The Processing and Storage Characteristics of Glandless Cottonseed

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Abstract

Two consecutive storage tests of seven and six-months' duration were conducted to determine the relative effects of adverse storage conditions on glandless and glanded cottonseed and the products derived from each.

The moisture conditions during storage resulted in extreme quality deterioration in both glandless and glanded seed. The damage sustained by glandless seed was not substantially different from damage occurring to glanded seed. Neither did glandless seed appear to deteriorate at a faster rate.

Normal direct solvent extraction processing methods were followed to process seed for products quality evaluations as measured by nitrogen solubility, epsilon amino free lysine, and gossypol content for meals and FFA, cup refining loss, refined color, bleach color and gossypol content for oils.

Oil from glandless seed refined and bleached to lower AOCS colors than corresponding glanded seed oils. Refining losses for oils from damaged seed were slightly higher for glandless seed oils.

The meal quality from glandless seed was superior in all categories measured.

Introduction

IDENTICAL PILOT plant scale processing of California grown glanded and glandless cottonseed was done in the Cottonseed Products Research Laboratory (CPRL). Processing and analytical data on California grown seed for 1961, 1962, and 1963 were compared with data on Arkansas glandless seed of a different genetic background grown in 1963. Processing by direct solvent extraction and mechanical pressing were compared.

The study was conducted under the sponsorship of the National Cottonseed Products Association.

Processing Methods

Glandless and glanded seed were processed the first year with and without the use of heat. One half of each type of seed was processed each way.

In subsequent years, all lots of seed were given a mild, low-temperature cook before extraction and after extraction were desolventized with heat. Processing procedures devised and employed regularly after the first year were as follows:

Preparation

Both types of seed were sampled and then delinted to 3% linters content. Before decorticating and flaking, the seeds were moistened sufficiently to bring the moisture content in the meats to 9% when allowed to equilibrate from 24 to 48 hr. Flakes were rolled to a thickness of 0.010 in.

A mild cook was given in a 22 in. diameter steam-jacketed cooker to 75 lb batch charges. During cooking, the temperature was raised to 180F within the first 10 min. Moisture was adjusted at that point to 12% and the cooking continued for 20 min. longer. Temperatures inside the cooker were controlled to a maximum of 225F.

Upon discharge, the cooked flakes passed immediately over a shaker screen to remove for breaking up any conglomerates ("waterballs") formed in the cooker and to achieve a rapid temperature drop in the material. Rapid lowering of the temperature had a "crisping" effect which improved extraction characteristics.

Extraction

Two 55-gal vertical batch extractors were each loaded with 150 lb of flakes, filled with commercial hexane from the bottom and allowed to set full for 1 hr. The resulting miscella was drained continuously thereafter from the bottom. Fresh hexane entered at the top.

Extraction by gravity percolation continued for a period of approximately 4 hr. A solvent to flakes weight ratio of 5:1 was necessary to achieve a residual oil content in the meal of 0.5% or less.

Heat was supplied to the extractors by steam in in a copper tubing jacket.

Desolventization

Extracted flakes were desolventized in a 10 in. diameter steam-jacketed, horizontal tube 20 ft in length. The tube contained a ribbon conveyor machined to fit the inside diameter and equipped with agitating paddles. Meal temperatures at discharge measured 200F. No measurement of the temperature inside the desolventizer was possible. The temperature there was estimated to be near the boiling point of water i.e., 212F.

Residence time of meal in the desolventizer was 12 min.

Solvent and Oil Separation

Miscella was concentrated in a rising film evaporator until it contained 85–90% oil by weight. The maximum temperature used in this stage of separation was 170F.

Further desolventization of the oil was effected in an oil stripping column constructed integrally with the evaporator. In this operation, concentrated miscella was preheated to 200F at entry to the top of the column. Superheated steam introduced at the column base supplied additional heat to the descending feed and removed remaining solvent. Hexane vapors and uncondensed steam passed over the top and were liquefied and collected together.

The insulated glass column, 6 in. in diameter and 7.5 ft long, was packed with ceramic berl saddles.

