EVALUATION OF MACADAMIA NUT VARIETIES FOR PROCESSING

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SUMMARY

Over 100 selections of Macadamia nut were evaluated in 1954 and 16 were regarded as promising for propagation. Further evaluation of 13 of the selections was made in 1955.

The main features required in nuts for processing are a high recovery of first-grade kernels, a spherical shape, large enough size to obviate undue labour costs for sorting and grading, a medium-thick shell, uniform pleasing colour, and good palatability.

The effects on quality of time of harvesting and method of harvesting were shown to be variable.

I. INTRODUCTION

Up to 1950, commercial orchards of Macadamia nut in Australia had been developed from seedling plantings following some degree of selection of parent trees. However, material of the two principal species, *Macadamia integrifolia* and *M. tetraphylla* (Smith 1956), found even in the best orchards was extremely variable in type, yield and quality.

With a view to establishing orchards of grafted trees of known quality and cropping characteristics, a Departmental survey of orchards was made in 1952 by A. A. Ross and J. McG. Wills (unpublished Departmental report 1952) and 64 selections of nuts were made and subjected to laboratory examination. This survey, and a similar one conducted by officers of the New South Wales Department of Agriculture, served as the basis of the further selection and evaluation for processing purposes of over 100 samples taken from an area extending from Maryborough in Queensland to the Lismore district in New South Wales. The original screening evaluation was made in 1954 and some of the most promising selections were evaluated again in 1955.

Since Ripperton and his associates (Ripperton, Moltzau, and Edwards 1938; Moltzau and Ripperton 1939) had reported that the quality of Macadamia nut varies throughout the season in Hawaii and that nuts should be harvested frequently, these aspects were examined in relation to Queensland selections in 1955.

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II. 1954 EVALUATION

(a) Methods

The nuts were harvested at what was considered to be the peak of the season, husked, and stored at room temperature for 4–5 weeks to allow them to partly dry. The moisture content of the kernels was then reduced to approximately 3 per cent. by placing them for 2–3 days at 140° in a forced-draught dehydrator with an air velocity of approximately 300 ft per min. Reduction to this extent allowed the kernels to be readily extracted from the shell either whole or in halves.

The following characteristics were evaluated for each selection in the manner described:—

(i) *Shape and Size of Nut.*—The shape was observed by eye and sizing was done on a commercial grader. Measurements were made on a representative sample comprising 10 per cent. of each selection. Diameter A (Tables 1 and 2) was measured from apex to base and diameter B at the centre of suture.

(ii) *Thickness of Shell.*—Shell thickness was measured at the base (C) and midway between the apex and the base (D).

(iii) *Kernel Diameter.*—The maximum kernel diameter was measured since this is a more accurate guide to average size than shell diameter, because shell thickness varies.

(iv) *Kernel Colour.*—Colour was noted visually.

(v) *Kernel Recovery.*—This is expressed as the percentage of the dry weight of the whole nuts represented by the weight of the kernels obtained. Kernels damaged by insects and mould were included in the weight.

(vi) *Quality of Kernel.*—This was assessed by the specific gravity method of Moltzau and Ripperton (1939). As blemishes due to insect and mould damage may be controlled by cultural and harvesting practices, kernels so affected were removed from the samples before grading for quality. The average wastage was about 15 per cent. of the kernels, but it was as high as 55 per cent. in some samples.

(vii) *Palatability.*—A panel of tasters reported on the palatability of roasted first grade kernels. The oil roasting technique recommended by Moltzau and Ripperton (1939) was adopted, highly refined coconut oil similar to that used in margarine manufacture being employed. *M. integrifolia* samples were roasted at 275°F and *M. tetraphylla* at 260°F. After roasting for 12–15 min, draining, cooling and salting, the kernels were packed in vacuum jars and stored for 4–6 weeks before being examined.

(b) Observations

The results of measured observations are given in Tables 1 and 2.

