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January 30, 1979

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Peanut Science (1979) 6, 43-45

Removal of Raw Peanut Flavor and Odor in Peanut Flour Processed by Direct Solvent Extraction[1]

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ABSTRACT

Peanut slices can be directly extracted with hexane yielding more soluble protein and better color than pre-press solvent extraction; however, flavor and odor are characterized as raw and "green beany". The utilization of secondary extraction with hexane: ethanol azeotrope, hexane: methanol azeotrope and absolute ethanol subsequent to hexane extraction significantly improved flavor and odor characteristics of peanut flour. Hexane: propanol azeotrope did not significantly improve sensory evaluations. Hexane: ethanol azeotrope did not reduce soluble protein, yielding an NSI value of 95%. Hexane: methanol azeotrope and absolute ethanol slightly reduced NSI to 88% and 92% respectively. Color of peanut flour was not affected by secondary solvent extraction. Direct extraction of peanut slices with hexane, followed by hexane: ethanol azeotrope extraction, resulted in flour with good flavor and odor characteristics and with lighter color and more soluble protein than peanut flour produced by commercial pre-press solvent extraction.

Key Words: peanut, peanut flour, peanut flavor, solvent extraction.

Approximately 57% of the world's peanut production is crushed. Peanut oil is the primary valued product and the defatted meal is generally relegated to animal feed for lesser value. Oil removal is accomplished by screw pressing or by pre-press solvent extraction. High pressure and severe heat treatment during expeller pressing and to a lesser extent, during pre-press solvent extraction, darken color and reduce water solubility of peanut protein (8). Some of the native properties of peanut protein are destroyed, reducing the potential of peanut meal as an ingredient for human food.

Sliced peanuts can be direct solvent extracted in conventional, shallow-bed, continuous, solvent extractors (9). The cellular structure of flaked or ground peanuts does not maintain sufficient integrity to allow efficient separation of the meal from the miscella after extraction (4). Direct solvent-extracted peanut meal is white in color, possesses a high nitrogen solubility index (NSI) and contains less than 2% residual oil. However, due to the lack of heat treatment the meal has pronounced raw, "beany" flavor and aroma that are unacceptable in many food systems. Deodorization with steam sparging under reduced pressure slightly improves flavor and odor but the intensity of each remains appreciable (8). Secondary extraction of hexane extracted soybean meal with alcohol and azeotropic mixtures of alcohol and hexane has been successfully used to improve flavor (2, 3, 5). Although the flavor of soy meal is improved, these solvents reduce the solubility of soy protein.

This work was undertaken to evaluate the feasibility of using alcohol and hexane: alcohol azeotropes to reduce the flavor and odor of direct solvent-extracted peanut meal and to determine the effect of these solvents on peanut protein solubility.

Materials and Methods

Extraction of Peanuts

United States Number 1 Southwest Spanish peanuts were purchased locally. The peanuts were flash heated in a Proctor & Swartz Variable Circulation Dryer for 5 min at 98°C with through-bed air circulation. The nuts were passed through a Bauer Split Nut Peanut Blancher to remove skins and hearts. The peanut halves were cooled to 30°C and sliced to 0.4-0.6 mm thickness with an Urschel Comitrol 3600 Slicer. The slices were extracted batchwise as a single lot is 3 extraction stages at 30°C to less than 1% residual oil. The extracted slices were desolventized with ambient air (30°C) and divided into 5 lots. One lot served as the hexane-extracted control. The other 4 lots were extracted again with 4 different solvents (secondary extraction) each being more polar than hexane. The solvents evaluated were absolute ethanol, hexane: methanol azeotrope (75.25), hexane: ethanol azeotrope (72:18), and hexane: 2-propanol azeotrope (80:20). The azeotropic mixtures were prepared on a volume: volume basis. Secondary extractions were conducted batchwise on hexane-extracted peanut slices at ambient temperature (30°C). After 3 hr extraction, part of the slices were removed and the remainders were extracted with their respective solvents for an additional 3 hr. Therefore, samples with 3 and 6 hr secondary extraction periods were obtained. The extracted slices were desolventized with ambient air (30°C) and ground to flour fineness in an Alpine Mill.

