Effect of Hot Water Immersion on Storage Stability of Non-Refrigerated Peanuts[1]

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ABSTRACT

Oxidative stability of Fla Early Bunch and NC7 peanuts immersed in hot water (79 C) for 90 sec and stored under non-refrigerated conditions was evaluated. Scanning electron microscopy revealed that water immersion disrupted structural makeup of the surface to form a glaze and caused coalescence of subcellular bodies. Initial hot water immersion resulted in decreased lipoxygenase activity. Throughout storage, peroxide values, free fatty acid values and lipoxygenase activity were lower in the immersed peanuts than in the non-immersed peanuts. Free fatty acid and peroxide values were significantly higher in the Fla Early Bunch cultivar than the NC7 cultivar.

Key Words: Peanuts, storage, electron microscopy, hot water immersion, lipoxygenase, peroxides.

Storage of peanuts after harvest must be carefully monitored due to the semiperishable nature of the nut. As the seeds are high in oil content (45-50%), unsuitable storage conditions may lead to the development of oxidative rancidity and staling as well as absorption of undesirable aromas. Environmental conditions considered necessary for maintenance of initial quality of peanuts include temperatures near 0 C, relative humidity of 65%, low initial moisture content of 7%, and an odorless and well-ventilated storage environment (13).

Temperatures around O C for peanut storage environments may not be appropriate in many areas due to the high cost. Developing appropriate technology for long term storage of peanuts in tropical areas where refrigeration is not feasible is a major objective of the peanut collaborative research project being conducted at the University of Georgia, Kasetsart University in Thailand, and University of Philippines at Los Banos.

Heaton and Cecil (4) found peanuts stored at room temperature to be extremely resistant to oxidative rancidity, staling, and insect infestation up to a 2 yr period if water blanched by commercial means at 79 C for approximately 1 min. Woodroof (13) noted that hot water treatment of peanuts for seed coat removal would result in increased stability during subsequent storage. Specific data to support these observations were not presented by either Heaton and Cecil (4) or Woodroof (13).

Lipid oxidation and rancidity in peanuts may involve enzyme catalysis. Lipoxygenase, the enzyme responsible for oxidation at the double bonds of unsaturated fatty acids, was found to be totally inactivated in peanuts treated in hot water at 86 C for 90 sec (9) or steamed for 2 min at 100 C (7).

Storage stability of peanut oil has been observed to differ among botanical types due to differences in fatty acid contents. Peanut cultivars having high levels of linoleic acid were found to be highly susceptible to oxidative rancidity (3,5,16). Several investigators have directed their research efforts to develop cultivars with low levels of unsaturated fatty acids in order to increase shelf-life (1,12,16).

The purpose of this study was to examine the immersion of peanuts in water at 79 C for 90 sec as a means of enhancing shelf-life of peanuts stored at non-refrigerated conditions for 8 mo. Oxidative stability and ultrastructural changes in two cultivars with high (Fla Early Bunch) and low (NC 7) linoleic acid levels were evaluated.

Materials and Methods

Cultivar selection

Two peanut cultivars of the virginia type (*Arachis hypogaea* L. subsp. *hypogaea*) were studied. Shelled peanuts of the Fla Early Bunch cultivar, high in the unsaturated fatty acid, linoleic acid, were obtained from the Georgia Seed Foundation, Plains, GA, and the NC7 cultivar, low in linoleic acid were obtained from the VPI Tidewater Research Center, Suffolk, VA. The Fla Early Bunch peanuts were received already graded, but the NC 7 samples were manually graded to eliminate small and immature seeds. Both cultivars were held at 2 C, 65% relative humidity (RH) until time of treatment.

Processing and storage

Peanuts were immersed in hot water (79 C) for 90 sec in a Groen steam kettle (Groen Mfg. Co., Chicago, IL). Samples were immersed in small aliquots (ca. 1.4 kg) so as to maintain the desired temperature of water (79 C) in the steam kettle during the treatment. After manually removing the seed testa from half of the water immersed samples, all wet samples were dried overnight to approximately 7% moisture in an environmental room maintained at 27 C-55% RH.