TABLE 1

SUMMARY OF QUEENSLAND MACADAMIA SELECTION EVALUATIONS, 1954 SEASON

Grower and District	Code No. of Tree	Diameter A (mm)	Diameter B (mm)	Thickness C (mm)	Thickness D (mm)	Maximum Kernel Diameter (mm)	Kernel Recovery (%)	Insect and Mould Damage (%)	1st Grade (by weight) (%)	1st Grade Kernel Recovery (%)	Comments	Point of Harvest
Taylor (Currumbin)	11	22·8	21·7	4·1	1·9	18·1	38·7	Not Est.	90·7	35·0	Many small nuts, shell too thin	Tree
,, ,, ,,	12	22·6	19·3	3·9	1·5	16·8	43·1	Not Est.	97·5	42·0	Many small nuts	Tree
,, ,, ,,	13	25·1	22·5	5·2	2·1	18·9	36·0	Not Est.	95·7	34·4	Pointed shell	Tree
,, ,, ,,	T0	22·3	21·2	3·9	1·8	18·1	43·9	Not Est.	87·0	38·2	Shell too thin, germinates readily	Tree
Thompson (Victoria Point) ..	X	24·7	23·0	4·6	1·9	20·7	34·6	Not Est.	81·3	28·1		Tree
,, ,, ,,	XII	27·0	25·2	5·9	2·9	21·5	32·6	Not Est.	100·0	32·6		Tree
Samson (Manly)	S	24·6	23·3	5·4	2·3	17·8	31·2	Not Est.	94·3	30·7		Ground
Hill (Gilston)	H1	27·8	23·3	5·5	2·3	20·4	37·1	Not Est.	100·0	37·1	Pointed shell	Tree
,, ,, ,,	H2*	24·6	23·9	6·4	2·8	20·2	30·6	Not Est.	93·8	28·6	Fairly thick shell	Tree
,, ,, ,,	H3	27·0	25·3	5·2	1·9	21·7	38·1	Not Est.	99·3	37·7	Shell too thin, germinates easily	Tree
,, ,, ,,	H4	25·6	23·3	5·1	1·9	19·1	50·0	Not Est.	94·0	47·0	Shell too thin, germinates easily on tree	Tree
Powell (Gilston)	P1	21·6	22·7	3·3	1·4	19·7	40·1	Not Est.	100·0	40·1	Sample stale on arrival ..	Ground
Ardrey (Flaxton)	J4	23·8	22·0	3·7	1·6	16·0	39·0	30·0	10·2	3·9	Wind blown Kernels crack to small pieces	Ground
,, ,, ,,	J6	22·9	21·2	3·4	1·1	16·6	40·0	8·9	6·8	2·7	Wind blown Kernels crack to small pieces	Ground
Howard (Maleny)	L1	29·6	27·5	5·1	1·9	22·1	33·5	0·0	50·0	16·7	Very cleanly cracked	Ground
,, ,, ,,	L2	28·8	27·5	5·7	2·5	22·2	32·5	1·5	62·1	20·2	Very cleanly cracked	Ground
,, ,, ,,	L4	28·2	26·8	5·0	1·9	23·0	38·4	0·0	48·5	18·6	Verg cleanly cracked	Ground
,, ,, ,,	L5	28·9	27·1	5·8	2·5	22·0	30·9	4·9	96·3	29·8	Very cleanly cracked	Tree
Hampson (8 Mile Plains) ..	G4	23·3	22·8	3·2	1·2	19·0	44·8	38·5	65·0	29·1	Severely damages by bugs, shell thin	Tree
,, ,, ,,	G5	23·5	24·3	3·7	1·6	19·8	42·2	55·1	42·2	23·5	Many immature and of low quality	Tree

* integrifolia types

TABLE 1—*continued*

SUMMARY OF QUEENSLAND MACADAMIA SELECTION EVALUATIONS, 1954 SEASON—*continued*

Grower and District	Code No. of Tree	Diameter A (mm)	Diameter B (mm)	Thickness C (mm)	Thickness D (mm)	Maximum Kernel Diameter (mm)	Kernel Recovery (%)	Insect and Mould Damage (%)	1st Grade (by weight) (%)	1st Grade Kernel Recovery (%)	Comments	Point of Harvest
Sewell (Tamborine)	N1	24·5	23·5	4·7	2·0	19·0	38·5	4·0	43·6	16·8		Ground
,, ,, ,,	N2	23·9	22·0	4·3	1·7	18·0	36·2	8·6	65·3	23·6		Ground
,, ,, ,,	N3	25·7	24·8	4·6	2·0	20·9	38·5	4·8	89·5	34·4	Clean crack, very even coloured kernel	Ground
,, ,, ,,	N4	27·0	24·8	4·5	1·9	19·3	36·5	31·6	47·0	17·3		Ground
,, ,, ,,	N5	25·5	24·3	4·3	2·2	18·6	36·4	17·8	42·8	15·6		Ground
,, ,, ,,	N6	23·2	21·7	5·1	2·0	16·4	33·0	8·7	65·5	21·6	Very small nut	Ground
,, ,, ,,	N7	23·4	23·4	3·6	1·5	19·8	46·0	13·3	77·0	25·4		Ground
	N8	22·6	21·6	4·2	1·7	17·4	35·7	5·0	67·8	24·2		Ground
Rickards (Maryborough) ..	B5*	24·4	23·5	3·7	2·2	18·7	34·3	3·3	88·0	30·2	Even coloured kernel, even shell	Ground
,, ,, ,,	B6*	23·6	23·5	3·7	1·9	18·1	36·5	7·5	92·8	33·9	Fairly even coloured kernel ..	Tree
,, ,, ,,	B10*	26·5	25·8	6·6	2·9	20·8	29·8	2·2	90·5	27·0	Faily even coloured kernel, cracks well	Ground
,, ,, ,,	B20	28·9	26·8	7·1	3·2	20·3	25·0	2·9	90·2	22·6	Very even coloured kernel, cracks well	Tree
,, ,, ,,	B22*	27·6	26·0	6·3	2·8	19·6	25·4	0·7	88·8	22·6	Cracks well	Tree
Hurwood (Maleny)	M1	26·4	25·2	4·0	1·6	20·0	38·8	19·9	27·7	10·7		
,, ,, ,,	M2	25·5	24·9	5·0	1·2	20·9	40·2	2·9	59·0	3·7		Tree
,, ,, ,,	M3	25·2	24·5	4·4	1·9	19·9	34·0	2·9	31·8	10·8		Ground
Greber (Gympie)	D1	22·7	21·8	2·9	1·1	20·1	43·4	0·0	91·0	39·4	Thin shell, tending to germinate	Tree and ground
,, ,, ,,	D4	27·9	25·0	5·1	2·5	19·6	31·7	7·7	88·6	28·1	Tough shell	Ground
	D8	24·8	22·8	4·4	1·9	19·8	40·7	11·8	71·8	29·2	Cracks to small pieces ..	Ground
,, ,, ,,	D9	24·0	22·8	4·4	1·7	19·9	39·2	12·3	45·8	18·0	Cracks to small pieces ..	Ground

