Feature Article

Mongana Basics: Part 20 – Processing of Nut**

N Ravi Menon*

GENERAL

The Cake

The extraction of oil, regardless of the process used, leaves a cake consisting of nuts and fibre. The latter is, in fact, composed of fibrous filaments and cellular debris. The composition of the cake varies with the extraction process and the type of fruit from which it is derived.

It has been mentioned in Chapter 3 of *Mongana Report* (1953) that the cake composition varies over very wide limits from a ratio of nuts to fibre of 5 to 1 for the Congo type *dura* fruit, 1 to 1 for *tenera* fruit.

In addition to variations in the composition of the cake inherent in the fruit origin, important differences in the analysis and the morphology of the fibre are observed depending on the extraction process. Moreover, the type of fruit affects the size distribution of nuts.

The analysis of the fibre shows that the oil content on dry basis can reach 30% or be as low as 3% to 4%, moisture content can range between 35% to 55% and that, in addition, the size of the fibrous filaments and the proportion of cellular debris in the fibre can vary widely.

For these reasons, a large number of variables or parameters have to the considered in the study of the processing of nuts.

In this article, we shall examine the following fundamental operations:

- separation of fibre and nuts;
- nut cracking;
- separation of kernels from the cracked mixture; and
- kernel drying.

Besides these fundamental operations, a number of auxiliary treatments are performed. Their objective is to make the operation easier or to improve upon it.

Before going into the study of this fundamental operation, let us examine the effect on the cake composition of the extraction process and the type of fruit.

EFFECT OF THE EXTRACTION PROCESS

Wet Extraction Process

- The fibre does not contain large amount of cellular debris. The ratio of nuts to fibre is high.
- The fibre has high water content and relatively low oil content.

* *Malaysian Palm Oil Board, P. O. Box 10620, 50720 Kuala Lumpur, Malaysia.*

** *Continued from p. 33 of* Palm Oil Engineering Bulletin Issue No. 93.

Centrifugal Extraction Process

- The fibre contains a high proportion of cellular debris.
- The ratio of nut to fibre is normal.
- The fibrous filaments are long.

The Discontinuous Press Extraction Process

- The fibre contains less cellular debris than that derived from the centrifugal extraction process, more, however, than that resulting from wet extraction.
- The ratio of nuts to fibre is higher than that pertaining to centrifugal extraction.
- The fibre is drier than that of centrifuges and the oil content is lower. The fibrous filaments are long.

Continuous Press Extraction Process

- The fibre has a low cellular debris content.
- The fibre is dry and has a low oil content.
- The ratio of nuts to fibre is higher than that of centrifugal extraction.
- The fibrous filaments are shredded.

EFFECT OF THE TYPE OF FRUIT

***Dura* (natural palm grove)**

- High ratio of nuts to fibre.
- Short fibrous strands generally with high oil content.
- Large size nuts with thick shell.
- Numerous multi kernel nuts.

Tenera

- Low ratio of nuts to fibre.
- Long fibrous strands generally with lower oil content.
- Small size nuts with thin shell and a tuft at one end.
- Multi kernel nuts seldom encountered.
- Loose fruit: very low impurities content, therefore high nuts to fibre ratio.
- Bunch: high proportion of trash and impurities, therefore low ration of nuts to fibre.

It is of interest to provide data for some of the factors listed above.

The Average Length of Fibres

Tenera fruits have longer fibre. *Figure 1* shows a size distribution curve for the two types of fruit.

The Fibrous Matter Content of the Fibre

In the laboratory, dry, oil extracted pulp is found to contain a proportion of fibrous matter raging from 24% to 30%. The accurate determination is rather difficult. After a number of unsuccessful attempts to use gravity separation and fractionated dissolution (nitric acid, sodium hydroxide at Schweitzer reagent), a method of mechanical separation by screening under a flow of water was adopted.

