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Storage and Moisture Effects on Peanut Composition and Roasted Flavor[1]

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ABSTRACT

Shelled, raw peanuts were placed in storage approximating commercial conditions at 6.2-6.3% and 8.7-9.2% moisture contents during a two year period. The 1978 storage period was from December, 1978 through August, 1979. The 1979 period was from October, 1979 through March, 1980. The moisture condition 8.7% for 1978 and 9.2% for 1979 showed significant differences in free amino acids and free sugars when compared to the 6% treatment. This suggests that 9% moisture content allows increased hydrolysis of complex constituents and significant deterioration of quality to occur. Peanuts with 9% moisture contents produced darker peanut butter with reduced flavor quality than those with 6%. Hunter reflectance values indicated that the skins of raw peanuts with higher moisture content were also darker. Evaluation of the lipid fractions suggested that only the phospholipid fraction from the 9% moisture treatment was significantly changed. Since phospholipids are primarily associated with the membrance portions of plant cells this change suggests that a breakdown in cellular compartmentation may be occurring. Iodine values and oxidative stability values were not significantly affected and approximated values already published in the literature for stored peanuts.

Key Words: *Arachis hypogaea* L., Free Amino Acids, Free Sugars, Sensory Evaluations, Lipids, Phospholipids.

Research involving various legumes has shown quality deterioration during storage at high moisture levels (2,5, 9, 10, 16, 17). Chapman and Robertson (6) investigated the effects of moisture content on soybeans during short term storage. Moisture levels had little effect on the major lipid constituents. However, at highest moisture levels (13% and 18%) the phospholipid level in crude oil decreased, while the level of free fatty acids increased during the last three weeks of storage.

The importance of maintaining moisture levels of peanuts which inhibit mold growth during extended storage, prevent splitting during blanching, and prevent weight loss has long been recognized (16,17). Grades and standards for peanuts are based more on economic considerations than on quality (7). However, little is known concerning the effects of storage moisture levels on the components of peanuts. Recently, a series of papers by Pattee and co-workers (12, 13) has shown the qualitative and quantitative changes in amino acids and sugars which occur among selected market screen sizes of virginia-type peanuts. These changes were related to sensory panel evaluations of peanut butter produced from the screen-size segregated peanuts (15). Significant flavor-quality differences were observed in these studies. The objective of this study was to investigate the effects of moisture and storage time on various components of peanuts.

Materials and Methods

Peanuts used in this study were grown in North Carolina in 1978 and 1979. Peanuts from the 1978 crop were obtained from a commercial sheller pregraded as U.S. No. 1 with a moisture level of 8%. Sublots of this purchase were used in work already reported (12,13,15). Moisture levels of the peanuts during storage were 6.2% for the low and 8.7% for the high moisture treatments. The initial storage sample from the 1978 storage test was taken December 12, 1978. The last storage sample was taken August 16, 1979.

The 1979 peanuts (cv Florigiant) were grown at the Peanut Research Station, Lewiston, NC, using recommended cultural practices. These peanuts were harvested, windrowed and then combined on October 29, 1979, with a moisture content of approximately 15%. The peanuts were taken to the laboratory and forced-air dried at room temperature to approximately 8% moisture content and then shelled. The storage-moisture levels of peanuts in the low and high treatments were 6.3% and 9.2%, respectively. The initial storage sample from the 1979 storage test was taken October 29, 1979. The last storage sample was taken March 24, 1980.

Three samples were prepared each year for storage by the following procedure. The peanuts were screened for size range uniformity by selecting those peanuts which fell through a 7.94 mm screen and rode a 5.95 mm screen. Peanuts used in the low moisture treatment were forced-air dried at room temperature until the specific moisture level was attained. Moisture levels were determined by using a Steinlite moisture meter. Due to conditions in the handling area, the samples used in the high moisture treatment dried to less than 7% moisture. These peanuts were placed in a large plastic bag and stored at 4 C for seven days during which time moisture was aspirated into the container periodically to raise the moisture level. Both high and low moisture peanuts for each year were divided into 15 samples each containing 1120 g. Each individual sample was heat sealed in a special film packaging material (70 g OP400S with a 0.00125 mil white EVA coating) supplied by Champion International Corp., San Leandro, CA. This film has high O_2 and CO_2 transfer capabilities and is nearly impermeable to H_2O.