* integrifolia types

TABLE 2

SUMMARY OF N.S.W. MACADAMIA SELECTION EVALUATIONS, 1954 SEASON

Grower and District	Code No. of Tree	Diameter A (mm)	Diameter B (mm)	Thickness C (mm)	Thickness D (mm)	Maximum Kernel Diameter (mm)	Kernel Recovery (%)	Insect and Mould Damage (%)	1st Grade (by weight) (%)	1st Grade Kernel Recovery (%)	Comments	Point of Harvest
	1	..	..	..	..	..	34·9	15·7	78·2	27·3	Some immature	Ground
	2	27·9	25·1	5·1	2·0	20·7	39·6	11·0	72·4	28·6	Pointed shell, germinating readily	Ground
	7	23·5	21·9	4·2	1·5	19·0	37·4	33·0	83·3	31·1		Ground
	8	..	..	..	..	..	29·1	10·4	99·0	28·8		Ground
	9	..	..	..	..	..	28·3	19·5	86·5	24·5		Ground
	10	21·3	20·4	3·5	1·2	16·7	40·5	18·6	61·0	24·7	Some immature	Ground
	11	22·9	21·9	4·7	1·3	17·4	35·6	36·8	26·9	10·0	Many immature	Ground
	12	23·5	21·6	4·1	1·6	17·2	34·3	48·0	93·5	32·0		Ground
	13	22·2	21·8	3·6	1·1	17·5	40·7	8·9	89·3	36·3	Small	Ground
	14	..	..	..	..	..	32·8	5·2	87·3	28·6		Ground
	15	23·3	21·8	4·4	1·5	17·6	35·2	19·5	90·6	30·7		Ground
	16	21·9	21·7	3·3	1·4	17·5	39·0	47·0	87·5	34·1	Some immature	Ground
	23	..	..	..	..	..	29·4	24·0	77·5	22·8		Ground
	24	26·0	26·2	5·4	2·4	19·8	38·7	42·5	46·2	17·7		Ground
	27	24·9	22·6	4·9	2·0	18·2	30·5	39·0	97·0	29·6		Ground
	31	21·6	21·0	4·2	1·7	16·7	40·5	10·5	99·0	40·0	Fairly small	Ground
	33	..	..	..	..	..	27·8	36·0	35·3	9·8	Many immature	Group
	34	25·5	23·2	4·3	2·0	18·9	37·8	26·0	49·4	18·6		Ground
	35	..	..	..	..	..	43·0	44·0	74·3	31·9	Shell too thin, many germinating	Ground
	36	25·2	25·2	4·7	1·8	18·5	36·0	32·0	41·2	14·6	Many immature, spherical and regular	Ground
	37	25·3	23·6	4·8	1·7	18·8	35·5	32·0	71·5	25·4	Some immature	Ground
	38	23·9	21·4	3·7	1·5	17·0	38·2	28·0	46·1	17·3	Many immature	Ground
	39	22·2	20·0	3·9	1·0	16·3	47·3	7·0	87·0	41·0	Very small, thin-shelled ..	Ground
	42	..	..	..	..	..	33·0	18·0	47·6	15·7	Some immature	Ground
	43	25·5	22·9	4·6	1·5	17·0	35·0	3·1	41·9	14 6	Some immature	Ground
	44	..	..	..	..	..	33·3	29·0	84·5	28·2		Ground
	45	22·8	20·8	3·4	1·4	16·3	36·1	16·0	34·6	12·5		Ground
	46	22·3	22·1	4·0	1·4	16·7	34·4	25·0	93·4	32·1		Ground
	48	..	..	..	..	..	28·0	21·0	37·7	10·5	Many immature	Ground
	49	25·8	23·7	4·1	1·9	18·8	39·2	19·0	76·8	30·0		Ground
	51	27·8	24·8	5·1	1·9	20·6	37·2	3·0	90·0	33·5	Tapered nut	Ground
	52	24·8	23·0	4·0	1·6	18·1	39·1	25·0	58·3	22·6	Some immature	Ground