In the course of industrial extraction of oil from the pulp, it may be observed that more cellular debris than fibrous matter pass over into the crude oil. *Table 1* gives an indication of the proportion of fibrous strands in the extracted fibre and shows that the proportion is higher after extraction, particularly in the case of the wet process. For wet extraction, after repeated and thorough washing, it is possible to reach as much as 90% of fibrous matter. Continuous pressing, when applied to fruit with a high proportion of *tenera*, also leads to high percentage of fibrous matter (approximately 70%). To a certain extent, the ability of the fibre to cake up depends on the ratio of fibrous matter to the fibre. Beyond 70% of fibrous material, that is less than 30% of cellular matters, the fibre no longer cakes up in the normal conditions of oil and moisture content.

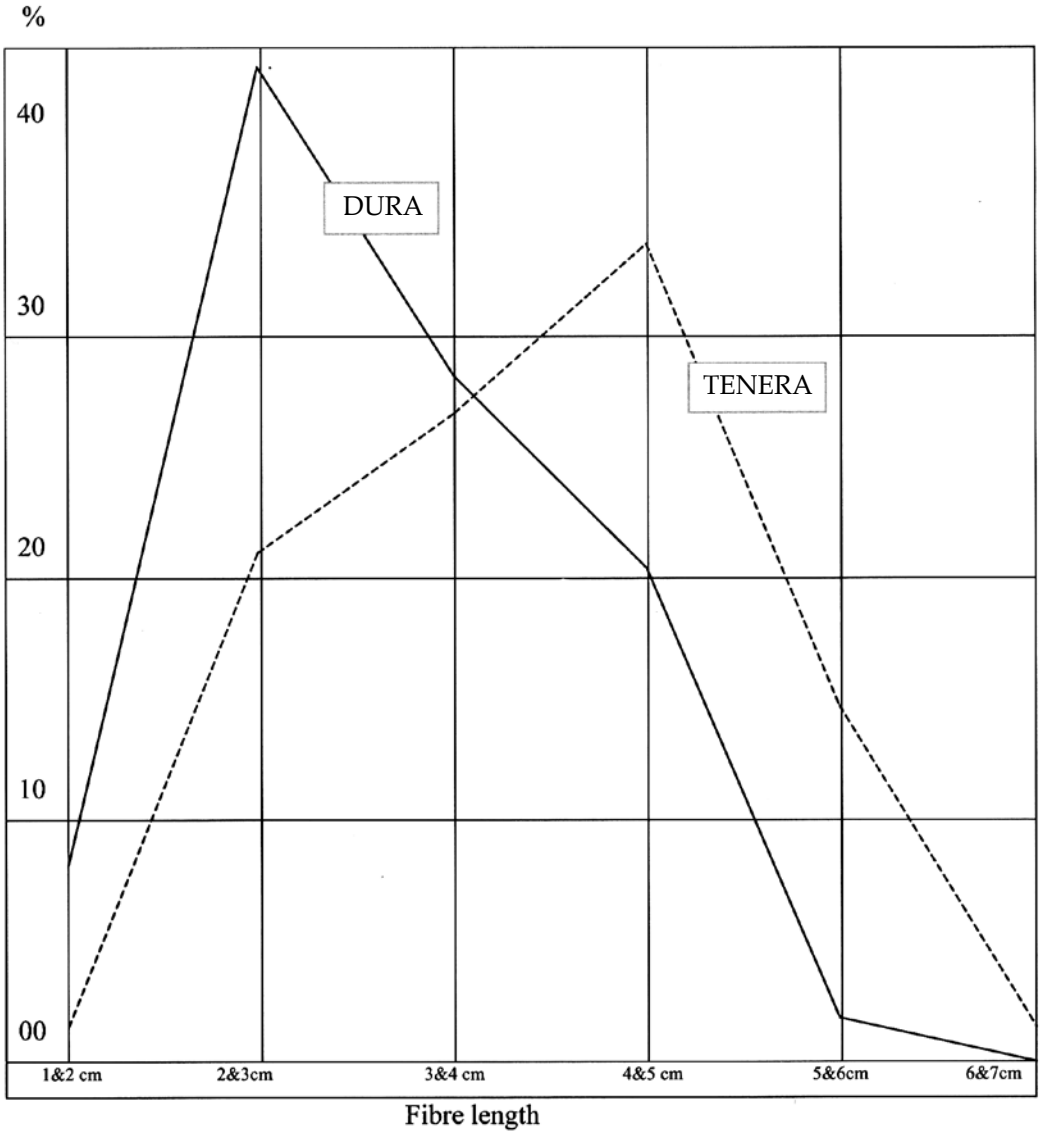

Figure 1. Proportion of fibrous strands of various length in dura *and* tenera *fruits.*

