Effect of Shell Content and Storage on Expelling of Tung Nuts[1]

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KNOWLEDGE of the effect of varying proportions of shell in tung meal upon oil recovery is of fundamental importance in the operation of oil expellers. It is of especial importance in connection with the substitution of field hulling with a portable huller that removes the hulls of the tung fruits but leaves the hard nut shells unbroken, for mill hulling with a machine that removes not only the hulls but also about half the shells.

All mill operators do not agree concerning the advantage or disadvantage of having a considerable proportion of shell in the meal. Some believe that the shell is needed to create friction for building up enough pressure for efficient expelling. Others favor keeping the amount of shell at a minimum in the belief that excessive wear on the expellers is thus avoided and that increased weight of expeller cake produced when much shell is present increases loss of oil in the cake. It is evident, therefore, that actual data are needed on which to base conclusive opinions.

During the course of cooperative work with the Bureau of Plant Industry, Soils, and Agricultural Engineering on the hulling and storing of tung, the need for just such data arose. It was necessary to know how meal containing practically all the shell would expel in comparison with similar material prepared from fruit passed through the factory disc huller, which removes nearly half the shells. The tests made to obtain such data are described below.

A laboratory-size expeller was not available for the tests, so it was arranged to run them on a full-size commercial unit (an Anderson Red Lion Expeller[2]). The full-size expeller tests are directly indicative of results obtainable in commercial practice, and are therefore more significant than tests on a laboratory-size expeller would be.

It was found that 600 to 1000 lbs. of material was enough to give a fair test on the expeller used. As soon as the hopper above the expeller was empty, the test material was fed into the attrition mill, from which the meal passed to the hopper. Since the temperer above the expeller held enough meal for about 10 minutes' operation, and since no break in the expelling operation could be made, a certain amount of mixing of the material under test with that preceding and following it could not be avoided. Consequently, it was not possible to obtain accurate results on short runs simply by weighing out a batch of material, feeding it to the attrition mill, then weighing the expeller cake and oil produced. Such a method was tried, but the following method proved more accurate. The weight of the meal fed to the expeller during a given period can be calculated with a fair amount of accuracy, if the weights of the expeller cake and oil, and the moisture contents of composite samples of the meal, expeller cake, and oil are known for that period, by taking the total weight of dry matter in the cake and oil and dividing it by the percentage of dry matter in the meal, expressed as a decimal fraction. (Although considerable moisture is evaporated during the process of expelling, it may be assumed that there is no change in the total weight of dry matter during its passage through the expeller.)

TABLE I

Expeller Tests March 29, 1945
(Each test ran for one hour)

	Test No. 1 Fresh nuts from field huller	Test No. 2 Fresh material from factory disc huller
Meal		
(1) Wt. lbs	269.0	231.0
(2) % Shells, plus debris	34.4	25.2
(3) Ratio, wt. shells to wt. kernels, %	63.0	40.0
(4) % Moisture	11.3	12.4
(5) % Oil	36.2	41.6
Expeller Cake		
(6) Wt., lbs	150.9	118.6
(7) % Moisture	7.2	7.5
(8) % Oil	4.7	6.4
(9) Wt. Oil, lbs	7.1	7.6
Crude Oil		
(10) Wt., lbs	98.7	93.1
(11) % Solids	2.1	3.3
(12) % Moisture	.2	.4
(13) Wt. pure oil, lbs	96.4	89.7
Filtered Oil		
(14) Ref. index at 25°C	1.5186	1.5184
(15) Acid value	1.1	1.7
(16) Recovery $\frac{(13)}{(9) \text{ plus } (13)} \times 100$	93.1	92.2
(17) Lbs. water evaporated	19.4	19.3

In March, 1945, two batches of dehulled tung nuts from an experimental field huller (1), containing all the shell material and with nearly all of the shells intact, were put into storage in bags in a well-ventilated shed. At the time of hulling the kernels contained 18.1% moisture. One batch of nuts was dried at 100° C. to 8% estimated moisture and the other was put in storage directly from the field huller without artificial drying. After the undried nuts had been in storage for 10 days, expeller tests were run on them in comparison with material from the factory disc huller which was being currently expelled in the mill where the tests were made. At the end of the first month and again at the end of the second month of storage, tests were made on both the dried and undried nuts from the field huller as well as on the material from the disc huller then being processed in the mill. At the time of the last tests, one test was also made on kernels from which the shells had been completely removed by hand.

