14.8% starch (wb). If the extrudate is dried and water is reduced to 4% in a similar manner to pecans, the final composition would be 52.4% of soybean flour; 25.3% pecan paste; and 17.5% starch. Unfortunately, the Moyno pump used in this study did not deliver a constant flow of pecan paste into the extruder barrel. Paste injected into the barrel was successfully incorporated into the starch and soybean flour matrix. It is also important to note that the paste was incorporated at a point in the extruder following wetting, mixing and heating of the starch and soybean flour mixture. The screw configuration chosen for this phase of the study appeared to produce to much shear to pre-gelatinized starch which was responsible for loss of texture. In addition to destroying the starch texture, the high shearing action appeared to release the pecan lipid from the fat globules and produce an oily extrudate. The mean compression force for 4 samples was 1193.4 N/g. The color of the extrudate for this phase was also unacceptable. The mean tristimulus color measurements for 3 replicates was as follows: L-value=20.22; a-value=3.84; and b-value=4.35. Further work is necessary to determine the effect of reduced barrel heating and shear forces on the color of the extrudate.

The successful production of a remanufactured pecan piece will significantly impact a struggling pecan industry and may result in the output of a potentially important value-added food ingredient.

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Table 1. Nutritional composition of dried, non-roasted pecan halves (McCarthy and Matthews, 1984).

Portion: 100 grams (3.53 oz.)			Water weight: 4.80 g		
Calories	667		Pyridoxine-B6	0.188	mg
Protein	7.75	g	Cobalamin-B12	0	μg
Carbohydrates	18.2	g	Folacin	39.2	μg
Dietary Fiber	6.50	g	Pantothenic acid	1.70	mg
Lipid-Total	67.7	g	Vitamin C	2.00	mg
Lipid-Saturated	5.42	g	Vitamin E	3.15	mg
Lipid-Monounsaturated	42.2	g	Calcium	36.1	mg
Lipid-Polyunsaturated	16.8	g	Copper	1.19	mg
Cholesterol	0	mg	Iron	2.13	mg
Vitamin A-Carotene	12.8	RE[1]	Magnesium	128	mg
Vitamin A-Preformed	0	RE	Phosphorus	291	mg
Vitamin A-Total	12.8	RE	Potassium	392	mg
Thiamin	0.848	mg	Selenium	5.09	μg
Riboflavin	0.128	mg	Sodium	0.926	mg
Niacin	0.887	mg	Zinc	5.47	mg

[1] RE=Retinol Equivalents.

Table 2. Nutritional composition of oil roasted, non-salted pecan halves (McCarthy and Matthews, 1984).

Portion: 100 grams (3.53 oz.)			Water weight: 4.20 g		
Calories	685		Pyridoxine-B6	0.164	mg
Protein	6.95	g	Cobalamin-B12	0	μg
Carbohydrates	16.16	g	Folacin	34.5	μg
Dietary Fiber	6.50	g	Pantothenic acid	0.413	mg
Lipid-Total	71.2	g	Vitamin C	0.4840	mg
Lipid-Saturated	5.71	g	Vitamin E	3.11	mg
Lipid-Monounsaturated	44.4	g	Calcium	33.6	mg
Lipid-Polyunsaturated	17.6	g	Copper	1.20	mg
Cholesterol	0	mg	Iron	2.11	mg
Vitamin A-Carotene	3.18	RE[1]	Magnesium	142	mg
Vitamin A-Preformed	0	RE	Phosphorus	294	mg
Vitamin A-Total	3.18	RE	Potassium	359	mg
Thiamin	0.305	mg	Selenium	100.0	μg
Riboflavin	0.112	mg	Sodium	0.909	mg
Niacin	0.795	mg	Zinc	5.50	mg

[1] RE=Retinol Equivalents.

Table 3. Extruder configuration for Phase I.

Barrel Length (mm)	Screw Type[1]	Location
200	50P	Inlet Feeder
100	35P	(Dry and Wet)
50	25P	
50	15P	
50	MD/BL	
100	50P	
100	35P	
100	25P	
100	15P	
50	-15RS	
100	15P	Die

[1] Screw Type: 50P=50 mm pitch; 35P mm pitch; 25P=25 mm pitch; 15P=15 mm pitch; MD/BL=mixing discs/bilobal; -15RS=slotted with reversing 15 mm pitch.

Table 4. Extruder operating parameters for Phase I, samples 1 to 7.

Sample No.[1]	1	2	3-4	5	6	7
Water (%)	80	70	80	80	60	90
Water (g/min.)	212	188	212	212	162	237
Temperatures (°C):						
Zone 1	22	26	33	36	39	39
Zone 2	90	90	125	124	150	150
Zone 3	140	187	180	180	209	210
Zone 4	140	90	90	90	90	90
Die Pressure & Bearing Bar Press. (bar)	22	10	12	10	12	13
Screw Speed (RPM)	150	154	250	250	115	114
Feeder Speed (RPM)	17	57	58	58	58	58
Throughput (g/min)	454	---	704	704	704	704

[1] Sample No.:
1. 100% soybean flour
2. 50% soybean flour; 50% raw pecan meal
3. 50% soybean flour; 50% raw pecan meal
4. 50% soybean flour; 50% raw pecan meal
5. 45% soybean flour; 55% raw pecan meal
6. 40% soybean flour; 50% raw pecan meal; 10% corn starch
7. 60% soybean flour; 40% raw pecan meal

Table 5. Extruder parameters for Phase I, samples 8 to 14.