Peanuts were stored in controlled environment rooms at 4 C and 65% RH. At preset times, designated samples were opened, a 250 g sample withdrawn, and the bags resealed. Moisture determinations were immediately made on the sample to determine whether the moisture had been maintained at the designated level. The 250 g sample was divided into a 50 g subsample for sugar and amino acid analyses and a 75 g subsample for lipid analysis. All samples were dried to 5% moisture content and kept at 1 C until analyzed. Carbohydrate and amino acid contents were analyzed by the methods of Oupadissakoon et al. (11). The major lipid constituents were extracted and analyzed using procedures of Pattee et al. (14).

The remaining sample portion was sent by priority mail to the National Peanut Research Laboratory for the following analyses. Oxygen bomb times determined by the method of Blankenship et al. (4) were used as a measure of oxidative stability of the raw peanuts. Iodine values of raw peanuts were determined by tentative methods of the American Peanut Research and Education Society (1).

Peanuts from the 1978 study were made into peanut butter for flavor and objective color measurements. Samples were roasted at 117 C for 22 min. in a modified Blue M 'Power-O-Matic 60' laboratory oven. A 4-compartment roasting cylinder allowed replicate randomization for the roasting process.

Color measurements were made with a Hunter Color Difference Meter, Model D25D2L, on raw peanuts with intact skins and on finely-ground butter of 100% peanuts (no additives) which had been roasted, blanched and degermed. The butter was sealed in plastic bags and refrigerated overnight or longer before it was brought to room tempera-

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ture and emptied into 12-cm square containers with frosted plastic sides and optically clear bottoms, through which the three color-reflectance parameters were measured. The skin color of the raw peanuts was also measured using the 12-cm square containers.

Peanut butter flavor scores were obtained using a 10-member experienced flavor panel, individual red-masking-lighted booths and a randomized order of presentation. Evaluation was a 5-category hedonic scale ranging from excellent (1) to very poor (5).

Statistical analysis of the data was performed as described by the General Linear Models procedures of Barr et al. (3).

Results and Discussion

It is the marketing policy of the Virginia-Carolina peanut area to use 8% moisture content as a standard for value calculations. During extended storage of farmers stock peanuts there is a gradual moisture loss and peanuts may average 6-7% moisture content after 3-4 months of storage. Thus a moisture content about 8% and one near the low moisture content range were chosen for evaluation. Table 1 shows the free sugars and free amino acids which were significantly affected by the different moisture levels. Both the 1978 and 1979 tests showed significant differences in both free amino acids and free sugars. The 1979 test produced more significant differences between the high and low treatment than did the 1978 test. This suggests that the 8% moisture content used for marketing peanuts may allow component hydrolysis to occur during storage. That complex component, i.e. protein and starch, cleavage may be occurring is indicated by the majority of increases observed in the free sugar and free amino acid fractions and decreases in polycomponent fractions.

Table 1. Effect of moisture content on concentration of free sugars and free amino acids in peanuts.[a]

	1978 Moisture Level		1979 Moisture Level	
COMPONENT	6.2%	8.7%	6.3%	9.2%
		Free Sugars µg/g		
Fructose	290	419**	300	408**
Glucose	128	189**	116	163**
Inositol	236	288**	227	310**
Raffinose	555	598	562	590
Stachyose	4,452	4,369	4,082	3,814*
		Free Amino Acids µg/g		
Unknown	762	640**	1,000	670**
Glutamic	9,022	8,489*	7,445	7,965**
Alanine	3,080	3,440	2,248	2,916**
Peptide	168	158**	160	135**
Isoleucine	381	372	244	260**
Leucine	284	286	194	219**
Tyrosine	544	554	377	425**
Histidine	1,242	1,702**	1,010	1,495**
Lysine	356	369	348	410**
Ammonia	1,671	1,720	1,053	1,139**
Arginine	4,079	4,125	4,494	5,200**

[a]Average of three replications over storage time.