TABLE 2—*continued*

SUMMARY OF N.S.W. MACADAMIA SELECTION EVALUATIONS, 1954 SEASON—*continued*

Grower and District	Code No. of Tree	Diameter A (mm)	Diameter B (mm)	Thickness C (mm)	Thickness D (mm)	Maximum Kernel Diameter (mm)	Kernel Recovery (%)	Insect and Mould Damage (%)	1st Grade (by weight) (%)	1st Grade Kernel Recovery (%)	Comments	Point of Harvest
Johnson (Carool)	53	25·0	25·0	3·5	1·4	20·9	43·0	1·0	85·2	36·7	Good shell	Ground
" " "	54	29·0	26·4	5·3	1·9	22·2	37·8	4·0	95·5	36·0	Pointed shell	Ground
	55	24·4	22·5	4·1	1·6	18·5	38·2	6·0	69·8	26·6	Regular shell	Ground
	56	25·2	22·6	4·2	1·5	18·2	39·8	5·0	60·5	24·2	Pointed nut	Ground
	57	..	..	..	..	..	32·5	12·0	80·0	26·0		Ground
	58	..	..	..	..	..	29·2	7·0	41·0	12·0	Some immature	Ground
	59	24·8	21·8	4·8	1·1	18·2	41·6	1·0	96·0	40·2	Even thin shell	Ground
	60	23·5	21·7	3·8	1·1	20·0	38·1	13·0	83·6	31·8	Too thin	Ground
Ellis (Highfield)	61	25·4	24·3	4·5	2·0	20·3	40·2	23·0	90·8	36·5	Regular thickness, good size	Ground
	63	23·1	22·4	4·3	2·0	16·0	39·6	9·0	42·0	16·7	Some immature	Ground
	64	23·8	23·5	3·9	1·8	18·2	38·2	5·0	98·0	37·4		Ground
	80	23·7	22·7	4·4	2·1	19·0	34·0	8·0	94·6	32·2		Ground
	81	23·4	22·6	4·7	1·7	18·3	34·8	4·0	91·0	31·7	Pale-coloured Kernel ..	Ground
	82	..	..	..	..	..	33·3	7·0	80·8	26·9		Ground
	83	22·2	21·2	4·5	2·0	17·2	39·4	8·0	86·0	33·9		Ground
	85	24·7	22·5	4·1	1·4	19·0	39·4	4·0	69·8	27·5	Pointed shell, some immature	Ground
	89	..	..	..	..	..	33·8	16·0	54·1	18·3	Many immature	Ground
	90	21·5	20·6	4·4	1·9	17·1	36·3	2·0	97·6	35·1	Some fairly small	Ground
	91	24·1	22·9	4·2	1·6	19·9	44·6	3·0	100·0	44·6		Ground
	92	25·9	24·0	5·0	1·9	21·0	36·8	7·0	74·5	27·4	Grade 2 and 3 immature ..	Ground
	93	23·7	22·2	4·5	1·6	18·9	37·8	9·0	80·0	30·2	Grade 2 and 3 immature ..	Ground
A. R. Nelson (Stokers Siding)	..	26·5	24·6	5·0	2·0	21·4	39·1	2·0	92·0	36·0		Ground

(i) *Shape and Size of Nut.*—It was found that oval and pointed nuts (typical examples are shown in Figure 1) did not grade true to size and frequently blocked the jaws of the cracking plant. As efficient mechanical handling is an essential feature of Macadamia nut processing, nuts should be as close as possible to spherical in shape.