Analytical Characterization

The blanched peanuts and experimental flours were analyzed for protein, crude free fat, and NSI by standard AOCS procedures (1). Color was measured using the Hunter Color Difference Meter on both dry and wet (66% moisture) flours. Foaming capacity and foam stability were evaluated by the procedure of Lawhon et al. (7) modified for 6% dispersions.

Sensory Panel Evaluation

Samples of each 8 extraction treatments were evaluated for blandness of flavor and odor in 3% flour: distilled water dispersions against hexane-extracted, peanut flour by multiple comparison difference testing (6). In order to prevent sensory fatigue, evaluation was divided into 2 sessions. In each session 4 randomly chosen, secondary-extracted samples were evaluated in comparison with the hexane-extracted control. The panel consisted of 8 members and each panelist evaluated the series of 8 secondary-extracted samples against the control twice for odor and flavor. Odor and flavor scoring was based upon a 7-point scale where 1 designated a much stronger intensity than the control, 4 designated equivalent intensity as the control and 7 designated much blander than the control. The responses were analyzed using analysis of variance and the Duncan's Multiple Range Test.

[1]This paper reports research funded by the Natural Fibers and Food Protein Commission.

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This is an article from *Peanut Science*,6(1) 1979;43-45
doi: http://dx.doi.org/10.3146/i0095-3679-6-1-8 posted with permission.

Results and Discussion

Peanut slices that were direct solvent extracted with hexane contained 0.75% crude free fat after 3 stages of extraction. The NSI of peanuts extracted directly with hexane without pre-pressing was much higher than in commercial peanut flour produced by pre-press, solvent extraction, 93.6% versus 69.0%, respectively.

Hexane extracts crude free fat, while the solvents used in secondary extraction (subsequent to hexane extraction) were considerably more polar and extracted bound lipid as well as residual free fat. The solvents evaluated in secondary extraction were absolute ethanol, hexane: methanol azeotrope, hexane: ethanol azeotrope and hexane: propanol azeotrope for 3 and 6 hr extraction times (Table 1). The residual oil content of peanut slices was reduced from 0.75% after hexane extraction to 0.18-0.28% after 6 hr extraction with direct secondary extraction. Protein content was correspondingly increased.

Table 1. Effect of secondary extraction treatments on residual oil, protein content and NSI of peanut flour.

Solvent	Secondary Extraction Time (hr)	Analysis[1] Residual Oil (%)	Protein[2] (%)	NSI (%)
Unextracted Peanuts	-	45.55^{a}	29.8^{a}	97.5^{a}
Hexane	-	0.75^{bc}	55.5^{e}	93.6^{bcd}
Absolute Ethanol	3	0.46^{de}	58.0^{b}	93.6^{bcd}
Absolute Ethanol	6	0.18^{f}	58.0^{b}	92.4^{cd}
Hexane:Methanol Azeotrope	3	0.27^{ef}	58.3^{b}	91.4^{d}
Hexane:Methanol Azeotrope	6	0.27^{ef}	58.3^{b}	87.7^{e}
Hexane:Ethanol Azeotrope	3	0.44^{de}	56.4^{d}	95.3^{abc}
Hexane:Ethanol Azeotrope	6	0.20^{f}	57.0^{cd}	94.9^{abc}
Hexane:Propanol Azeotrope	3	0.57^{cd}	56.9^{cd}	96.0^{abc}
Hexane:Propanol Azeotrope	6	0.28^{ef}	57.1^{c}	96.4^{ab}
Commercial Peanut Flour	-	0.79^{bc}	52.9^{f}	69.0^{f}

[1]Any two means with the same superscript are not statistically different at 0.05 level.

[2]Protein estimated as N x 5.46

The effect of secondary extraction upon NSI was dependent upon extraction time and solvent used. The highest NSI value was observed with hexane: propanol azeotrope yielding 96.4% of the protein soluble after 6 hr of secondary extraction. NSI did not decrease with increasing extraction time. Hexane: ethanol azeotrope also resulted in a high NSI value of 94.9% after 6 hr extraction. A slight decrease in NSI was observed as extraction time increased. Hexane: methanol azeotrope exhibited the greatest reduction in NSI during secondary extraction. After 6 hr secondary extraction with hexane: methanol azeotrope, 87.7% of the protein was soluble. Secondary extraction with absolute ethanol resulted in NSI values intermediate to hexane:ethanol and hexane:methanol azeotropes, 92.4% after 6 hr extraction.