Samples were stored in open containers and kept in three environmental rooms maintained at approximately 23 C-55% RH, 27 C-45% RH, and 35 C-65% RH. Water immersed peanuts were stored both with and without seed testa. Throughout the paper, INS, IWS and NI wil refer to peanuts immersed in water and stored without skins, peanuts immersed in water and stored with skins, and peanuts not immersed in water, respectively. Control samples were NI peanuts stored at 2 C-65% RH.

Scanning electron microscopy

For scanning electron microscopy (SEM), peanuts were treated for 2 min at 79 C. Surface areas and cross sections of the unstored Fla Early Bunch samples were cut with a clean, sharp razor blade and mounted on aluminum stubs with silver conductive paint. The samples were coated with a thick layer (200-300A) of gold-palladium alloy using a sputter coating device (Hummer III Sputter Coater, Anatech, Ltd., Alexandria, VA) and examined in a Stereoscan Mark 2A SEM (Cambridge Instrument Co., Ltd., London, England) operating at 25 kV.

Solvent extraction of oil

Approximately 8 g of seed and 25 mL of hexane were mixed in a Sorvall Omni Mixer (Ivan Sorvall, Inc., Newtown, CT) for 1 min at a power setting of 7. The slurry was centrifuged at 4,080 x g for 10 min at 20 C in a Sorvall RC2-B Refrigerated Centrifuge (Ivan Sorvall, Inc., Newtown, CT) with the extract being suction filtered through a fritted filter funnel, and solvent removed with a Buchner Model PF-9GN flash evaporator (Buchner Instruments, Inc., Fort Lee, NJ).

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Peroxide value determination

Peroxide values of the extracted lipid were determined in triplicate at 0, 2, 5, and 8 mo of storage. The modified iodometric procedure of Dahle and Holman (2) for semimicrodetermination of lipid peroxides was used. Oil samples of about 200 mg were dissolved in 3 mL of the lipid solvent mixture. The test mixture was titrated with a 0.01N iodine solution prepared in 70% ethanol until a yellow color persisted. Peroxide values were expressed as meq of peroxide/1000 g of oil.

Lipid analyses

At months 0, 2, 5, and 8, the percentage of free fatty acids (FFA) was measured in triplicates by adding 0.5 mL of 0.2 mg/mL concentration of internal standard (heptadecanoic acid) to 200 mg of solvent extracted oil in duplicates. The lipid (ca. 300 µL) was streaked on 500 µm silica gel G 20 x 20 cm thin layer plates (Analtech, Inc., Newark, DE). The plates were developed in a 90:10:1 hexane:diethyl ether:acetic acid solvent system. The developed plates were sprayed with a general lipid reagent (6), and observed under UV light. Free fatty acid bands were isolated from the plates and methyl esters were prepared by a modification of the procedure described by Worthington (15). The samples were treated with 2 mL of 3:1 methanol:benzene reaction solution containing 3% H_2SO_4 and transesterified in a 90 C water bath for 2 h. After cooling, 1 mL petroleum ether (Skelly F) was added and the mixture was shaken. Distilled water (2 mL) was added to effect phase separation. The petroleum ether-benzene layer was removed and filtered through anhydrous sodium sulfate. The solvent was evaporated under a stream of nitrogen.

Methyl esters were analyzed on a Micro Tek 220 gas chromatograph equipped with dual flame ionization detectors and a Hewlett Packard 3390A Electronic Integrator (Hewlett-Packard Co., Avondale, PA). A 1.85 m x 4 mm I.D. glass column packed with 10% Silar 7Cp on 80/100 mesh chromosorb W (AW) (DMCS) was used. Separation was performed isothermally at 215 C with injection and detector port temperatures at 275 and 300 C, respectively, and a helium flow rate of 100 mL/min. A standard fatty acid methyl ester mixture (Nu-Check Prep. Inc., Elysian, MN) was run in order to use retention times in identifying sample peaks. Free fatty acids were calculated as percent of oleic acid and calculations were made using the following formula.

$$\% \text{ FFA} = \frac{Cs - C_{17:0}}{Ws} \times \frac{W_{17:0}}{C_{17:0}} \times 100$$

where FFA = free fatty acid
Ws = weight of oil sample (mg)
Cs = total area integrator counts of sample
$C_{17:0}$ = area integrator count for internal standard
$W_{17:0}$ = weight of internal standard (mg)

Fatty acid levels were determined by digital integration and were reported as relative proportions of total fatty acids.