TABLE 1. RATIO OF FIBRE TO TOTAL CELLULOSIC MATERIAL IN THE CAKE IN RELATION TO THE TYPE OF FRUIT AND TO THE EXTRACTION PROCESS

Fruit	Wet process	Centrifugal	Manual hydraulic press	Continuous press
P.G.	76	49	54	51
TxT	-	57	61	69
DxP	-	57	66	72

Oil Content of Fibrous and Cellular Debris

The oil retention power of fibrous matter and cellular debris from a single sample of fibre is very different. The latter retains a significantly higher amount of oil. This occurrence may be explained by difference in the ratio of surface to volume for the two constituents. The ratio is higher in the case of cellular debris (absorption).

A few results are given in *Table 2*. They are the averages of a series of tests with high variability. The fact that the oil content of cellular debris is higher than that of fibrous matter is clearly apparent from the comparison between O/FM (oil on fibrous matter) and O/CD (oil on cellular debris).

Nut Grading

The grading of nuts is carried out on screens with round perforations. *Tables 3, 4* and *5* give the following information in relation to nut size as defined by the diameter.

- The number of nuts in each of the classes.
- The ration of the number of nuts in each class the total number of nuts subjected to grading.
- The weight of nuts in each of the classes.
- The ration of the weight of the nuts in each class to the total weight of nuts.
- The nut average weight in each class.
- The average thickness of the shell of the nuts in each class.
- The kernel average weight in each class.
- The ratio of kernel to nut in each class.
- The ratio of the weight of kernels in each class to the total weight of kernels.

In these grading test, the kernels are considered to be commercially dry (approximately 7% moisture content).

The examination of the grading results shows clearly the difference between the three types of nuts. A few typical results are given in *Table 6* (vide also *Figure 2*).

It is of interest to plot on a graph the thickness of shell against the diameter of nut for the three types of fruit under study (*Figure 3*).

For an identical diameter, the nuts of DxP bunches have a thinner shell than those of the *dura* nuts (palm grove) in the range of small diameters. The reverse is true for the area of large diameters. In other words, the increase in shell thickness follows more or less a linear relationship in the case of the P.G. nuts but the representative curve clearly presents on inflexion point in the case of DxP nuts. This inflexion point is situated approximately at 17 mm to 18 mm. The nuts of diameter comprised between 17 mm to 18 mm and 20 mm have an average shell thickness of 3.1 mm whereas those with a diameter slightly lower than 17 mm have an average shell thickness of 1.8 mm.

TABLE 2. EFFECT OF THE EXTRACTION PROCESS ON THE OIL CONTENT OF THE CONSTITUETNS OF FIBRE

Fruit	Wet process		Centrifugation		Manual hydraulic press		Continuous press	
	O/F	O/CD	O/F	O/CD	C/F	O/CD	O/F	O/CD
P.G.	14	22	20	33	16	21	16	25
TxT	-	-	15	23	15	26	6	20
DxP	-	2	31	40	18	31	5	17

Note: F = fibre. CD = cellular debris.