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TABLE I

Analytical Comparison of Solvent Extracted Meals and Oils from Glandless and Glanded Cottonseed (2)

Cottonseed Meals

Seed type	Flakes preparation	Moisture %	Oil content %	Protein %	Protein solubility %	Gossypol Free %	Gossypol Total %
Glandless							
	Mild cook	6.97	0.18	49.31	89.6	0.002	0.013
	No cook	12.88	0.46	43.31	95.1	0.006	0.006
Glanded							
	Mild cook	6.80	0.39	49.88	84.8	0.084	1.024
	No cook	11.25	0.40	45.50	85.4	0.600	0.800

Cottonseed Oils

Seed type	Flakes preparation	Refining loss %	Refined color	Bleach color	Gossypol %	FFA %	Crude oil color
Glandless							
	Mild cook	6.53	1.97	0.72	0.000	0.50	4.90
	No cook	7.12	1.95	0.37	0.002	0.49	3.75
Glanded							
	Mild cook	3.06	2.90	0.93	0.054	0.56	.....
	No cook	4.88	3.07	0.49	0.464	0.95	.....

Screw Press Processing

Five hundred pounds each of glandless and glanded seed from the 1961 California lots were processed by mechanical pressing. A scale model V. D. Anderson Expeller was used for this work. Flake preparation methods were the same as for solvent extraction except additional drying was administered in the cooker to lower the moisture for pressing.

Processing Results and Discussion

Table I contains data which permit an analytical comparison of solvent extracted meals and oils from glandless and glanded seed processed with and without the use of heat.

The most notable difference in the meals other than the disparity in gossypol content is the higher percentage of soluble nitrogen in glandless seed meals. This quality difference becomes even more pronounced as flakes are subjected to increased heat during processing.

Oils from glandless seed refined to lower photometric colors than did glanded seed oils but with higher cup refining losses.

Products from Arkansas glandless seed were not significantly different from products from California glandless seed.

Comparative data presented in Table II contrast meals and oils from screw pressing glandless and glanded seed.

The same differences were present in these meals and oils as were found in solvent extracted products.

TABLE II

Comparative Data on Screw Press Meals and Oils from Glandless and Glanded Cottonseed (2)

Cottonseed Meals

Seed type	Moisture %	Oil %	Protein %	Protein solubility %	Free gossypol %	Total gossypol %
Glandless	3.8	6.4	45.88	91.1	0.000	0.0500
Glanded	4.5	5.1	44.96	59.3	0.026	0.967

Cottonseed Oils

Seed type	Refining loss %	Refined color	Bleach color	Gossypol %	FFA %
Glandless	6.7	2.74	1.26	0.002	0.720
Glanded	6.5	5.06	2.08	0.066	0.900

TABLE III

Analyses of Glandless and Glanded Cottonseed Used in Storage Test Number Two

	Glandless %	Glanded %
Dirt and trash	0.9	0.2
Moisture	8.8	7.6
FFA	0.5	0.30
Oil	18.3	19.4
Protein	20.69	22.81
Lint	12.2	11.80
Unit weight[a]	0.1314	0.1317
Volume index[b]	242	280
Free gossypol	0.011	0.694
Total gossypol	0.025	0.832
Hulls	44.63	45.55
Meats	55.37	54.45

[a] Ave. wt. per seed, g.
[b] No. of delinted seeds in 50 cc.

The protein solubility of screw press glanded meal is significantly lower, however, because of additional heat and gossypol binding occurring in the pressing operation.

Glandless Seed Storage Tests

Storage Test Number One

The first storage test of glandless seed spanned a seven-month period which included the second half of 1963. The seed tested were grown in California in 1962.

The initial study was exploratory in concept. It was designed to assess the relative effects of adverse storage conditions on glandless and glanded seed and the products derived from each.

Fifty-pound quantities of each type seed were moistened to 12 and 15% moisture levels and stored. Storage units consisted of cylindrical fiber drums with perforated bottoms, housed in insulated metal containers. Iron-constantan thermocouples planted within the seed beds reflected seed temperatures. The seed were compressed in the beds to an average density of 31.55 lb/cu ft.

Periodically, seed samples were withdrawn for free fatty acid (FFA) and moisture determinations. At conclusion of the test period, all seed were sampled and then processed by solvent extraction.

Storage Test Number Two

A second and more comprehensive study of glandless seed in storage was undertaken in May, 1964. Identical 4-ft plywood and angle iron cubical units were constructed to store 1000 lb each of glandless and glanded seed. Facilities were designed for moistening the seed in storage rather than prior to storage as in the previous test. The storage and moistening facilities are pictured in Figure 1.