Oil content was determined in duplicate with a Goldfisch extractor. A 3 gram sample of ground and dried peanuts was extracted for 24 h with 50 mL of petroleum ether (Skelly F). The oil sample was dried in a vacuum oven at 70 C prior to weighing.

Fatty acid methyl esters were prepared from the extracted samples and analyzed by gas chromatography. Percentage fatty acid compositions were determined.

Lipoxygenase assay

Lipoxygenase extracts were prepared in triplicates by homogenizing peanuts (ca. 8 g) in 25 mL 0.05 M Tris buffer (pH 7.5) at 4 C in a Sorvall Omni mixer for 1 min at a #7 setting. The homogenate was centrifuged at 4 C for 20 min at 4,080 x g. After the supernatant was squeezed through cheesecloth to remove the fat layer, the pellet was rehomogenized, recentrifuged, and collected under the same conditions. The combined supernatants were brought to 50 mL volume by addition of 0.05 M Tris buffer. Replicate extractions of lipoxygenase were made from each sample.

Lipoxygenase activity was assayed at 25 C with a YSI Biological Oxygen Monitor (Yellow Springs Instrument Co., Yellow Springs, OH) fitted with a Clark oxygen electrode and coupled to a Linear Instruments strip chart recorder (Linear Instruments Corp., Irvine, CA). The polarographic method of Nelson *et al.* (8) was followed in measuring initial rates of oxygen uptake. The 3.0 mL reaction vessel contained 0.2 mL of 1.8 mM linoleic acid substrate and 2.7 mL of 0.1 M phosphate buffer (pH 6.2). The 0.1 mL enzyme solution was introduced into the reaction vessel with a 0.1 mL syringe.

Total lipoxygenase activity was calculated as nmol O_2/min/g of sample. Due to the instability of the enzyme preparations during storage, lipoxygenase activity was expressed as percentage of lipoxygenase activity in relation to the enzyme of the control peanut samples.

Statistical analysis

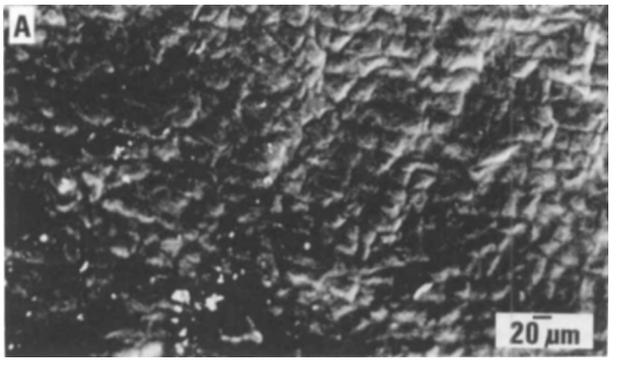
Statistical analysis of objective data was performed on the IBM computer using Statistical Analysis System (10). Preliminary analysis of objective data collected from peanuts stored at non-refrigerated conditions showed time to be a highly significant variable. To avoid the masking effect, covariance analysis was performed with time as the continuous variable. Untreated peanuts including samples stored at 2 C were analyzed using the SAS General Linear Model procedure (10).

Results and Discussion

Scanning electron microscopy

The effects of hot water treatment upon the ultrastructure of peanut epidermal cells are shown in Figs. 1A and 1B. In the NI peanut (Fig. 1A), well-defined rectangular cells appear to be tightly packed. Scanning electron microscopy of the INS peanut (Fig. 1B) revealed a smooth, glazed surface similar to the blanched peanut surface described by Woodroof (13) and shown previously by St. Angelo *et al.* (9).