TABLE 3. SIZE FREQUENCY DISTRIBUTION OF NUTS FROM PALM GROVE FRUITS

Diameter of nuts (mm)	Number of nuts	% of the total number	Weight of nuts (g)	% of the total weight	Nut average weight	Shell thickness (mm)	Kernel average weight (g)	% of kernel to nut	% weight of kernel to total weight
10	1	0	0.7	0	0.7	-	-	-	-
11	4	0.2	5	0.1	1.0	1.2	0.34	27	0.04
12	10	0.4	16	0.1	1.6	1.3	0.47	29	0.17
13	17	0.7	25	0.1	1.5	1.6	0.52	35	0.31
14	38	1.5	80	0.4	2.1	1.7	0.53	25	0.71
15	48	1.9	105	0.6	2.2	1.4	0.64	29	1.10
16	135	5.2	420	2.3	3.1	1.9	0.71	23	3.40
17	139	5.4	505	2.7	3.6	2.3	0.78	22	4.00
18	170	6.6	765	4.1	4.5	2.4	0.90	20	5.45
19	242	9.4	1 200	6.5	5.0	2.9	0.92	18	7.70
20	511	19.7	3 100	16.9	6.1	3.5	1.00	16	17.70
22	541	21.0	4 180	22.6	7.7	3.9	1.14	15	22.40
24	368	14.3	3 480	18.8	9.5	4.1	1.24	13	16.1
26	260	10.1	3 030	16.4	11.6	4.6	-	13	14.00
28	50	1.0	710	3.80	14.2	4.6	2.35	13	3.20
30	30	1.2	485	2.6	15.1	4.7	-	13	2.25
32	12	0.5	225	1.2	16.7	4.5	-	-	1.04
34	3	0.1	68	0.4	22.0	-	-	-	0.32
36	2	0.1	55	0.3	27.5	-	-	-	0.25
Total or average	2 581	100	18 455	100	7.15	-	-	15.2	100

TABLE 4. SIZE FREQUENCY DISTRIBUTION OF NUTS FROM TxT FRUITS

Diameter of nuts (mm)	Number of nuts	% of the total number	Weight of nuts (g)	% of the total weight	Nut average weight	Shell thickness (mm)	Kernel average weight (g)	% of kernel to nut	% weight of kernel to total weight
<10	14	0.3	8	0.05	0.7	0.8	0.23	-	-
10	18	0.4	14	0.1	0.8	0.8	0.29	21	0.1
11	78	1.7	70	0.4	0.9	0.9	0.40	23	0.4
12	210	4.7	270	1.5	1.3	1.0	0.51	33	2.3
13	212	4.7	327	1.8	1.5	0.9	0.58	32	2.7
14	415	9.2	740	4.1	1.8	1.1	0.63	32	6.0
15	331	7.3	727	4.0	2.2	1.2	0.66	34	6.5
16	616	13.7	16.7	8.8	2.6	1.3	0.75	30	12.2
17	552	12.3	1 755	9.6	3.2	1.8	0.74	22	9.8
18	328	7.3	1 245	6.8	3.8	2.0	0.84	22	7.0
19	440	9.7	1 995	11.0	4.5	2.2	0.87	21	10.7
20	561	12.3	3 166	17.4	5.6	3.1	1.10	21	10.7
22	383	8.5	2 700	14.8	7.0	3.4	1.00	17	11.7
24	196	4.4	1 754	9.7	9.0	3.8	1.08	16	7.1
26	111	2.5	11 230	6.8	11.0	4.4	1.17	15	4.7
28	18	0.4	250	1.4	14.0	4.5	1.35	14	0.9
30	16	0.3	245	1.3	16.3	5.5	1.32	13	0.8
32	3	0.1	59	0.3	19.6	5.5	1.34	14	0.2
34	1	0	27	0.1	27.0	5.5	1.34	14	0.1
Total	4503	100	18 189	100	4.0	-	-	20.6	100