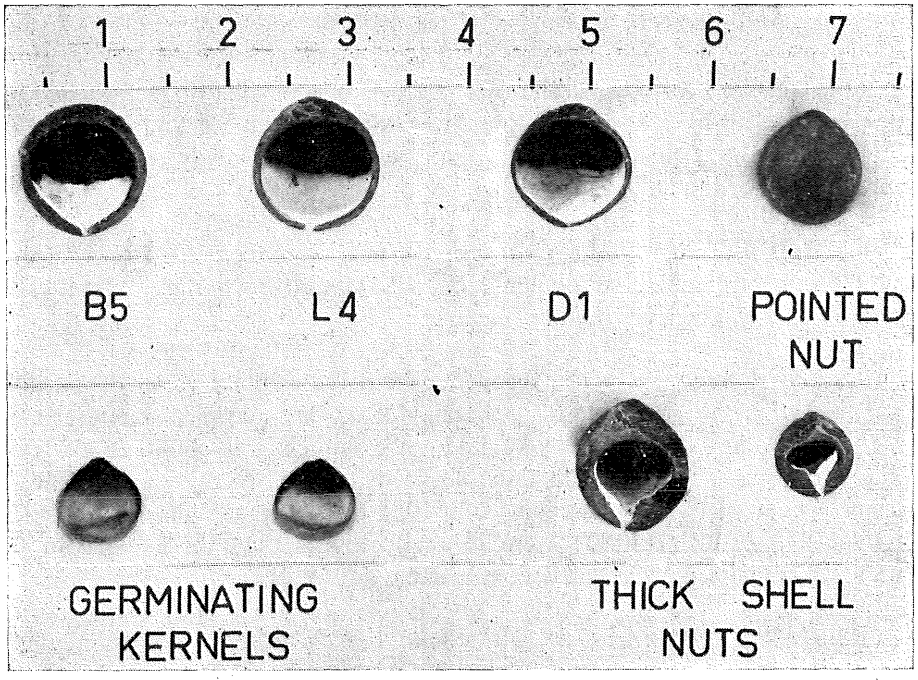

Fig. 1.—Samples of various nuts.

The size of the nut is also important. Labour costs for sorting and grading after cracking were found to be excessive for nuts passing a $\frac{3}{4}$ in. screen. On the other hand, the kernels from large nuts not only caused cooking difficulties due to slow penetration of heat to the centre but also yielded too few "kernels to the packet" for satisfactory retail marketing in transparent bags.

(ii) *Thickness of Shell.*—Nuts with a thick or medium-thick shell shattered very easily with little damage to the kernels. Thin-shelled nuts were not so brittle and the kernel was easily damaged during cracking operations.

The type of nut in which the shell was extremely thin at the apical end was readily attacked by ants. Such nuts frequently germinated while still on the tree and in some cases while still in the green pericarp. Germinating kernels were easily identified after dehydration by a yellow or brown stripe at the point of growth (Figure 1). Nuts of this type were frequently attacked by a fruit-spotting bug (*Amblypelta lutescens* Dist.), which was identified by Brimblecombe (1948) as the cause of serious damage to the kernels. It is interesting to note

that Selection H3, which falls within this class, is proving successful in California (Schroeder and Frolich 1960). It is understood that this selection matures during the dry season in California and germination is therefore not a problem.

Selection D1, a nut with a thin shell of even thickness (Figure 1) was regarded as the ideal type for table purposes.

(iii) *Kernel Diameter.*—Kernels of 18–22 mm dia were considered to be the most satisfactory for commercial use. Kernels of a smaller diameter tended to shatter readily during cracking as there was too small an air gap left between the kernel and the shell after drying. Small kernels, as already stated, increase labour costs in sorting and grading.

(iv) *Kernel Colour.—M. integrifolia* kernels were consistently of a light even colour before and after cooking, but *M. tetraphylla* kernels were usually variable in colour, particularly after roasting.

(v) *Kernel Recovery.*—The recoveries from the samples varied from 25 to 50 per cent., the average being 37 per cent. for *M. tetraphylla* and 30 per cent. for *M. integrifolia.* The recovery of first-grade kernels was about 26 per cent. for the two types. Samples with thick shells had kernel recoveries of about 16 per cent. The kernel recoveries reported in 1952 by Ross and Wills and quoted by Schroeder and Frolich (1960) were generally higher than those given in this paper, as no dehydration was carried out by Ross and Wills.

(vi) *Quality of Kernel.—M. integrifolia* kernels were of consistently high quality, all samples being over 88 per cent. first grade and the average being 91 per cent. *M. tetraphylla* samples varied from 6·8 to 100 per cent. first grade, and the average was 70 per cent. These figures correspond with the findings of Moltzau and Ripperton (1939).

(vii) *Palatability.*—The palatability of most samples was rated very good, but opinions were divided as to the relative qualities of the sweet-flavoured, firm to hard-textured *M. tetraphylla* and the nutty-flavoured, tender and crisp-textured *M. integrifolia.* As a general rule, rancidity developed much earlier in *M. tetraphylla* than in *M. integrifolia.* This was considered to be due to the lesser heat treatment.

(viii) *Moisture Content.*—The moisture content was as high as 30 per cent. at harvest. The loss in weight during dehydration was a guide to the initial moisture content, which could not be determined accurately for ground-harvested nuts whose preharvest history was not known.

The fresh undried kernels of *M. tetraphylla* types often had a much higher moisture content than those of *M. integrifolia* types, they took longer to dry, and they often tended to have a shrivelled appearance.

