Time of harvesting and storage of soyabeans: influence on oil quality

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RESUMEN

Momento de recolección y tiempo de almacenamiento de soja: influencia sobre la calidad del aceite

Se recolectó soja de la variedad IAC-8 en cinco momentos diferentes, dos previos (R7 y R8) y dos siguientes (C1 y C2) al tiempo normal de recolección comercial (H). Las semillas se secaron al aire a temperatura ambiente después del almacenamiento. Aquellas con un 15% de humedad pudieron ser conservadas durante solo tres meses. Aquellas con un 12% de humedad fueron guardadas durante seis meses. La caracterización inicial de las semillas mostró el más bajo contenido en aceite en semillas procedentes de la cosecha R8. Además la muestra R8 tuvo la menor acidez y el aceite presentó las mejores propiedades al almacenamiento considerando el índice de peróxido. Durante el almacenamiento, se observó un incremento general en la acidez en los aceites de semillas de todas las muestras y a dos niveles de humedad. El indice de peróxido de los aceites disminuyó después de tres meses de almacenamiento, ecepto para aceites R8, y fué incluso menor en las semillas con un 15% de humedad. La absorción espectrofotométrica en el rango ultravioleta indicó la formación de dobles enlaces conjugados cuando el periodo de almacenamiento aumentó, independientemente del momento de cosecha y humedad de la semilla. Hubo pequeños cambios en los índices de iodo de algunas muestras durante el periodo de almacenamiento. Los aceites de R8 fueron aquellos que mostraron la menor deterioración oxidativa durante el periodo estudiado, mientras que los aceites de semillas R7 y C2 fueron los que sufrieron mayor deterioración.

PALABRAS-CLAVE: Aceite (calidad) — Almacenamiento — Recolección— Soja.

SUMMARY

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Soybean var. IAC-8 was harvested in five different times, two previous (R7 and R8) and two subsequent (C1 and C2) to the usual commercial harvest time (H). The seeds were air dried at normal ambient temperature before storage. Those with 15% moisture could be kept for only three months. Those with 12% moisture were kept for six months. Initial characterization of the seeds revealed the least oil content in seeds from the harvest of R8. In addition, the sample R8 had the least acidity and the oil had better storage properties regarding peroxide value. During storage a general increase in acidity has been observed in the oil from seeds from all the samples and at the two moisture levels. Peroxide value of the oil decreased after three months of storage, except for R8 oils, and were even lower in the 15% moisture seeds. Spectrophotometric absorption in the ultraviolet range indicated the formation of conjugated double bonds as the period of storage increased, independently of the harvest time and seed moisture. There was little change in the iodine values of any of the samples during the storage period. The oils from R8 were the ones that showed the least oxidative deterioration during the period studied, whereas R7 and C2 seed oils were considered to have deteriorated the most.

KEY-WORDS: Harvesting — Oil (quality) — Soybean — Storage.

1. INTRODUCTION

Soyabeans are mechanically harvested when they are mature and have an acceptable moisture level. The delay in harvesting is generally associated with losses of seed quality which affect the storage period and result in losses during oil refining and in inferior quality of the refined oil.

Several studies have been conducted on the influence of storage conditions on oil quality. Egli, White and Tekrony (1979) recommended mild temperatures and relative humidity under 70% for soyabean storage with moisture level below 12%. According to Robertson, Morrison III and Burdick (1973), field injured seeds stored with high moisture levels deteriorated rapidly, producing oils with high free fatty acid levels, unpleasant flavor and high refining losses. Fatty acids with a high degree of unsaturation showed faster rate of deterioration.

Evans et al. (1974) found a close correlation between iron content and free fatty acid content in field injured soyabeans, which also affected the quality of the refined oil (List et al., 1977). Oil acidity increases with time of storage and is proportional to the initial free fatty acid content (Yao, Wei and Steinberg 1983). Hydrolytic deterioration is minimal when the seed is stored at low moisture levels. Seeds stored with 13% moisture did not show an increase in peroxide value during a 50 day storage (Frankel, Nash and Snyder 1987).