TABLE 5. SIZE FREQUENCY DISTRIBUTION OF NUTS FROM DxP FRUITS

Diameter of nuts (mm)	Number of nuts	% of the total number	Weight of nuts (g)	% of the total weight	Nut average weight	Shell thickness (mm)	Kernel average weight (g)	% of kernel to nut	% weight of kernel to total weight
< 10	25	1.0	12	0.2	0.5	0.9	0.19	36	0.2
11 – 12	142	5.7	206	3.4	1.4	1.0	0.30	43	4.8
12 – 13	697	28.0	879	14.4	1.3	1.3	0.46	40	19.0
14 – 15	709	28.5	1241	20.3	1.7	1.3	0.62	39	23.0
16 – 17	483	19.4	1253	20.5	2.6	1.8	0.68	34	9.9
18 – 19	191	7.7	761	12.5	4.0	3.1	0.62	24	9.9
20 – 21	119	4.8	657	10.8	5.5	3.7	0.76	28	4.2
22 – 23	74	3.0	532	8.7	7.2	4.2	0.78	15	2.1
24 – 25	30	1.2	346	5.7	11.5	4.5	0.69	11	1.0
26 – 27	15	0.6	171	2.8	11.4	4.5	0.77	13	0.1
28 – 29	2	0.1	24	0.4	12.1	4.4	-	-	0.0
30	1	0.0	19	0.3	19.0	8.5	-	-	
Total	2 488	100.0	6 101	100.0	2.5	-	-	31	100.0

TABLE 6. GRADING ANALYSIS OF THREE TYPES OF NUTS

	Palm grove	TxT	DxP
Nut average weight (g)	7.15	4.05	2.45
% ratio of kernel of nut	15.2	20.6	31.0
Percentage of nuts with shell less than 2 mm Thick: (% by weight)	3.6	30.3	58.8
(% by number)	9.9	54.3	82.6

TABLE 7. SIZE FREQUENCY DISTRIBUTION OF KERNELS FROM PALM GROVE NUTS

Nut diameter (mm)	Number of kernels of the following diameter													Total
	7	8	9	10	11	12	13	14	15	16	17	18	19	
11	1	3	0	-	-	-	-	-	-	-	-	-	-	4
12	1	0	8	1	0	-	-	-	-	-	-	-	-	10
13	0	4	4	6	1	0	-	-	-	-	-	-	-	15
14	3	6	4	11	10	0	-	-	-	-	-	-	-	34
15	0	8	7	17	11	11	0	-	-	-	-	-	-	54
16	1	2	8	49	27	27	10	1	0	-	-	-	-	120
17	2	3	9	21	31	31	21	6	1	0	-	-	-	120
18	0	5	5	25	33	33	17	4	0	0	-	-	-	128
19	0	0	4	19	73	73	49	20	11	2	0	-	-	215
20	1	7	2	10	89	89	86	85	33	15	15	4	0	383
22	0	3	10	28	58	58	67	127	72	31	7	0	0	428
24	0	3	2	18	52	52	48	101	62	57	14	3	0	389
26	-	0	1	9	24	24	39	54	34	65	26	13	1	282
28	-	-	0	0	2	2	1	1	4	4	0	0	1	16
30	-	-	0	1	6	6	2	3	6	13	8	5	2	49
32	-	-	1	4	4	4	7	5	10	5	1	2	2	45
34	-	-	0	2	2	2	2	1	0	6	1	1	2	22
36	-	-	0	0	0	0	2	2	0	0	0	0	0	4
Total	9	44	65	221	265	412	351	421	233	198	72	28	8	2 318 Kernels