(c) Selection

After eliminating samples with small kernel diameter, the kernel recovery and the percentage of first-grade kernels were taken as the principal measures of processing quality. The other factors discussed above were then taken into consideration in the final choice of eight selections.

Of the few *M. integrifolia* selections examined, B5 and B6 were considered to have outstanding qualities for processing, including a spherical shell of even thickness and a good recovery of first-grade kernels. The shell of B5 is shown in Figure 1. Both parent trees were fairly young and their potential cropping capacity was accordingly unknown. Selection H2, though not quite so good in shape and kernel recovery as B5 and B6, was known to yield consistently 300 lb of nuts per annum even after the age of 60 years.

Of the *M. tetraphylla* selections, N3 and N7 were of high standard, but little was known of the cropping characteristics of the trees, which were fairly young. N3 when roasted had a flavour best described as coconut.

Selections L1 and L4 (Figure 1) were fairly large and had good mechanical handling characteristics. However, in both cases the nuts tended to fall readily as they approached maturity, yielding a kernel which was high in moisture content and shrivelled on dehydration. The kernels also were invariably hard in texture and unacceptable to some tasters for this reason. L1 was known to yield up to 100 lb of nuts per annum and L4 about half this quantity. Since it was felt that the premature fall of nuts may have been due to abnormal weather, both of the varieties were retained as selections.

Selection G5, although variable in quality, was considered worth retaining for further investigation as its physical characteristics were generally good.

Five other Queensland varieties of *M. tetraphylla*—H1, H3, P1, G4 and L5—showed some promise and were considered worthy of further investigation.

Three selections—53, 61 and A. R. Nelson—were made from the New South Wales samples.

III. 1955 EVALUATION

(a) Methods

Samples of the eight top and five reserve selections of Queensland samples made in 1954, and two others, were harvested at the peak of their crop and dehydrated several days later. The loss in moisture was calculated and all samples stored at 40°F in plastic bags until all samples were assembled. The maximum kernel recovery obtainable from sound nuts was determined as described earlier. A larger sample taken direct from the crop without any selection was cracked by a processor and the commercial recovery determined. Germinating kernels, those attacked by insects and those sticking to the shell were separated and their percentage by weight calculated. Grading for quality was carried out as already described.

(b) Observations

The results of the observations are shown in Tables 3 and 4.

TABLE 3

PROPERTIES OF MACADAMIA NUT SELECTIONS DURING THE 1955 HARVESTING SEASON

Code No. of Tree	Method of Harvesting	Date of Harvest	Loss on Drying (%)	Kernel Recovery* (%)	1st Grade Kernels Recovered* (%)	Colour Comparison
B5	Ground	Apr. 4	..	37·3	95·0	White / No significant difference
		May 4	12·0	36·7	99·5	
		June 6	9·0	36·4	100	
		July 5	13·4	36·5	99·5	
		Aug. 1	9·4	..	..	
B5	Tree	Apr. 4	11·5	37·2	100	White / No significant difference
		May 4	12·2	36·8	100	
		June 6	18·0	37·4	99·0	
		July 5	20·7	38·0	99·0	
B6	Ground	Apr. 4	..	40·0	98·0	White / No significant difference
		May 4	14·0	40·6	99·5	
		June 6	10·0	40·6	100	
		July 5	18·1	41·4	100	
		Aug. 1	14·0	..	..	
B6	Tree	Apr. 4	..	38·2	100	White
		May 4	12·1	40·5	100	White
		June 6	21·0	39·6	100	Off white
		July 5	21·2	40·3	100	Off white
L1	Ground	Mar. 30	..	34·8	11·3	Light brown
		Apr. 13	..	36·8	31·2	Pale straw
		May 4	18·0	37·5	41·5	Off white
L1	Tree	Mar. 30	25·0	36·5	56·5	Light brown
		Apr. 13	..	37·7	57·5	Pale straw
		May 4	22·0	38·8	68·0	White
L4	Ground	Mar. 30	..	35·7	10·3	Light straw
		Apr. 13	..	35·6	17·8	Slightly lighter straw
L4	Tree	Mar. 30	..	35·8	35·8	Light straw
		Apr. 13	..	37·5	45·8	Slightly lighter straw
G5	Ground	Apr. 7	..	42·3	98·0	White / No significant difference
		Apr. 14	..	45·0	100	
		May 27	..	46·0	100	

* Based on sound nuts only.