Soyabeans are Brazil's most important oil seed in terms of volume of harvested seeds and oil produced. There is a lack of information on the recommended time of harvesting and its influence on seed quality. This study has provided information for rural producers on the maintenance of the quality of raw material and in consequence, the valorization of the crop for the industrial sector.

2. MATERIAL AND METHODS

Soybean var. IAC-8 was planted at Malabar farm, in Itatiba, State of São Paulo. Part of the field was reserved for the experiment, the randomized blocks distribution was adopted with six replicates for the experimental design. Sowing was done in December 1989. The randomized blocks were given identical treatments as the main crop.

Harvesting was carried out at five different times:

I) Usual commercial harvest time (H);

II) Previous to H (R7 and R8), according to Fehr and Caviness (1980), which meant 28 and 13 days before H respectively;

III) 13 and 28 days after H (C1 and C2, respectively).

Harvesting was carried out manually, after which the whole plant was trimmed for separation of the seeds from the pods and leaves. Because of unusual and intermittent rains, the seeds were very humid at the harvesting times. They were dried in the shade until they reached a moisture level of 15%. Half of the lot was stored in a closed (hermetic) room (A_1) provided with forced air circulation (average Temperature, 24ºC; average Relative Humidity (R.H.) 83,4%). The other half was dried until a moisture level of 12% and stored in another room (A_2) under normal ambient conditions (average temperature 24ºC; average R.H., 70.2%). The moisture levels of the seeds were maintained during the whole storage period.

Oil content of the seeds was evaluated according to the NGD (Norme Grassi e Derivati) A-4 method (1976). The seeds were stored in 1kg paper bag packages, for a total period of six months. Oil characterization was performed initially, after three months and six months of storage for the seeds stored with 12% moisture level. However, part of the seeds stored at 15% moisture level were mouldy within the first three months and therefore further analytical determinations on these samples were interrupted.

Oil quality was evaluated from the free fatty acid content (NGD C-10) (1976), the peroxide value (NGD C-35) (1976), iodine number (NGD C-32) (1976), iron and copper contents (AOCS Ca 18-79 with adaptations) (1983) and from the spectrophotometric determination in the ultraviolet range (NGD C-40) (1976). The seeds were solvent extracted with hexane (40-60ºC) in 500g capacity Soxhlet extractors. The solvent was recovered in a rotary evaporator under vacuum at maximum temperature of 60ºC.

The analysis of variance (ANOVA) was performed and for comparison of the means was used the Turkey test at 5% of significance level.

3. RESULTS AND DISCUSSION

Table I shows the oil content of the seeds at the five harvest times considered in this study. The values varied between 17.3% and 20.2%. The lowest value was found in R8 seeds. However, no significant statistical differences were found among the average values.

Table I. **Oil content (%) in dry matter of the seeds from the different harvests***

Harvests	R7	R8	H	C1	C2
Average	18,6AB	17,3B	19,8A	19,3A	20,2A
V.C. (%)			2,7		

* Means within a row followed by the same letter are not significantly different at P=0.05 according to the Tukey test

Table II shows that the least acid oils from seeds stored with 15% moisture level were R8 and H, although statistically they did not differ from C1 and C2 and those, differed only from R7. The least acid oil from the seeds with 12% moisture was H, although it did not differ statistically from R8 and C1. Storage resulted in an increase of acidity. Seeds with an average free fatty acid content of 0.86% showed an increment of 94% in the oils from seeds with 15% moisture, and of 62% in the seeds with 12% moisture. Therefore increments in acidity indicated to be a function of the initial moisture levels.

Table II. **Free fatty acid content (%) of the oils from different harvest times stored in room (A_1) and under normal ambient conditions (A_2)***

	A_1 (months)			A_2 (months)			
Harvests	0	3	Average	0	3	6	Average
R7	1,16	1,92	1,52A	1,16	1,80	1,72	1,54A
R8	0,62	1,50	1,02B	0,62	1,29	1,25	1,03BC
H	0,62	1,72	1,10B	0,62	1,33	1,20	0,97C
C1	1,03	1,65	1,32AB	1,03	1,28	1,23	1,18BC
C2	0,94	1,57	1,24AB	0,94	1,51	1,31	1,24AB
Average	0,86b	1,67a		0,86b	1,39a	1,34a	
V.C. (%)	14,3				13,0		

* Means within a row followed by the same lower-case letter are not significantly different at P=0.05, according to the Tukey test. Means within a column followed by the same capital letter are not significantly different at P=0.05, according to the Tukey test.