Results

The data for all tests, calculated on the basis of one hour's operation of the expeller, are shown in Tables I to IV. To show the effect of different proportions of shells to kernels on efficiency of expelling, the figures for the three tests on the material from the

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[2]Identification of equipment, by giving name of manufacturer, should not be construed as an endorsement of such equipment by the U. S. Department of Agriculture.

TABLE II

Expeller Tests May 2, 1945
(Each test ran for one hour)

	Test No. 3 Dried nuts from field huller. Stored 1 mo.	Test No. 4 Undried nuts from field huller. Stored 1 mo.	Test No. 5 Fresh material from factory disc huller
Meal			
(1) Wt., lbs.	303.0	312.0	258.0
(2) % Shells plus debris	29.5	34.4	19.8
(3) Ratio wt. shells to wt. kernels, %	47.0	60.0	28.0
(4) % Moisture	8.1	8.0	8.5
(5) % Oil	41.6	38.4	47.8
Expeller Cake			
(6) Wt., lbs.	167.5	174.3	126.2
(7) % Moisture	5.2	4.8	6.5
(8) % Oil	3.1	2.9	8.9
(9) Wt. oil, lbs.	5.2	5.1	11.2
Crude Oil			
(10) Wt., lbs.	119.7	114.8	119.1
(11) % Solids	3.8	3.4	5.1
(12) % Moisture	.3	.2	.6
(13) Wt. pure oil, lbs.	114.8	110.7	112.3
Filtered Oil			
(14) Ref. index at 25°C.	1.5184	1.5179	1.5183
(15) Acid value	1.6	1.7	4.2
(16) Recovery $\frac{(13)}{(9) \text{ plus } (13)} \times 100$	95.7	95.6	90.9
(17) Lbs. water evaporated	15.4	23.0	13.1

factory huller were averaged, as were those for five tests on the nuts from the field huller. These averages are shown in Table IV along with the data on the one test on hand-shelled kernels.

The recovery is calculated as the percentage of oil expelled based on the total oil in the meal, and it should be understood that not all the oil recovered is available as commercial oil unless an efficient solvent-extraction process is used on foots collected in the filter presses.

No significant difference in recovery was found for the field hulled nuts tested when fresh and after one month's and two months' storage, nor was there any significant difference between the results on field-hulled nuts which had been artificially dried and those which had not been artificially dried.

An examination of the data shows that the weight of oil obtained per hour from the nuts from the field huller (33% shell) was about the same as that from the material from the disc huller (24% shell), but that the weight of expeller cake obtained from a given amount of meal was greater for the nuts from the field huller. A lower percentage of oil, however, was left in the cake from the field hulled nuts, so that the amount of oil lost per hour was correspondingly lower and the recovery correspondingly higher, than for the material hulled at the mill in a disc huller. The recovery in the case of the hand-shelled nuts (entirely free of shell) was very low, although in the one test more oil was obtained per hour of expeller operation.