*Significant at the 0.05 level between moisture levels within years.

**Significant at the 0.01 level between moisture levels within years.

The significant storage time changes in concentration of free amino acids and free sugars are given in Table 2 for the 1978 and 1979 tests. Although the storage time was shorter in 1979 more significant changes took place in both free amino acids and sugars. The data trends for storage time are not as consistent as those shown for moisture effects. A majority of the components show an increase in concentration in both years. However, several components, glucose, raffinose, ribose, ammonia, arginine, and methionine show mixed trends. Stachyose and an unidentified nitrogen-containing compound (which is referred to as a peptide) were the only two components to show a consistent decrease with storage time. The multiple complexities of establishing trends in lots of mixed size peanuts can be seen by examining the previously reported work on seed size and storage effects on free amino acids and free sugars (12, 13) which used seeds from a sublot of the commercial lot used in the 1978 portion of this study. Those studies showed trends with storage time varied across seed size for some components, i.e., glucose, raffinose, ammonia, and arginine. Thus, in addition to variations from environmental, cultural, handling, and other sources, one must also consider the seed size distribution of a peanut sample as a possible source of variation when studying storage effects on peanut quality.

Table 2. Effect of storage time on concentration of free sugars and free amino acids in peanuts.[a]

	1978 Storage Time		1979 Storage Time	
Component	0	7 months	0	5 months
		Free Sugars µg/g		
Fructose	330	381*	274	425**
Glucose	194	158**	111	166**
Inositol	242	279	223	298**
Raffinose	568	511*	551	677**
Ribose	18	25	61	28**
Stachyose	4,797	3,712**	4,084	3,413**
Sucrose	35,213	36,152**	34,935	37,267*
		Free Amino Acids µg/g		
Alanine	2,832	3,582**	2,426	2,798
Ammonia	1,810	1,439**	959	1,007*
Arginine	3,827	4,337*	4,440	3,999**
Glutamic	8,458	9,075	7,433	8,224**
Histidine	1,402	1,547	1,114	1,355**
Lysine	320	417*	352	415**
Methionine	44	35**	26	27
Peptide	167	162	149	123**

[a]Average of three replications over moisture levels.

*Significant at the 0.05 level between storage times.

**Significant at the 0.01 level between storage times.

The effects that the above component differences had on product flavor and roasting color are seen in Table 3. The 8.7% moisture level reduced flavor quality and produced a darker colored product than the 6.2% moisture level. Both moisture levels produced an increasingly darker colored product with storage time but the difference due to moisture content did not change. This continuity of change with storage time could suggest that the rewetting treatment used to raise the moisture level to 8.7% produced the intial difference between the high and low moisture treatments. Nevertheless one can say that results of this study show that the moisture content of stored peanuts can have significant effects on composition and quality. Both amino acid and sugar components showed significant differences when the storage moisture was 9.2% and 8.7%. This suggests that increasing moisture levels accelerates the changes which take place as a result of biological function at 6% moisture (12, 13). Thus storage at 6% moisture content is preferred for the maintenance of high product quality potential of raw peanuts. One should remember that the overall moisture content value is the average of the individual seed values. The moisture content of individual seed within a sample may vary ± 1.5% or more of the sample moisture content (8). Thus in any given peanut lot there will always be some peanuts which have higher moisture contents than might be desirable. By storage at 6% moisture content one is able to keep these excessive moisture peanuts to a minimum.

Table 3. Hunter L values and flavor scores of peanut butter as influenced by storage time of 1978-crop raw peanuts at different moisture levels.[a]

Storage Time	Moisture Level 6.2% L Value	6.2% Flavor Score	8.7% L Value	8.7% Flavor Score
December, 1978	47.0[b]	2.8[c]	44.6	3.1
January, 1979	48.0	2.9	45.2	2.7
February, 1979	47.9	3.0	45.1	2.9
March, 1979	47.4	2.7	44.2	2.9
April, 1979	43.8	3.6	40.8	3.8
May, 1979	42.9	3.2	39.3	3.7
June, 1979	41.7	3.5	39.0	4.0
July, 1979	42.2	3.1	39.6	3.8
Mean	45.1	3.1	42.2	3.4
LSD_{95} (Hunter L) and (Flavor) Moisture Means = 0.2				

[a]Average of three replications.