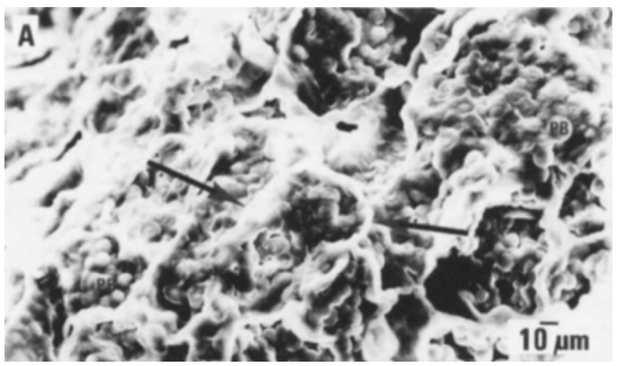
Fig. 1. Scanning electron micrographs of peanut epidermal cells. A. Cotyledon surface of NI peanut. Note the well-defined rectangular cells.



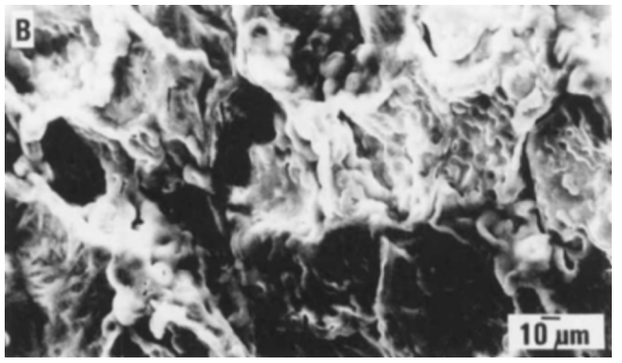
B. Cotyledon surface of INS peanut. Disrupted epidermal cells appear smoother than those in Fig. 1A due to hot water immersion.

Cross sections of cotyledon parenchyma cells are shown in Figs. 2A and 2B. The greater portion of the peanut embryo is composed of large, almost iso-diametric parenchyma cells with pitted, cellular walls and small, distinct intercellular spaces (14). Major subcellular bodies located within the parenchyma cells include the aleurone grains (protein bodies), spherosomes (lipid bodies), and starch grains. Schadel *et al.* (11) found the aleurone and starch grains to be 2-10 µm in diameter and the spherosomes to be 1-2 µm.

Fig. 2. Scanning electron micrographs of peanut parenchyma cells.
A. Cross sections of NI peanut cotyledon. Note the cell walls as indicated by arrows and the protein bodies (PB).



B. Cross sections of INS peanut cotyledon. Note the coalesced protein and lipid bodies resulting from the hot water immersion.



As shown in Fig. 2A, the subcellular bodies present are distinct in shape. These subcellular organelles were identified as aleurone grains, 2-12 µm in diameter. A cytoplasmic network containing lipid bodies appeared to be present surrounding the protein bodies. Small lipid bodies surround the larger cell constituents (11).

In Fig. 2B, structural details are obscured by a spongy network where some protrusions throught to be protein bodies are visible. During hot water immersion, the moisture content of the seed increased. Since the proteins are soluble in water, high temperature and high moisture associated with the hot water immersion are believed to have caused disruption of the individual protein and lipid bodies, and probable formation of a lipoprotein complex. These results confirmed the electron microsopy study of St. Angelo *et al.* (9).

Peroxide values, free fatty acids, and lipoxygenase activity

Table 1 shows time-treatment, time-cultivar, and cultivar-storage condition interactions to have a significant effect on peroxide values. Means and standard deviations of peroxide values are illustrated in Tables 2 (NC 7 peanuts) and 3 (Fla Early Bunch peanuts). Peroxides were detected by the second storage month in all samples except the control peanuts and NC 7 peanuts stored at 23 C-55% RH. By the fifth month, measurable quantities of peroxides were found in all peanuts. Peroxide values were about the same in INS and IWS peanuts (Tables 2 and 3).

Table 1. Levels of significance for the main and interactive effects in covariance analysis of the objective data.

	DEPENDENT VARIABLES		
SOURCE	PEROXIDE VALUES	FREE FATTY ACID	LIPOXYGENASE
Cultivar	NS	*	NS
Treatment	NS	NS	**
Storage Condition	*	NS	NS
Time	**	**	**
Time X Time	**	NS	**
Cultivar X Treatment	NS	NS	NS
Time X Cultivar	**	**	NS
Cultivar X Storage Condition	**	NS	NS
Treatment X Storage Condition	NS	NS	NS
Time X Treatment	**	NS	**
Time X Storage Condition	NS	NS	NS

NS - not significant
** ($P \leq 0.01$)
* ($P \leq 0.05$)

Table 2. Means and standard deviations of peroxide values for NC7 peanuts at 0, 2, 5 and 8 months of storage.