Sample No.[1]	8-9	10-11	12	13	14
Water (%)	100	100	50	100	100
Water (g/min.)	272	272	136	272	272
Temperatures (°C):					
Zone 1	41	42	13	25	27
Zone 2	150	150	151	252	151
Zone 3	210	210	210	187	189
Zone 4	90	90	140	90	90
Die Pressure &					
Bearing Bar Press. (bar)	10	14	50	13	23
Screw Speed (RPM)	110	115	142	103	104
Feeder Speed (RPM)	18	41	36	52	52
Throughput (g/min)	704	704	704	704	704

[1]Sample No.:

8. 50% soybean flour; 40% roasted pecan meal; 10% corn starch (> water)
9. 50% soybean flour; 40% roasted pecan meal; 10% corn starch (< water)
10. 50% soybean flour; 40% roasted pecan paste; 10% corn starch
11. 40% soybean flour; 50% roasted pecan paste; 10% corn starch
12. 50% soybean flour; 50% corn starch
13. 25% soybean flour; 50% roasted pecan meal; 25% corn starch
14. 30% soybean flour; 40% roasted pecan oil; 30% corn starch

Table 6. Extruder configuration for Phase II.

Zone	Temperature Barrel (°C)	Temperature Product (°C)	Barrel Length (mm)	Screw Type[1]	Location
1	11.8	15.7	250	FS	Dry Feed Inlet[2]
2	53.5	50.7			Water Inlet
3	110.7	109.1	76	30F	
4	138.5	126.3	33	60R	
			75	SL	
			43	60F	
5	64.1	79.6	50	SL	
			22	90P	
			33	45R	
			75	SL	
6	29.6	63.5	43	60F	
			50	SL	
7	15.2	---	76	30F	Pecan Paste Inlet
			75	SL	
8	15.2	30.2	43	60F	
			50	SL	
			22	90P	
9	15.2	33.0	33	45R	
			50	SL	
10	---	30.2	50	Die	Die

[1]Screw Types: FS=feed screw; 30F=30 degree forwarding paddle; SL=single lead screws; 60R=to degree reversing paddle; 90P=90 degree mixing paddle; 45R=45 degree reversing paddle.
[2]Dry Feed: Starch and soybean flour mixture.

Table 7. Tristimulus color of remanufactured pecan pieces in Phase I.

	Sample[1]	Color[2] L-value	a-value	b-value
1.	100% SBF	42.53	4.35	16.05
2.	50% SBF; 50% RaPM	38.27	3.95	11.47
3.	50% SBF; 50% RaPM	39.46	3.32	11.42
4.	50% SBF; 50% RaPM	38.35	3.67	11.19
5.	45% SBF; 55% RaPM	36.67	3.46	10.25
6.	40% SBF; 50% RaPM; 10% CS	39.46	3.18	10.17
7.	60% SBF; 40% RaPM	32.76	4.91	8.40
8.	50% SBF; 40% RoPM; 10% CS (> water)	25.81	4.06	5.36
9.	50% SBF; 40% RoPM; 10% CS (< water)	23.48	3.87	4.72
10.	50% SBF; 40% RoPP; 10% CS	26.49	4.87	6.75
11.	40% SBF; 50% RoPP; 10% CS	24.31	4.23	5.70
12.	50% SBF; 50% CS	49.99	5.27	17.32
13.	25% SBF; 50% RoPM; 25% CS	18.05	2.46	2.19
14.	30% SBF; 40% RoPO; 30% CS	34.60	3.50	11.98

[1] SBF=soy bean flour; RaPM=raw pecan meal; CS=corn starch; RoPM=roasted pecan meal; RoPP=roasted pecan paste; RoPO=oil from roasted pecan meal.
[2] Standard Tile L=78.46; a=-2.20; b=23.40.

Table 8. Moisture and shear force of remanufactured pecan pieces in Phase I.

	Sample[1]	Moisture (%)	Compression Force (N Force/g product)
1.	100% SBF	20.22	875.1
2.	50% SBF; 50% RaPM	6.24	499.8
3.	50% SBF; 50% RaPM	5.02	732.1
4.	50% SBF; 50% RaPM	4.89	564.5
5.	45% SBF; 55% RaPM	5.36	713.4
6.	40% SBF; 50% RaPM; 10% CS	5.82	470.4
7.	60% SBF; 40% RaPM	9.16	992.7
8.	50% SBF; 40% RoPM; 10% CS (> water)	7.24	1992.3
9.	50% SBF; 40% RoPM; 10% CS (< water)	12.42	1246.6
10.	50% SBF; 40% RoPP; 10% CS	5.94	1460.2
11.	40% SBF; 50% RoPP; 10% CS	8.23	441.0
12.	50% SBF; 50% CS	12.11	421.4
13.	25% SBF; 50% RoPM; 25% CS	12.29	992.7
14.	30% SBF; 40% RoPO; 30% CS	10.60	2433.3

[1] SBF=soy bean flour; RaPM=raw pecan meal; CS=corn starch; RoPM=roasted pecan meal; RoPP=roasted pecan paste; RoPO=oil from roasted pecan meal.