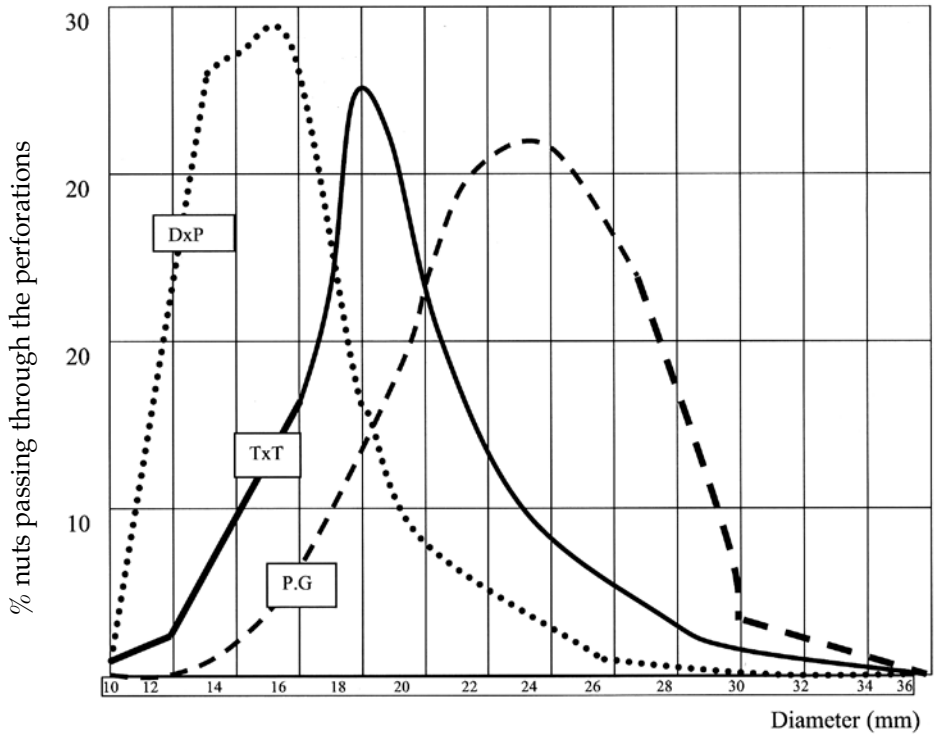

Figure 2. Size frequency diagram for DxP, TxT and P.G. nuts.

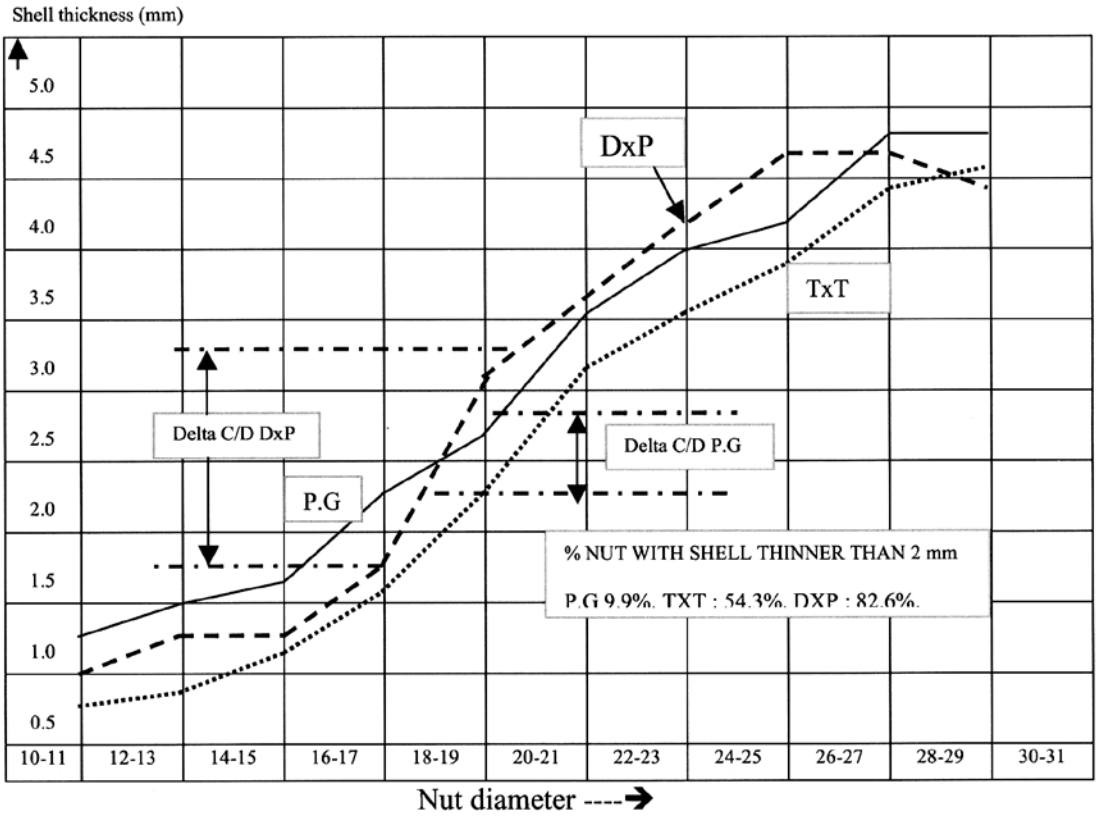

Figure 3. Thickness of shell in relation to the nut diameter.