Protein solubility of peanut protein was much more stable to hexane: alcohol azeotrope extraction than that of soy protein. Eldridge et al. (3) found the same order of effect of hexane:alcohol azeotrope extraction upon soy protein solubility; however, the extent of decrease in NSI value was greater for soy protein. In that work, 6 hr of extraction reduced the NSI from 82% in full-fat soy flour to 78% with hexane:propanol azeotrope, to 69% with hexane:ethanol azeotrope, and to 25% with hexane:methanol azeotrope.

Peanut flour produced by direct hexane extraction was limited in foaming capacity (Table 2). Secondary extraction in which additional residual oil and bound lipid were extracted resulted in greater foaming capacity. Foaming capacity was increased 200% after 6 hr extraction with hexane:propanol azeotrope, hexane: ethanol azeotrope and absolute ethanol and 100% with hexane:methanol azeotrope. Hexane-extracted peanut flour had greater protein solubility, greater residual oil and poorer foaming capacity than hexane:methanol azeotrope-extracted flour. Generallly, lipid reduces foaming capacity of protein; therefore, differences observed in foaming capacity of the flours probably reflected differences in fat content rather than differences in solvent:protein interaction.

Table 2. Effect of secondary extraction solvent on foaming of peanut flour.[1]

Solvent	Secondary Extraction Time (hr)	Time After Whipping (min) 0	5	30
Hexane	-	110/85	110/88	108/88
Absolute Ethanol	3	320/16	320/36	320/67
Absolute Ethanol	6	335/12	335/35	335/63
Hexane:Methanol Azeotrope	3	230/48	230/64	230/76
Hexane:Methanol Azeotrope	6	225/46	225/63	225/74
Hexane:Ethanol Azeotrope	3	355/11	355/32	355/63
Hexane:Ethanol Azeotrope	6	325/18	325/41	325/70
Hexane:Propanol Azeotrope	3	355/8	355/28	355/64
Hexane:Propanol Azeotrope	6	330/15	330/38	330/68

[1]Volume foam (ml)/volume liquid (ml)

Minimal effects of secondary extraction upon color were observed in both dry and moist flours (Table 3). The solvents extracted yellow pigments, as was indicated by increased yellow color of the extracts, but the Hunter Color Difference Meter did not detect large differences in color of the flours. The commercial peanut flour produced by pre-press solvent extraction was considerably darker in both moist and dry systems than flour produced by direct solvent extraction.

Table 3. Effect of secondary extraction on color of peanut flour.

Solvent	Secondary Extraction Time (hr)	Hunter Color Difference Dry L	Dry a	Dry b	Moist L	Moist a	Moist b
Hexane	-	90.0	0.3	6.8	72.9	2.4	13.1
Absolute Ethanol	3	89.6	0.4	6.6	73.2	2.5	11.9
Absolute Ethanol	6	89.3	0.0	6.6	72.1	2.7	12.7
Hexane:Methanol Azeotrope	3	89.1	0.0	7.1	72.0	3.2	12.7
Hexane:Methanol Azeotrope	6	89.0	0.3	7.3	75.1	2.5	11.0
Hexane:Ethanol Azeotrope	3	89.6	0.5	6.4	70.8	3.1	13.1
Hexane:Ethanol Azeotrope	6	89.2	0.3	6.3	71.1	3.1	13.0
Hexane:Propanol Azeotrope	3	89.4	0.2	6.4	70.0	3.0	13.4
Hexane:Propanol Azeotrope	6	89.9	0.1	6.5	71.3	2.8	13.1
Commercial Peanut Flour	-	82.9	1.2	12.6	67.8	2.8	14.9

Analysis of variance of panel data for the evaluation of odor of 3% aqueous dispersions of peanut flour indicated statistically significant differences among treatments (Table 4). The hexane-extracted peanut flour from direct-extraction of peanut slices possessed raw, "green beany" odor. All solvent treatments used in secondary extraction gave mean panel scores higher than the hexane-extracted control flour (Table 5). However, haxane:propanol azeotrope with 3 and 6 hr extraction times did not give statistically significant improvements. Although not totally odorless, absolute ethanol, hexane:ethanol azeotrope and hexane:methanol azeotrope produced significant improvements in odor after 6 hr extraction.