[b]Higher L value indicates lighter butter color.

[c]Excellent (1) to Very Poor (5).

The Hunter L, aL (red), and bL (yellow) reflectance values of raw peanuts with intact skins were significantly affected by storage time. These results indicate that skins of the high moisture peanuts darkened more than the low moisture ones during storage. They also lost yellow influence more rapidly without significant change in the red parameter, which probably indicates a dulling of the appearance of the raw high moisture peanuts in storage.

The moisture-content and storage-time effect on the lipid components of peanuts is primarily in the phospholipid fraction (Table 5). Storage at 8.7% moisture content produced a significant ($P < 0.01$) decrease in phospholipids. Quantitative analysis of the major phospholipid components showed phosphotidylinositol, phosphotidylcholine, phosphotidylethanolamine and phosphatidic acid to be the components that decreased. Since phospholipids are primarily associated with the membrance portions of plant cells, this change in the proportions of phospholipids at the 8.7% moisture content suggests that a breakdown in cellular compartmentation may be occuring. This breakdown could have a significant impact on the quality of products produced from such seeds because of interaction between enzymes and substrates previously separated by cellular compartmentation. The primary type of reaction postulated to occur is hydrolysis, which we suggest is accounting for the increase in free sugars and lysine with storage time.

The 8.7% moisture treatment (Table 5) shows a significant trend for increasing peanut lipid with storage time.

Table 4. Changes in Hunter reflectance values of raw redskin peanuts across moisture contents and storage time.

Moisture Content %	L Storage Time 0		L 7 months	aL Storage Time 0		aL 7 months	bL Storage Time 0		bL 7 months
6.2	42.8	*	39.4	13.0	ns	13.5	15.3	ns	15.0
	*		*	*		*	*		*
8.7	41.7	**	36.1	12.0	ns	12.2	14.7	**	13.3

*Comparison significant at the 0.05 level.

**Comparison significant at the 0.01 level.

[ns]Comparison non-significant.

Table 5. Moisture content and storage time effects on the lipid fractions from raw peanuts.[a]

Storage Time Months	Lipid Content %	Tri-glyceride	1,2 Di-glyceride	1,3 Di-glyceride	Sterol	Glyco-lipid	Phospho-lipid
		% of Lipid Content					
		6.2% Moisture Content					
0	47.5	91.33	0.45	0.25	0.26	0.36	1.35
3	47.3	92.48	0.33	0.28	0.26	0.31	1.44
5	47.9	92.05	0.40	0.36	0.28	0.32	1.27
7	47.4	94.44	0.24	0.41	0.29	0.38	1.47
		8.7% Moisture Content					
0	45.6	93.30	0.42	0.30	0.30	0.30	1.20
3	46.1	94.23	0.55	0.39	0.26	0.24	1.06
5	47.8	93.43	0.44	0.45	0.24	0.28	0.82
7	46.8	97.86	0.53	0.25	0.26	0.28	0.84
LSD_{95}	1.4	4.78	0.11	1.38	0.06	0.11	0.28

[a]Average of three replications.

The reason for this increase is not clear. The oxidative stability values for 6.2 and 8.7% moisture treatments (1978) were 118 and 117, respectively, after 7 months storage time. Iodine values were 98.0 and 97.8, respectively, for the same storage periods. These values complement those previously reported (15) for seed size-storage time relationships. Thus moisture content during storage had no apparent effect on oxidative stability or iodine values. The complementary nature of the oxidative stability and iodine values lends support to what we consider to be the general stability of the lipid values observed during storage.

Further investigations will seek to provide information on the following questions. First, after the initial 120-day changes will a lowering of the moisture content to 5 or 6% maintain the quality of the product during storage? Second, will the product quality decrease if the moisture content should increase during storage? Third, does the manner of the moisture increase (rapid, slow, etc.) affect product quality? The results seem to suggest that a quality decrease will result from an increase in moisture content, particularly if the level should approach 9%.

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