		Peroxide Values[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	N.D.[2]	-[3]	N.D.	-	3.5	-	3.0	-
23 C 55% RH	NI	N.D.	-	N.D.	-	4.3	-	4.5	-
	INS	N.D.	-	N.D.	-	3.3	-	2.5	-
	IWS	N.D.	-	N.D.	-	3.2	-	2.5	-
27 C 45% RH	NI	N.D.	-	2.5	-	5.0	-	5.5	-
	INS	N.D.	-	2.0	-	4.1	0.2	4.0	-
	IWS	N.D.	-	2.0	-	4.0	-	4.0	-
35 C 65% RH	NI	N.D.	-	3.0	-	4.7	0.1	6.0	-
	INS	N.D.	-	4.0	-	3.2	-	4.5	-
	IWS	N.D.	-	4.0	-	3.3	-	4.5	-

[1]Expressed as milliequivalents of peroxide/1000 grams of oil

[2]Not detected

[3]Standard deviation < 0.01

Peroxides were higher in NI peanuts than INS or IWS nuts of both cultivars throughout the storage period with the exception of NC 7 peanuts stored at 35 C-65% RH at month 2 of storage. Peroxide formation was also greater over time in the Fla Early Bunch cultivar than in the NC 7 cultivar. High peroxide values in the Fla Early Bunch peanuts could be attributed to high linoleic acid content. At the eighth month, peroxide values were highest, 7.5 in NI Fla Early Bunch seed stored at 23 and 35 C as compared to values of 6.5 and 5.0 in INS seed. At the eighth month, peroxides were highest in seed of both cultivars stored at 35 C and in

Table 3. Means and standard deviations of peroxide values for Fla Early Bunch peanuts at 0, 2, 5 and 8 months of storage.

		Peroxide Values[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	N.D.[2]	-[3]	N.D.	-	4.0	-	3.0	-
23 C 55% RH	NI	N.D.	-	2.5	-	6.5	-	7.5	-
	INS	N.D.	-	2.5	-	6.0	-	6.5	-
	IWS	N.D.	-	2.5	-	5.5	-	6.5	-
27 C 45% RH	NI	N.D.	-	2.5	-	7.5	-	6.0	-
	INS	N.D.	-	2.0	-	4.6	0.1	4.5	-
	IWS	N.D.	-	2.0	-	4.5	-	4.5	-
35 C 65% RH	NI	N.D.	-	4.0	-	5.7	0.3	7.5	-
	INS	N.D.	-	3.5	-	5.0	-	5.0	-
	IWS	N.D.	-	3.5	-	5.0	-	4.8	0.3

[1]Expressed as milliequivalents of peroxide/1000 grams of oil

[2]Not detected

[3]Standard deviation < 0.01

the seed of the Fla Early Bunch cultivar stored at 23 C at the eighth month.

Total oil was 50.1% in the Fla Early Bunch peanuts and 46.4% in the NC 7 peanuts. As expected, a higher percentage of linoleic acid was determined in the Fla Early Bunch peanuts (38%) than in the nuts of the NC 7 cultivar (24%).

Rancid aromas were detected at the second month in INS and IWS Fla Early Bunch peanuts stored at 23 C and NI seed of the same cultivar stored at 27 and 35 C. By the fifth storage month, all NI peanuts of the Fla Early Bunch cultivar possessed rancid aromas and darkened skins, and by the eighth month additional findings of rancid odors in NI NC 7 seed held at 35 C were made. Fla Early Bunch (INS and IWS) nuts held at 27 and 35 C, NC 7 (INS and IWS) seed stored at all conditions, and NC 7 (NI) nuts stored at 23 and 27 C appeared to be relatively stable after 8 mo of storage as judged by absence of rancid aromas in raw samples.