Table III presents the average peroxide values obtained for the oils from different harvest times and different moisture levels. Statistics indicated there has been significant interaction between the time of harvesting and storage periods. Except for R8 oils, a reduction in peroxide values with storage time has been observed. This has been pointed out also by Robertson et al. (1973) when working with damaged and stored soyabeans. The least peroxide value was found for R8 and H, although statistically only R8 differs from C1 and C2 in the freshly harvested seeds. After three months of storage, the oils from the seeds with 15% moisture did not differ overall and just C1 and C2 showed some decrease in their values compared to the initial peroxide values. Among the seeds with 12% moisture, R8 oil had the least peroxide value, which statistically did not differ from oils from H and C2 after three months of storage. After six months of storage,peroxide values of the oils at all times of harvesting did not differ overall. During the storage period, R8 had an increase and C2 had a decrease in peroxide value.

From the observation of both tables II and III there is indication that the oil R8 showed the least deterioration in quality considering peroxide value and acidity. Despite the differences observed among the initial peroxide values, after six months of storage they did not differ statistically.

Table III. **Peroxide value (meq O_2/1000 g oil) of the oils from different harvest times stored in room (A_1) and under normal ambient conditions (A_2)***

	A_1 (months)		A_2 (months)		
Harvests	0	3	0	3	6
R7	2,14ABa	1,30Aa	2,14ABa	2,30Aa	1,03Aa
R8	0,19Ba	0,69Aa	0,19Cb	0,37Bab	1,30Aa
H	1,21ABa	0,79Aa	1,21BCa	1,13ABa	1,61Aa
C1	2,43Aa	0,65Ab	2,43ABa	1,86Aa	1,03Aa
C2	4,31Aa	0,18Ab	4,31Aa	0,83ABb	0,96Ab
V.C. (%)	7,9		5,1		

* Means within a row followed by the same lower-case letter are not significantly different at P=0.05, according to the Tukey test. Means within a column followed by the same capital letter are not significantly different at P=0.05, according to the Tukey test.

The minimum initial iodine value was found for R7 oil (Table IV). After storage, oils from 15% moisture seed showed a decrease in the iodine value, confirming Swern's observations (1964). There is statistical interaction between time of harvesting and period of storage in sedds with a 12% moisture level. No statistical difference has been found among the harvest times. However, after three and six months, oils from R8 presented the lowest iodine values.

The initial iron and copper contents of the samples was 0,5 ppm and 0,02 ppm respectively, thus one could think that they probably should have very little effect on the oxidation process.

Spectrophotometric absorption in the ultraviolet region of 232nm (E 1% 1cm) revealed an increase in diene concentration with time of storage for all the oils (Table V). The absorption data at 232nm confirms the observations made about the iodine values for the seeds of all harvest times before storage. The highest absorption value was found in R7 oils whose iodine value was the lowest. After three months of storage, seeds with 15% moisture showed higher absorption values at 232nm, inversely to what was found in their iodine values. Statistical analysis indicated there is no significant difference among the

Table IV. **Iodine number (mg Iodine/100 g oil) of the oils from different harvest times stored in room (A_1) and under normal ambient conditions (A_2).***

	A_1 (months)			A_2 (months)		
Harvests	0	3	Average	0	3	6
R7	124,08	117,94	121,00B	124,08Ba	121,92Aa	126,63Aa
R8	131,99	121,02	126,50A	131,99Aa	119,89Ab	124,10Ab
H	133,20	122,35	127,78A	133,20Aa	122,39Ab	127,18Ab
C1	130,67	123,30	126,98A	130,67ABa	125,97Aa	126,14Aa
C2	126,36	121,90	124,13AB	126,36ABa	125,80Aa	126,36Aa
Average	129,26a	121,30b				
V.C. (%)	3,4				3,4	

* Means within a row followed by the same lower-case letter are not significantly different at P=0.05, according to the Tukey test. Means within a column followed by the same capital letter are not significantly different at P=0.05, according to the Tukey test.