TABLE III

Expeller Tests May 28-29, 1945
(Each test ran for one hour)

	Test No. 6 Fresh material from factory disc huller	Test No. 7 Dried nuts from field huller. Stored 2 mos.	Test No. 8 Undried nuts from field huller. Stored 2 mos.
Meal			
(1) Wt., lbs.	267.0	326.0	338.0
(2) % Shells plus debris	21.0	31.8	31.1
(3) Ratio, wt. shells to wt. kernels, %	28.0	52.0	51.0
(4) % Moisture	7.9	7.6	8.0
(5) % Oil	47.4	40.4	40.6
Expeller Cake			
(6) Wt., lbs.	142.0	185.8	192.4
(7) % Moisture	6.3	4.6	4.6
(8) % Oil	5.9	4.1	3.8
(9) Wt. oil, lbs.	8.3	7.6	7.3
Crude Oil			
(10) Wt., lbs.	118.3	128.4	131.4
(11) % Solids	3.8	3.1	3.0
(12) % Moisture	.5	.4	.3
(13) Wt. pure oil, lbs.	113.0	124.0	127.0
Filtered Oil			
(14) Ref. index at 25°C.	1.5176	1.5184	1.5185
(15) Acid value	3.6	1.2	1.7
(16) Recovery $\frac{(13)}{(9) \text{ plus } (13)} \times 100$	93.2	94.2	94.5
(17) Lbs. water evaporated	7.0	12.0	14.0

These tests indicate that with the mill used in these investigations meal containing all the shell (or 33%) expels satisfactorily and even somewhat better than meal with lower proportions of shell. But it is not safe to conclude that in general meal with a high shell content expels better than meal with a low shell content. It is possible that an expeller of different design could be adjusted to give just as high recovery on meal of low shell content as is obtained on meal of high shell content with the design of mill and the setting used in these tests.

TABLE IV

Effect of Different Proportions of Shell on Expelling
(Data are for one hour's operation of expeller)

	Nuts from field huller. Average	Material from factory disc huller. Average	Hand-shelled kernels. Test No. 10
Meal			
(1) Wt., lbs.	310.0	252.0	295.0
(2) % Shells plus debris	32.9	24.4	0.0
(3) Ratio, wt. shells to wt. kernels, %	56.0	37.0	0.0
(4) % Moisture	8.6	9.6	4.9
(5) % Oil	39.0	44.0	60.0
Expeller Cake			
(6) Wt., lbs.	174.0	129.0	156.0
(7) % Moisture	5.3	6.8	5.5
(8) Oil	3.7	7.0	18.4
(9) Wt. oil, lbs.	6.5	9.0	28.7
Crude Oil			
(10) Wt., lbs.	119.0	110.0	138.0
(11) % Solids	3.1	4.1	3.4
(12) % Moisture	.3	.5	.5
(13) Wt. pure oil, lbs.	115.0	105.0	133.0
(16) Recovery	94.6	92.1	82.0

In this connection it should be noted that more electric power was required to operate the expeller, and the cake was expelled at a higher temperature, when meal high in shell content was being expelled.

As for the effects of storage on nuts on which practically all the shells were left intact, observations showed that the oil of such nuts suffered no measurable deterioration during a storage period of two months. The quality of the oil remained of the highest grade.

Summary and Conclusions

Expeller tests were made on ground tung nuts containing all of the shell (33%) at the time of hulling and after the nuts had been in storage for one and two months. Comparative tests were also made on material containing about 24% shell which had passed through the disc huller in regular mill operation. One test was made on hand-shelled kernels which were entirely free of shell.

It was found that meal containing all of the shell not only processed satisfactorily, but the recovery of oil from such material was somewhat higher than from material containing about two-thirds of the shell. The amount of oil expelled per hour was about the same in both cases. The kernels completely cleaned of shell expelled very inefficiently. In general, therefore, it seems that, with the particular type

of expeller used, a considerable amount of shell in the meal is essential for efficient expelling.

Bags of nuts with hulls removed but with the shells intact showed no deterioration after two months' storage in a well-ventilated shed.