TABLE 8. SIZE FREQUENCY DISTRIBUTION OF KERNELS FROM TxT NUTS

Nut diameter (mm)	Number of kernels of the following diameter															Total
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<10	2	4	0	1	0	-	-	-	-	-	-	-	-	-	-	7
10	0	5	4	1	0	-	-	-	-	-	-	-	-	-	-	10
11	2	3	33	4	1	0	-	-	-	-	-	-	-	-	-	43
12	0	5	63	95	29	2	0	-	-	-	-	-	-	-	-	194
13	0	0	22	50	101	13	1	0	-	-	-	-	-	-	-	187
14	1	9	32	46	176	109	9	3	0	-	-	-	-	-	-	385
15	0	4	18	30	75	118	49	1	1	1	0	-	-	-	-	297
16	0	5	21	67	94	178	226	41	1	1	0	-	-	-	-	634
17	0	2	2	50	94	116	168	69	16	0	0	-	-	-	-	517
18	0	3	14	22	68	73	63	58	31	0	0	-	-	-	-	332
19	0	2	7	12	62	136	124	69	48	17	2	0	-	-	-	479
20	0	0	13	22	45	90	189	109	78	30	26	1	0	-	-	603
22	0	4	13	16	30	48	98	84	100	45	17	1	0	-	-	456
24	0	0	5	6	11	30	31	32	60	38	43	9	1	0	-	266
26	0	0	3	8	17	26	17	16	13	13	35	11	1	0	-	160
28	0	0	0	0	2	4	5	1	1	3	4	5	1	0	-	26
30	0	0	0	0	4	1	1	2	3	4	3	4	2	0	1	25
32	0	0	0	0	0	0	3	1	2	2	1	2	0	1	-	9
Total	5	46	250	430	809	944	984	486	354	152	131	33	5	0	1	4 630

It should not be inferred however that an almost quantitative separation of *dura* and *tenera* nuts is possible by simple screening. The thicknesses given above are the average result of 20 to 50 measurements and the individual variations are large.

For the P.G. and TxT nuts, the separation into the two varieties is of no interest but in the case of DxP fruit, the separation has been investigated with a view to remove the shell from the cracked mixture by a pneumatic process. It has been observed that screening of DxP nuts through 15 mm perforations allows more than 99% of the nuts to pass through. By comparing various shapes of perforations, it has been noted that the retention on a screen with circular perforations of 15 mm diameter is about the same as that recorded with 14 mm square perforations. In oil mills, the screens used for nut grading have oblong perforations. In that case, the results of grading are very different. This is due of the fact that 86% of the nuts are flat and they therefore pass through oblong perforations using the small dimension which is equal to the diameter of circular perforations which do not allow the passage.

Kernel Grading

In addition to the grading of nuts, the grading of kernels obtained from the cracked mixture was also carried out. The size frequency diagram is shown in *Figure 4*.

As for nuts, a *Table 10* gives the percentage ratio of kernels of various diameters to the total number of kernels. It is to be noted that out of the 10 000 kernels subjected to screening for the preparation of the four tables given (*Tables 7, 8, 9* and 10), only one was found to be retained by a 20 mm perforation (circular). It has not been possible to carry out grading tests on nuts other than those originating from the Mongana area. If this were found to be a general features throughout the Congo, it would be worthy of interest and would be of practical usefulness since it would make it possible to sort out from kernels ready for packing the whole uncracked nut of diameter larger than 20 mm (case of small oil mills where the removal of uncracked nuts is often unsatisfactory).