Table V. **Ultraviolet absorption at 232nm of the oils from differente harvest times stored in room (A_1) and under normal ambient conditions (A_2).***

	A_1 (months)			A_2 (months)			
Harvests	0	3	Average	0	3	6	Average
R7	2,14	3,30	2,72A	2,14	3,27	3,45	2,95A
R8	1,67	2,92	2,30B	1,67	3,51	3,27	2,82A
H	1,76	2,82	2,29B	1,76	3,48	3,05	2,76A
C1	1,76	3,15	2,46B	1,76	3,27	3,27	2,77A
C2	1,80	2,51	2,16B	1,80	3,15	3,23	2,73A
Average	1,82b	2,94a		1,82b	3,34a	3,25a	
V.C. (%)	10,5				6,6		

* Means within a row followed by the same lower-case letter are not significantly different at P=0.05, according to the Tukey test. Means within a column followed by the same capital letter are not significantly different at P=0.05, according to the Tukey test.

diene values, except for R7 at 15% moisture. Considering the seeds stored with 12% moisture, there was a similar increase in diene content after three and six months of storage. As the numerical iodine values decrease, due to oxidation at the double bonds and consequent diene formation, absorbance values increase.

The behaviour of the absorbance values at 270nm (E 1% 1cm) would explain or be related to the variations in the peroxide values. The oxidized fatty acids detected at 270nm have their origin in the peroxides. According to Robertson et al. (1973) when oils like soyabean which contain linoleic and linolenic acids are oxidized, peroxide concentration increases rapidly reaching high values. In this work, it has not been possible to make a parallel between the peroxide formation and 270nm absorbance.

Table VI indicates an increase in 270nm absorption for the R7, R8 and H oils from seeds with 15%moisture. There was no significant statistical difference for the triene content of the oils from any of the harvest times stored at 12% moisture level.

These observations do not correlate with the information from Table III. The most oxidized oil, C2, considering the peroxide value, showed little change in triene content compared with the results for samples R8 and H. The seeds from these latter samples were harvested at the most favourable time to produce good quality seeds.

Table VI. **Ultraviolet absorption at 270nm of the oils from different harvest times stored in room (A_1) and under normal ambient conditions (A_2).***

	A_1 (months)		A_2 (months)			
Harvests	**0**	**3**	**0**	**3**	**6**	**Average**
R7	0,34ABb	0,74Aa	0,34	0,45	0,37	0,39A
R8	0,25Bb	0,52ABa	0,25	0,45	0,37	0,36A
H	0,25Bb	0,44Ba	0,25	0,47	0,44	0,38A
C1	0,51Aa	0,45Ba	0,51	0,39	0,38	0,43A
C2	0,29Ba	0,35Ba	0,29	0,45	0,38	0,37A
Average	**0,32b**	**0,49a**	**0,32b**	**0,44a**	**0,39ab**	
V.C. (%)	**28,0**			**34,7**		

* Means within a row followed by the same lower-case letter are not significantly different at P=0.05, according to the Tukey test. Means within a column followed by the same capital letter are not significantly different at P=0.05, according to the Tukey test.

4. CONCLUSIONS

Under the conditions of the experiment it was concluded that:

- -The time of harvesting and storage conditions for soyabeans indicated to have an effect on the quality of the oil extracted from these seeds.
- -The time of harvesting soyabeans is important and it has been shown that the time for R8 (early harvest) and H (commercial harvest) produce an oil with the highest resistance to oxidation.
- -After three months of storage seeds with 12% moisture level produced oils of better quality compared to the ones from seeds at 15% moisture level.
- -Early and late harvests, respectively R7 and C2, produced the most oxidized oils.

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