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Analysis of the Fruit of the Chinese Tallow Tree in Texas*

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THE Chinese tallow tree, Sapium sebiferum, of the Euphorbiaceae family, was introduced into Texas about 1910 by Edward Teas, although by 1848 many of the trees were growing in places in Florida, Louisiana, and South Carolina (6). The tree thrives on various types of soils but requires a somewhat semi-tropical climate. Experience has shown, for example, that in and about Houston they thrive whereas many other trees planted there fail to establish themselves satisfactorily.

Sapium sebiferum is a deciduous tree that attains a height of 40 feet or more. The tree branches freely, and the branches have a tendency to be pendant. The leaves are alternate and have slender petioles. The leaves are dark green on the upper surface and a lighter green below. In the fall the leaves are brilliantly colored, usually red.

The small flowers are 4-6 mm. long and are without petals and are unisexual. The male flowers are produced in groups of threes throughout the flexuous spike-like inflorescence. The female flowers are solitary and are usually found in the lower portion of the inflorescence.

The fruit is a 3-lobed capsule and is about 15 mm. in diameter. It is somewhat fleshy when green, but dry when ripe. When the capsule dehisces, the trees are defoliating or are in the process of losing their leaves. There is one large, white seed in each cavity of the capsule. The mature seed occupies practically all of the space in the cavity. The seed adheres to the placenta long after the capsule has opened.

The seed is small and covered with a white aril-like coating. When covered with the wax it is somewhat triangular, convex on the outer face, and flattened on the two inner faces. When the wax is removed, the seed is found to be orbicular in outline, but truncate on the micropylar end. It is somewhat flattened. The testa is brown and very hard. There is no caruncle present. In the mature seed the nucellus is papery and the endosperm abundant. The small embryo occupies the central axis of the seed.

Since the tallow tree thrives in parts of Texas, these investigations were carried out further to characterize the fruit and products obtained from it. The methods of the Association of Official Agricultural Chemists were employed in the analyses.

The composition of the seed and three of its parts are reported in Table I.

TABLE I.

	Whole seed	Extracted meats	Extracted hulls	Fiber
Moisture and volatile	4.58	7.62	7.95	....
Ash	1.74	6.78	2.79	7.86
Protein (N × 6.25)	11.27	76.43	2.78	5.22
Crude fiber	....	4.90	....	31.98
N.f.e. (by difference)	....	4.27	....	54.94
Insoluble SiO_2	....	.045	....	....
Soluble SiO_2	....	.020	....	....
Total SiO_2	....	.065	1.21	....
Potassium	....	.943	.016	....
Calcium	....	.27	.43	....
Magnesium	....	.875	1.06	....
Iron	....	.032	.011	....
Phosphorus	....	1.60	.073	....
Nitrogen	1.75	12.23	.44	.84
Tallow and oil (ether extract)	45.42	....	....	....
Hull (fiber, shell, tallow)	68.52	....	....	....
Kernel (meat, oil)	31.48	....	....	....
Shell and kernel	67.97	....	....	....
Seed-coat (fiber, tallow)	32.03	....	....	....

The following data were also obtained: tallow in seed-coat 74.75%, fiber in seed-coat 25.25%, tallow in hull 34.94%, oil in the kernel 64.10%. The percentage composition calculated from these data: oil 20.3, tallow 23.9, meat 11.3, fiber 8.1, shell 36.4.

A number of investigations have been reported in the literature on the characteristics of the oil and tallow and the fatty acids obtained from both the oil and tallow. The two most significant of these for the oil are those by Jamieson (3) and by Jamieson and McKinney (5). The most significant results on the tallow are reported by Jamieson (4) and by Hilditch and Priestman (2). There is little agreement among the data from other investigators. This is due to the difficulties encountered in obtaining samples of one component that are uncontaminated by the other.

For experimental purposes uncontaminated samples of each may be obtained by cutting the individual seed and picking out the kernel. The tallow and oil can then be obtained without contamination by extracting these two fractions. Oil and tallow samples numbered four were obtained by this method.

The oil and tallow are obtained in China by suspending the seed in water and heating this mixture

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