TABLE 4

SUMMARY OF QUEENSLAND MACADAMIA SELECTION EVALUATIONS, 1955 SEASON

Code No. of Tree	Date of Harvesting	Method of Harvesting	Weight Loss		Percentage of Kernels on Dry Weight		Loss in Commercial Recovery	Unsound Kernels (Commercial Recovery)			1st Grade Kernels by Weight	Commercial Recovery 1st Grade Kernels	Appearance of Sound Kernels
			Date Determined	Loss on Drying (%)	Kernel Recovery‡	Commercial Kernel Recovery	(%)	Germinating (%)	Attacked by Fruit Spotting Bug (%)	Sticking to Shell (%)	(%)	(%)	
B5 ..	June	Ground and tree	June 7	14·6	37·8	34·0	3·8	0·0	4·6	0·0	98·0	31·8	White, regular, even, full
B6 ..	June	Ground and tree	..	..	42·5	36·8	5·7	0·0	8·5	0·0	92·0	31·0	Mainly white, few brown, regular, even, full
H1 ..	May 18	95% tree ..	June 3	25·6	50·0	41·0	9·0	6·6	50·0	1·4	95·0	16·0	Mainly white, fairly regular, even, mainly full, many small
H2 ..	May 18	Ground, many wind-blown	June 3	16·6	34·7	32·0	2·7	0·0	0·0	0·0	79·0*	25·3	White, regular, even, full, flatter than B5 and B6
H3 ..	May 18	Ground ..	June 3	27·6	43·5	37·0	6·5	15·0	38·6	0·0	100·0	17·2	Mainly white, fairly regular, even, few shrivelled, tree crop better appearance
H3 ..	May 18	Tree ..	June 3	27·0	..	40·5	..	14·0	21·0	0·0	99·0	26·0	
HY† ..	May 18	Tree ..	June 3	19·2	30·9	28·4	1·6	0·0	0·0	0·0	85·0	24·2	White, regular, even, some shrivelled, some immature because tree stripped
P1 ..	May 18	Ground ..	June 3	11·1	44·0	37·5	6·5	0·0	4·5	0·0	64·5	23·0	Light brown, irregular, even, mainly full
P1 ..	May 18	Tree ..	June 3	13·6	..	40·0	..	0·0	2·1	7·0	93·0	33·9	Subject to twinning, white, regular, fairly even, full, tree crop better appearance
N3 ..	May 9	Ground	May 17	11·8	44·5	41·5	3·0	0·0	3·2	5·0	88·0	33·8	Tree crop, better colour, white, regular, even full, rather small kernels
			June 20	10·0									
N3 ..	May 9	Tree ..	May 17	10·0	..	42·8	..	0·0	12·3	0·0	98·0	36·8	
N6 ..	May 9	Tree ..	May 17	16·1	36·4	35·0	1·4	0·0	1·2	0·0	92·5	31·8	White, regular, even, full, too small
N7 ..	May 9	Tree ..	..	..	46·0	..	..	..	..	..	..	..	..
G4	Apr. 14	Ground ..	..	..	..	43·3	..	0·6	18·6	7·0	92·0	29·5	Fairly white, many with dark spots, regular, fairly even, full
	May 27												
G4	Apr. 14	Tree ..	June 7	12·0	47·5	43·1	4·4	0·9	19·6	19·0	92·5	24·1	This kernel had red scale from shell firmly attached
G5	Apr. 7	Ground ..	..	..	46·0	40·5	5·5	0·0	26·0	0·0	93·5	28·0	No significant difference between tree and ground, white (better than G4 and not subjected to dark spots), regular, fairly even, full
	Apr. 14												
G5 ..	Apr. 14	Tree ..	..	..	..	42·5	..	0·0	15·8	0·0	99·0	35·0	
L1 ..	Apr. 13	Ground ..	..	..	..	35·6	..	0·0	12·7	2·5	45·0	15·4	Brown (some very dark), irregular, uneven, shrunken
L1 ..	Apr. 13	Tree ..	..	..	38·2	36·6	1·6	0·0	4·8	2·5	57·5	19·5	Odd whites, irregular, uneven, shrunken, tree crops better appearance
L4 ..	Apr. 13	Ground ..	..	..	..	36·4	0·0	0·0	5·7	1·0	22·0	7·5	Light brown, irregular, dark, shrunken
L4 ..	Apr. 13	Tree ..	..	..	37·4	36·8	0·6	0·0	1·6	2·5	47·0	17·5	Few whites, irregular, dark, shrunken, tree crops better appearance
L5 ..	May 6	Tree ..	May 17	18·6	33·8	31·2	2·6	0·0	0·0	0·0	99·5	31·0	White, regular, fairly even, full

* Low value due to immaturity.

† Hybrid from Beechmont.

‡ Based on sound nuts only.

(i) *Loss on Drying.*—The loss on drying varied from 10·0 to 27·6 per cent., indicating the desirability of growers storing husked nuts in a good drying area for at least a month before despatch to the processor. This would reduce freight and dehydration costs and improve grower-processor relationships, since the weight on dehydration would be close to the weight at despatch.

(ii) *Kernel Recovery.*—The kernel recovery based on sound nuts was generally higher than that obtained in 1954. The difference between laboratory and commercial kernel recovery was due to the loss of small chips during commercial cracking, shrinkage due to the attacks of fruit-spotting bug, and hollow nuts due to ant and mice attacks. These losses varied from 0·8 to 9·0 per cent.