TABLE 9. SIZE FREQUENCY DISTRIBUTION OF KERNELS FROM DxP NUTS

Nut diameter (mm)	Number of kernels of the following diameter														Total
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
<10	4	8	4	3	0	-	-	-	-	-	-	-	-	-	19
10	0	12	46	21	1	0	-	-	-	-	-	-	-	-	80
11	0	5	45	93	10	0	-	-	-	-	-	-	-	-	153
12	0	0	0	0	312	31	0	-	-	-	-	-	-	-	343
13	0	2	12	97	97	120	19	0	-	-	-	-	-	-	347
14	0	0	8	35	67	140	72	9	0	0	-	-	-	-	331
15	0	1	17	20	19	86	81	34	0	-	-	-	-	-	258
16	0	4	17	64	75	112	133	68	16	8	0	-	-	-	497
17	0	6	5	15	22	23	34	30	21	2	0	-	-	-	158
18	0	1	4	11	25	18	20	19	9	12	0	-	-	-	199
19	0	1	1	12	12	20	21	16	8	6	1	0	-	-	198
20	0	0	2	4	13	30	30	32	9	2	2	3	0	-	127
22	0	1	1	9	9	10	19	26	11	5	0	0	0	0	91
24	0	0	0	3	6	11	9	11	8	2	2	1	0	0	52
26	0	0	0	2	2	5	2	2	2	4	0	0	1	0	20
28	0	0	0	0	0	0	1	0	2	0	0	0	0	0	3
Total	4	41	162	389	670	606	441	247	86	41	5	3	1	0	2 696

TABLE 10. SIZE FREQUENCY DISTRIBUTION OF KERNELS COMPUTED AS PERCENTAGE OF THE TOTAL NUMBER OF KERNELS

	Kernel diameter																Total
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
P.G.	0	0	0.4	1.9	2.8	9.5	11.5	17.8	15.2	17.8	10.1	8.5	3.1	1.2	0.3	0	100
TxT	0	0.1	1.0	5.4	9.3	17.5	20.4	21.2	10.5	7.6	3.3	2.8	0.8	0.1	0	0	100
DxP	0.2	1.5	6.0	14.4	24.8	22.5	16.4	9.1	3.2	1.5	0.2	0.2	0.0	0	0	0	100

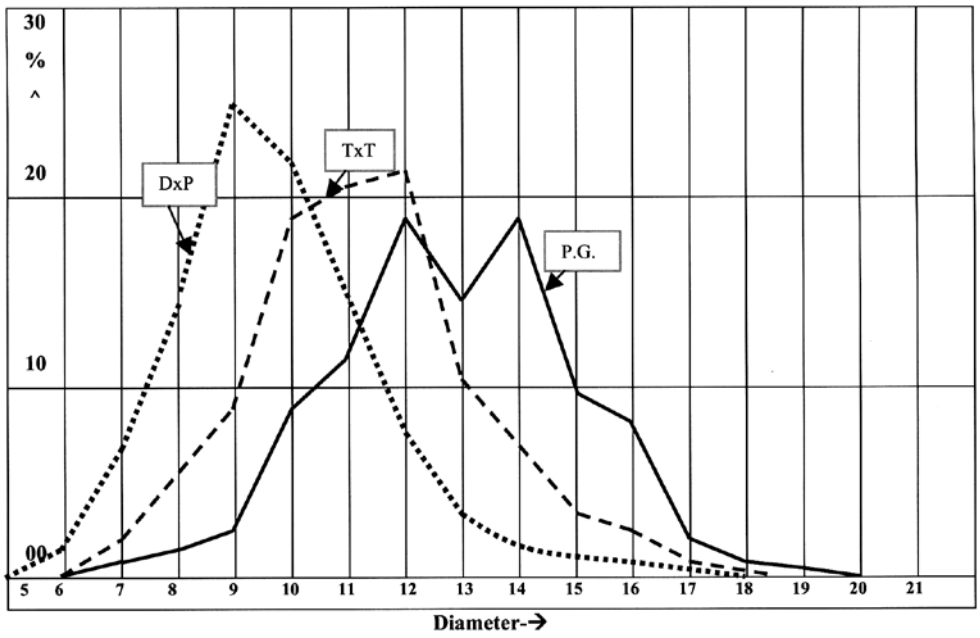

Figure 4. Size frequency diagram for kernel from D x P, T x T, and P.G. fruits.