No obvious relationship between levels of peroxides and rancid aromas could be made at the second month. Peanuts (INS and IWS) of both cultivars stored at 35 C had peroxide values of 4.0 and 3.5 as compared to values of 4.0 and 2.5 detected in the rancid peanuts. Since no rancid off-aromas were observed in INS or IWS samples held at 35 C, it would appear that the peroxides were relatively stable in those samples and had not yet decomposed into aldehydes, ketones, acids, and other products which cause rancid odors. At 5 and 8 mo of storage, those peanuts having peroxide values of 5.5 or greater were found to possess rancid aromas.

Tables 4 and 5 show the means and standard deviations of free fatty acids in the oil of the NC 7 and Fla Early Bunch peanuts, respectively. Data presented in Tables 4 and 5 indicate a marked difference in these two cultivars. Values for the NC 7 cultivar ranged from 0.13 to 1.55% whereas values for the Fla Early Bunch cultivar ranged from 0.24 to 2.58%. Statistical analysis (Table 1) showed a significant difference between the two cultivars over time which may be attributed to difference in lipase activity. Statistical analysis of free fatty acid values in NI peanuts showed that the interaction of time and storage condition was significant. In the NI peanuts of both varieties, free fatty acid values appeared to increase more rapidly during storage at the higher temperatures. This same relationship was also observed in the INS and IWS peanuts of the Fla Early Bunch variety. The extent of lipid hydrolysis in the water immersed NC 7 seed was greatest in peanuts stored at 23 C.

Table 4. Means and standard deviations of free fatty acid values of NC7 peanuts at 0, 2, 5 and 8 months of storage.

		Free Fatty Acids[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	N.D.[2]	-[3]	0.22	0.04	0.42	0.08	0.21	0.04
23 C 55% RH	NI	0.13	-	0.31	0.03	0.67	0.01	0.89	0.08
	INS	0.16	-	0.33	0.02	0.73	0.08	1.55	0.21
	IWS	0.16	-	0.40	0.03	0.64	0.01	1.27	0.01
27 C 45% RH	NI	0.13	-	0.57	0.08	0.89	0.13	1.19	0.04
	INS	0.16	-	0.41	-	0.81	0.06	1.08	0.16
	IWS	0.16	-	0.48	0.05	0.75	0.02	1.11	0.11
35 C 65% RH	NI	0.13	-	0.54	0.00	0.93	0.01	1.34	0.03
	INS	0.16	-	0.67	0.01	0.92	0.01	1.23	0.01
	IWS	0.16	-	0.73	0.02	0.87	0.01	0.88	0.05

[1]Expressed as % of free fatty acids as oleic acid

[2]Not detected

[3]Standard deviation < 0.01

Table 5. Means and standard deviations of free fatty acid values of Fla Early Bunch peanuts at 0, 2, 5 and 8 months of storage.

		Free Fatty Acids[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	0.38	0.02	0.43	0.01	0.64	0.02	0.53	0.04
23 C 55% RH	NI	0.38	0.02	0.85	0.04	1.31	0.01	1.52	0.10
	INS	0.24	-[2]	0.69	0.04	1.15	0.21	1.93	-
	IWS	0.24	-	0.68	0.04	1.09	0.01	1.70	0.06
27 C 45% RH	NI	0.38	0.02	0.98	0.05	1.26	0.07	2.34	0.11
	INS	0.24	-	0.69	-	0.93	0.21	2.57	0.12
	IWS	0.24	-	0.62	0.06	1.32	0.04	1.70	0.08
35 C 65% RH	NI	0.38	0.02	1.21	0.06	1.85	0.49	2.41	0.15
	INS	0.24	-	1.14	0.02	1.45	0.06	2.58	0.04
	IWS	0.24	-	0.89	0.01	1.33	0.08	2.27	0.01

[1]Expressed as % of free fatty acids as oleic acid

[2]Standard deviation < 0.01

Although the main effect of cultivar and interactive effects of cultivar with other variables for lipoxygenase activity were not found to be statistically significant (Table 1), means and standard deviations for both cultivars were not pooled (Tables 6 and 7). Lipoxygenase assays revealed that hot water immersion initally reduced enzyme activity by 46% in the NC 7 cultivar and 53% in the Fla Early Bunch cultivar (Tables 6 and 7). Activity continued to decrease during the 8 month storage period in peanuts stored under all conditions. At all months of testing, activity was lower in the INS and

IWS peanuts than the NI nuts. Statistical tests showed the time-treatment effect to be significant.