The percentage of unsound kernels ranged from 0 to 57·0. Damage by fruit-spotting bug was the main cause. Samples H1 and H3 showed 50·0 and 38·6 per cent. bug-damaged kernels respectively despite the application of recommended spraying schedules.

Two other faults contributing to lower kernel recovery—viz. tendency to germinate before harvest, and tendency of the kernel to stick to the shell—appeared to be inherent characteristics. G4 was ruled out as a selection because of the high percentage of kernels that stuck to the shell or were extracted with the dark lining of the shell attached.

(iii) *Quality of Kernel.*—The percentage of first-grade kernels was generally fairly high, though L1 and L4 gave low values as in 1954.

P1 showed a wide variation (64·5 to 93·0 per cent.) between tree-harvested and ground-harvested samples, indicating that this tree produced a variable crop.

H2, with a first-grade yield of only 79 per cent., was of much lower quality than in 1954 (93·8 per cent.), but this could have been due to an abnormal wind-storm causing early fall.

The commercial recovery of first-grade kernels was extremely variable and indicates the difficulties under which the processor would have to work when handling seedling crops.

(c) Selection

Adding the requirement of a minimum commercial recovery of first-grade kernels of 30 per cent. to the essential properties determined in 1954, B5, B6, N3 and H2 suggested themselves for propagation purposes, with L5 and N7 also worth consideration.

IV. EFFECT OF TIME AND METHOD OF HARVESTING

(a) Methods

M. integrifolia samples were taken at monthly intervals during a harvesting period extending over about four months. Because of the shorter bearing season, *M. tetraphylla* samples were drawn at weekly and fortnightly intervals during

March, April and May. Shortly before the first nuts reached maturity the ground under the selected trees was cleared of weeds and debris so that a complete harvest could be made each time to ensure true sampling. Two samples were taken at each harvest. Ground-harvested nuts were those taken from the ground at the commencement of harvesting. When this operation was complete the limbs of the tree were severely shaken to dislodge loosely attached nuts almost ready to fall. These were called tree-harvested nuts.

The samples were immediately despatched to the laboratory, where they were promptly dehydrated to 3 per cent. moisture and the loss during drying determined. The nuts were then cracked manually, using a hand cracker so that the kernel of each nut could be examined individually. Any kernel which was abnormal—that is, attacked by fruit-spotting bug or other insects, very immature or mouldy—was discarded together with its shell. The sound kernels and their shells were weighed and by this means it was possible to estimate accurately the percentage of kernel. The kernels were graded for quality on the basis of specific gravity as recommended by Moltzau and Ripperton (1939), weighed and then dehydrated to 1·5 per cent. moisture before packing in vacuum jars and storing at 40°F until all samples had been received. Any colour differences in each selection were observed.

(b) Observations

The results of the observations are set out in Table 4.

The loss of weight in drying was variable, but tree-harvested samples lost more than corresponding ground-harvested samples. The high weight losses of the tree-harvested samples of the *M. integrifolia* types B5 and B6 during June and July could possibly be explained by the cooler weather and poorer drying conditions.

The kernel recovery was good in all samples, but it was observed, particularly in B5 and B6, that by dehydrating within a week of harvesting the shells cracked readily while drying, apparently causing the kernel to brown. The cracks allowed mould spores to penetrate and were often large enough to permit small ants to enter the shell and devour the kernel. Hamilton and Fukunaga (1959) have reported similar problems in premature dehydration of Macadamia nuts.

Significant changes in quality during the harvesting period were shown by two of the *M. tetraphylla* types, L1 and L4, but the third, G5, available only from the ground, was of consistently high quality. B5 and B6 showed no significant changes in quality with time of harvest.

For each harvest date of L1 and L4, the tree-harvested nuts were of much higher quality than the ground-harvested nuts. This difference was so great that it was thought that both of the trees, particularly L1, had an inherent characteristic of allowing nuts to fall before maturity was reached. There was no significant

difference in quality between ground-harvested and tree-harvested nuts of B5 and B6. These findings on ground-harvested *v* tree-harvested nuts are contrary to those of Hamilton and Fukunaga (1959), who reported that nuts shaken from the tree are often immature and must be discarded as culls when processed.

The marked difference in quality between ground-harvested and tree-harvested nuts from L1 and L4 suggested that more frequent harvesting may have resulted in higher quality in the ground-harvested nuts.

It was observed in the *M. tetraphylla* types L1 and L4 that later harvested nuts were lighter in colour and tended to be more consistent in colour than those harvested earlier. The two *M. integrifolia* types, B5 and B6, and the *M. tetraphylla* type G5, showed no significant change in colour throughout the harvesting season.

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