Moisture in seed was adjusted by controlling the temperature and relative humidity of the air sur-

TABLE IV

Relative Rates of Increase in FFA in Seed During Storage Test Number One

Seed type	Calc. moist at storage %	Time in storage days	FFA in seed %	Moist. in seed %
Glandless	15	35	2.4	13.4
		95	18.5	12.7
		221	22.9	13.4
Glanded	15	34	7.5	13.4
		95	19.3	12.9
		221	33.3	13.2
Glandless	12	35	0.5	12.1
		95	2.3	11.6
		221	2.3	11.5
Glanded	12	35	1.3	12.1
		95	3.9	11.6
		221	3.9	12.1

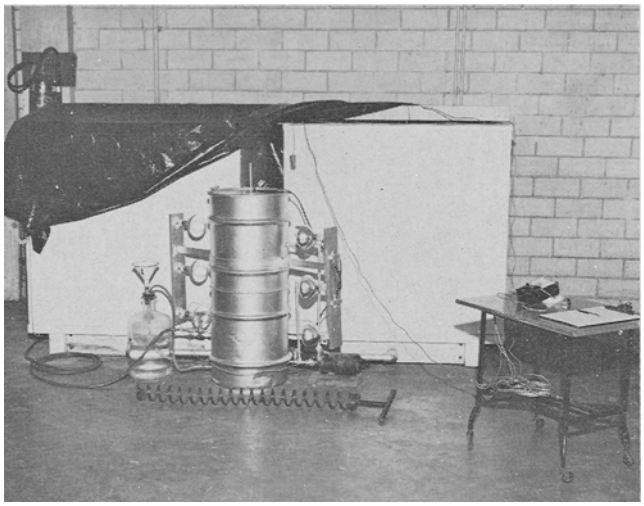

FIG. 1. Installations for seed storage test number two.

rounding it. To achieve the desired storage environment, nearly-saturated air was forced into the bottom of each bin to be distributed by tile ducts underlying the seed. As air passed up through the seed it was stripped of the moisture it carried. The tops of the bins were loosely covered by polyethylene plastic sheeting.

Humidification of air entering the seed was accomplished by passing it through a heat exchanger and a humidifier. The humidifier was constructed from two 30-gal steel drums stacked one above the other and welded with the bottom of the upper drum removed.

The upper drum was filled with packing to disperse water percolating downward countercurrent to the flow of air.

The lower drum contained water controlled to a level below the point of air entry. A small continuously operating pump circulated water from the lower to the upper drum and over the packing.

Additional heat was supplied to the water and air by two vertical stands of three 125-watt infrared lamps positioned on opposite sides of the humidifier. An electric thermostatic switch turned lamps on and off to maintain the temperature of air entering the seed bins.

The relative humidity of air entering and leaving the seed bins was read directly with an Electro-Hygrometer. Humidity sensors suspended approximately 3 in. above the seed in each bin registered the relative humidity of air exited. A sensor inserted through a tee provided in the flow line from the humidifier measured the relative humidity of air to the bins.

Mercury thermometers lowered through a vertical tube planted at the center of each bin were used to read seed temperatures. One thermometer was positioned in the lower half and another in the upper half of each bin.

At selected time intervals based on estimated FFA rise, stored seed was withdrawn for analysis. Quantities of seed weighing 100, 150 and 200 lb were removed in a uniform pattern from the bins and processed after 68, 83, and 88 days, respectively. The remaining 550 lb in each bin was processed after 175 days.

Analyses of glandless and glanded seed before storage are given in Table III.

TABLE V
Analyses of Solvent Extracted Meals and Oils from Seed in Storage Test Number One

Cottonseed Meals

Seed types	Calc. moist. at storage %	Moisture %	Oil %	Protein %	Protein solubility %	Gossypol	
						Free	Total
Glandless	15	13.2	0.64	60.56	69.7	0.022	0.052
Glanded	15	13.0	0.63	60.56	66.6	0.724	1.120
Glandless	12	10.6	1.52	56.16	99.1	0.022	0.028
Glanded	12	11.7	0.96	56.13	97.6	0.888	1.116

Cottonseed Oils

Seed type	Calc. moist. at storage %	FFA %	Refining loss %	Refined color	Bleached color	Gossypol %
Glandless	15	40.4	97.1	Insufficient oil to read	Insufficient oil to read	0.005
Glanded	15	44.4	99.5	Insufficient oil to read	Insufficient oil to read	0.179
Glandless	12	8.1	26.5	2.71	1.79	0.009
Glanded	12	7.5	24.1	2.21	1.01	0.241

Storage Tests Results and Discussion

Storage Test Number One

Data which show the relative rates of increase in FFA in the seed stored are reported in Table IV.

The analyses of meals and oils from processings after storage are given in Table V.

Any limitations inherent in the initial test design which restricted its actual simulation of commercial storage were equally present in units containing each type of seed.

Glandless and glanded seed were observed to follow essentially the same pattern of temperature behavior in storage. The FFA rise in glanded seed was slightly higher. Analytical evaluations, in general, showed meals and oils from severely damaged glandless seed to be of equal or superior quality to products from similarly damaged glanded seed.