Table 6. Means and standard deviations of % lipoxygenase activity values for NC7 peanuts at 0, 2, 5 and 8 months of storage.

		% Lipoxygenase Activity[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	100.0	-[2]	100.0	-	100.0	-	100.0	-
23 C 55% RH	NI	100.0	-	64.5	3.5	62.0	1.4	26.0	2.8
	INS	56.0	1.4	40.5	3.5	35.0	1.4	19.0	2.8
	IWS	56.0	1.4	41.0	8.5	35.5	2.1	18.0	-
27 C 45% RH	NI	100.0	-	61.0	5.7	56.0	-	28.5	0.7
	INS	56.0	1.4	25.5	0.7	22.0	2.8	18.5	3.5
	IWS	56.0	1.4	24.5	4.9	22.5	3.5	16.5	0.7
35 C 65% RH	NI	100.0	-	35.5	0.7	35.5	0.7	32.0	1.4
	INS	56.0	1.4	28.5	2.1	24.5	2.1	19.0	2.8
	IWS	56.0	1.4	24.5	2.1	21.5	0.7	15.5	0.7

[1]Expressed as % lipoxygenase activity in relation to enzyme of control (2 C-65% RH)

[2]Standard deviation < 0.01

Table 7. Means and standard deviations of % lipoxygenase activity values for Fla Early Bunch peanuts at 0, 2, 5 and 8 months of storage.

		% Lipoxygenase Activity[1]							
		Time (Months)							
		0		2		5		8	
STORAGE CONDITION	TREATMENT	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
2 C 65% RH	NI	100.0	-[2]	100.0	-	100.0	-	100.0	-
23 C 55% RH	NI	100.0	-	60.0	1.4	58.5	0.7	36.5	0.7
	INS	48.0	1.4	38.5	3.5	30.5	0.7	27.0	1.4
	IWS	48.0	1.4	44.5	0.7	36.5	0.7	26.0	-
27 C 45% RH	NI	100.0	-	78.0	5.7	46.0	1.4	39.0	-
	INS	48.0	1.4	38.5	10.6	36.0	2.8	29.0	-
	IWS	48.0	1.4	38.0	1.4	24.5	0.7	25.0	-
35 C 65% RH	NI	100.0	-	85.0	2.8	54.0	-	36.0	-
	INS	48.0	1.4	40.5	6.4	31.5	0.7	25.0	-
	IWS	48.0	1.4	39.5	4.9	23.0	-	15.5	0.7

[1]Expressed as % lipoxygenase activity in relation to enzyme of control (2 C-65% RH)

[2]Standard deviation < 0.01

Since St. Angelo *et al.* (9) found lipoxygenase activity to be inactivated in peanuts treated in hot water (86 C) for 90 sec, we expected lipoxygenase activity to be totally destroyed by the hot water. However, water immersion at 79 C was insufficient for total inactivation, and activity was reduced only 50%. We believe that the inability to inactivate enzyme activity could be attributed to cultivar differences.

Conclusions

Peanuts immersed in hot water at 79 C for 90 sec appeared to be more stable during the eight month storage period at non-refrigerated conditions than the untreated peanuts as measured by lower peroxide and free fatty acid values. Although hot water immersion did not initially alter peanut quality, large differences were observed after storage for 2, 5, and 8 mo.

Significant differences between cultivars were observed as shown by significantly greater hydroperoxide formation and hydrolytic breakdown in the Fla Early Bunch cultivar in comparison with the NC 7 cultivar. Little difference was observed between immersed seed stored with or without skins. This information indicated that hot water immersion may be utilized in preserving peanuts, low in linoleic acid such as the NC 7 cultivar.

This work confirms observations that immersion of peanuts in hot water extends shelf-life at non-refrigerated conditions. Longer shelf-life may be attributed to reduced lipoxygenase activity as the higher enzyme activity in NI nuts probably served as an oxidation catalyst. Further investigations are necessary to modify the water immersion method so that lipoxygenase activity is completely destroyed in peanuts leading to increased shelf-life at non-refrigerated conditions.

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