Table 4. Analysis of variance in evaluation of peanut flour odor and flavor.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Odor Evaluation				
Solvent	4	92.41	23.10	41.25***
Time	1	5.28	5.28	9.49**
Solvent·Time	3	4.41	1.47	2.64[NS]
Replications	1	1.00	1.00	2.13[NS]
Error	127	60.23	0.47	--
Total	143	177.22	--	--
Flavor Evaluation				
Solvent	4	43.32	10.83	11.83***
Time	1	3.45	3.45	3.76*
Solvent·Time	3	12.34	4.11	4.49**
Replications	1	0.01	0.01	0.01[NS]
Error	127	117.83	0.93	--
Total	143	182.66	--	--

***Significant at 0.001 level
** Significant at 0.01 level
* Significant at 0.05 level
NS Not significant

Table 5. Odor and flavor evaluations of seconday-extracted peanut flour.

Solvent	Secondary Extraction Time (hr)	Mean Panel Score[1]	
		Odor	Flavor
Absolute Ethanol	6	6.25[a]	6.06[a]
Hexane:Methanol Azeotrope	3	6.06[a]	5.75[ab]
Hexane:Ethanol Azeotrope	6	6.19[a]	5.56[ab]
Hexane:Methanol Azeotrope	6	6.06[a]	5.31[bc]
Absolute Ethanol	3	5.64[ab]	5.06[bcd]
Hexane:Ethanol Azeotrope	3	5.25[b]	4.69[cde]
Hexane:Propanol Azeotrope	3	4.44[c]	4.56[de]
Hexane:Propanol Azeotrope	6	4.31[c]	4.44[de]
Hexane	-	4.00[c]	4.00[e]

[1] Any two means with the same superscript are not statistically different at 0.05 level.

The flavor of peanut flour made by direct hexane extraction of peanut slices was also characterized as green, raw and "beany". Analysis of variance of flavor data indicated significant differences among treatments (Table 4). All experimental treatments gave higher mean scores for flavor than the hexane-extracted peanut flour (Table 5). Mean flavor scores exhibited the same trend as mean odor scores. Absolute ethanol, hexane: ethanol azeotrope and hexane: methanol azeotrope produce significant improvements in flavor over a hexane-extracted counterpart. Eldridge et al. (3) also reported the order of increasing improvement in soy flour flavor as: hexane:propanol, slight improvement; hexane:methanol azeotrope, intermediate: and hexane:ethanol, large improvement. Although flavor was improved which may improve consumer acceptance of peanut flour in food applications, a completely bland peanut flour was not achieved. Perhaps extending the time period for secondary extraction beyond 6 hr would result in further improvement of flavor and odor.

Considering solvent effects on NSI and foaming capacity as well as flavor and odor, hexane:ethanol azeotrope was the best solvent evaluated for direct extraction of hexane-extracted peanut slices. Hexane:ethanol azeotrope extraction resulted in an NSI value of 95%, good foaming capacity and more bland flavor and odor. Direct extraction with absolute ethanol and hexane:methanol azeotrope resulted in improved flavor and odor and good foaming capacity but somewhat reduced protein solubility. The protein solubility after extraction with these solvents, however, was much higher than in the commercial peanut flour. Extraction with hexane:propanol azeotrope did not significantly improve flavor and odor. Secondary extraction with hexane:alcohol azeotropes and absolute ethanol did not significantly affect color characteristics. Direct extraction of peanut slices with hexane followed by secondary extraction with hexane:ethanol azeotrope resulted in flour with good flavor and odor characteristics, and with lighter color and more soluble protein than in commercial, pre-press solvent extracted flour.

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Accepted January 30, 1979