Storage Test Number Two

The relative rise in FFA and temperature in glandless and glanded seed with increased moisture and time in storage is shown in Table VI.

Glandless seed acquired more moisture than did glanded seed. An uneven distribution of air between the bins probably caused this. A difference in the density to which seed were packed would result in differences in permeability to air thus allowing a larger flow through the more permeable bin. The flow of air entering the bins was not metered.

TABLE VI
Relative Rise in FFA with Increased Moisture and Time in Storage for Glandless and Glanded Cottonseed During Storage Test Number Two

Seed type	Time in storage days	Ave. moisture %	Ave. FFA %	Seed temp. F	Ambient temp. F
Glandless	0	8.8	0.50	80.5	80.5
	18	9.7	0.43	91.8	89.5
	38	11.2	0.90	97.9	82.0
	59	11.8	2.06	100.1	91.0
	68	.....	3.40[a]	99.5	90.5
	83	12.0	8.60[a]	101.5	89.0
	88	.....	11.60[a]	95.5	93.0
	175	12.3	14.50[a]	84.0	81.0
Glanded	0	8.1	0.50	80.5	80.5
	18	9.2	0.49	91.3	89.5
	38	10.3	0.54	96.0	82.0
	59	11.3	1.48	99.5	91.0
	68	.....	2.37[a]	99.3	90.5
	83	11.0	3.90[a]	99.8	89.0
	88	.....	8.40[a]	95.1	93.0
	178	11.8	12.90[a]	85.0	81.0

[a] FFA content as determined on cottonseed flakes samples.

TABLE VII

Solvent Extracted Cottonseed Meals and Oils Produced at Selected Intervals During Storage Test Number Two

	Cottonseed Meals									
	Glandless Time elapsed in storage, days					Glanded Time elapsed in storage, days				
	0	68	83	88	175	0	68	83	88	178
Moisture, %	5.24	8.04	7.36	6.96	4.50	5.10	6.98	6.24	7.56	4.82
Oil, %	0.47	0.61	0.59	0.78	0.41	0.28	0.55	0.39	0.46	0.40
Protein, %	61.19	60.25	62.31	62.88	63.88	59.44	58.81	60.63	59.88	60.94
Protein solubility, %	93.87	91.60	87.96	85.78	77.30	79.65	80.14	79.17	78.39	74.66
Free gossypol, %	0.01	0.01	0.01	0.01	0.005	0.08	0.12	0.13	0.12	0.17
Total gossypol, %	0.01	0.01	0.01	0.01	0.008	1.18	0.90	1.04	1.04	1.22
Available lysine, gms/16 gm. N.	4.12	3.98	3.89	3.92	4.02	3.51	3.87	3.72	3.82	3.66
	Cottonseed Oils									
FFA,	0.9	2.6	4.5	6.0	16.0	0.6	1.9	3.2	3.9	12.9
Refining loss, %	6.0	8.0	10.6	14.2	36.6	3.8	6.8	11.0	11.1	30.0
Refined color	2.7	2.7	3.1	2.8	4.9	4.9	4.8	5.4	5.5	7.3
Bleach color	2.0	2.0	2.2	2.7	4.2	3.1	3.1	3.0	1.3	4.5
Gossypol, %	0.01	0.01	0.01	0.01	nil	0.03	0.03	0.05	0.06	0.065

FFA rise was noticably higher in glandless seed, a condition commensurate with a higher moisture conucts from each bin of seed.

In every instance glandless cottonseed meals contained a higher percentage of soluble nitrogen and more available lysine than corresponding glanded seed meals.

Oil from glandless seed, with the exception of one sample, refined and bleached to lower AOCS colors. Refining losses were slightly higher for oils from glandless seed.

Findings from the second study did not conflict with indications gained from the initial tests, i.e., products from damaged glandless seed were of equal or superior quality to products from similarly damaged glanded seed.

Bagged Storage of Glandless Cottonseed

A meager amount of data on glandless and glanded seed stored in bags under comparable conditions was taken at the CPRL.

In 1961, 500 lb of each type seed was delinted and reserved in bags inside laboratory buildings for screw pressing. Glandless and glanded seed each had 0.2% FFA as received. After eight months' storage, the glandless seed had 0.7% and the glanded seed had 0.9% FFA.

REFERENCES

1. Harper, G. A., October, 1963, private correspondence.

2. Wamble, A. C., and J. T. Lawhon, Texas Cottonseed and Cottonseed Products, Cotton Economic Research, The University of Texas, Austin, Texas, 1962, p 57–70.

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