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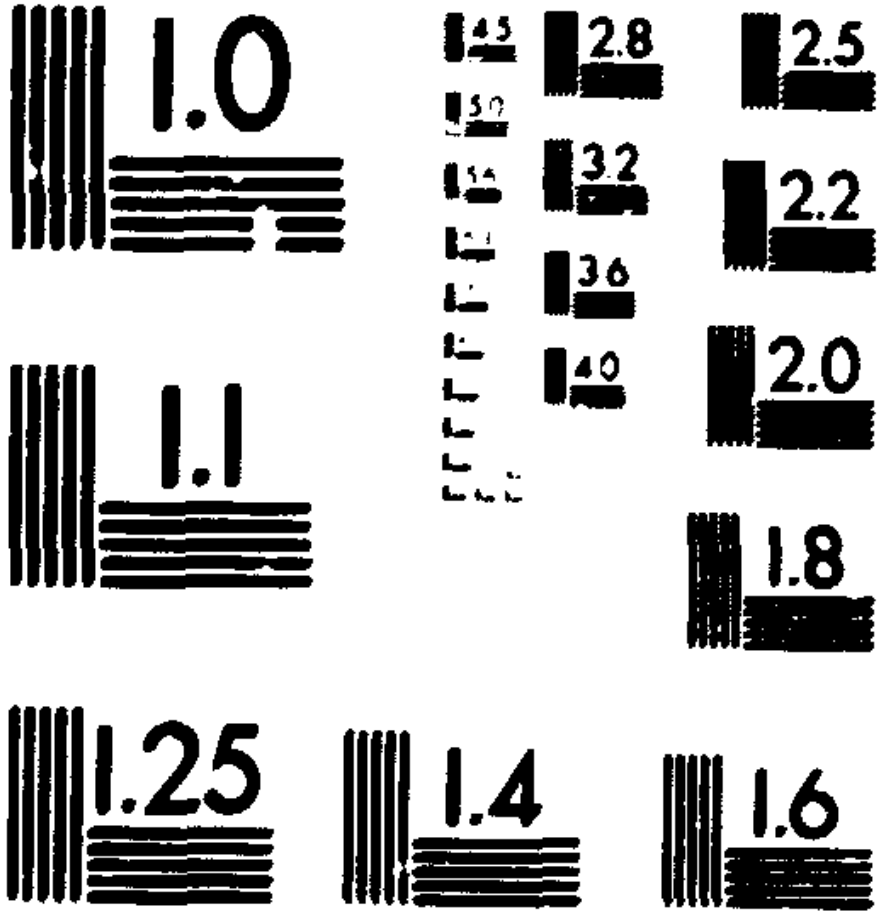

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DP/KEN/80/001

KENYA

Technical report: Macadamia, an important agro-industries potential in Kenya*

Prepared for the Government of Kenya
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of M.F. Huzny,
expert in agro-based industries

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Abstract

The technical report 'Macadamia - an important agro-industries potential in Kenya' was prepared within the framework of project DP/KEN/80/001 - Assistance to the Ministry of Industry - by Mr. M.F. Husny, expert in agro-based industries.

In reviewing the potentials of the agricultural sector in that report, special attention was given to MACADAMIA; - the importance in relation to other nuts, qualities, pecularities and utilization, as well as the situation of Macadamias in Kenya is discussed.

Processing and storage of Macadamia nuts are dealt with in detail, describing especially dehusking, dehydration, cracking the nuts, quality grading, roasting the kernels, salting and packaging.
It is recommended:

a) to replace within ten years 85% of the present macadamia orchards by planting young grafted seedlings;

b) to start research work and experimenting on processing of macadamia and extraction of nut oil; and

c) to initiate pre-planning activities for establishing a madacamia oil-extraction factory based on the results of research work and experimenting under b).

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I N T R O D U C T I O N

Due to the fact that macadamia nuts have become the most valuable and most-liked of all edible tree nuts in the world,

And, since the demand for macadamia nuts exceeds significantly the present supply,

And, since Kenya has already over 4000 hectares of macadamia, out of which, unfortunately, 85% are from Macadamia tetraphylla variety, and only 15% of the M. integrifolia which is the only variety favoured by the processors,

The UNIDO-expert thought that the study of the primary sector of agriculture would not be complete without presenting to the Government of Kenya a full report about macadamia, on the hope that it will be of use in improving the situation of macadamia orchards in the country, prior to establishing new factories for the processing of the nuts and the extraction of the oil for the different purposes.

RECOMMENDATIONS

1. Serious action has to be taken by the Ministry of Agriculture in order to replace within 10 years from now, 85% of the present macadamia orchards which are planted with the M. tetraphylla, by planting between the old undesirable trees, young seedlings that are grafted by high yielding M. integrifolia which is the most suitable variety in the world for nut production and processing; and, as soon as the new trees will start giving their first commercial crop, the old trees should be removed.

2. KIRDI could start from now experimenting on the extraction of macadamia nut oil, partly or fully, in order to utilize the oil commercially later on, whether for edible purposes, or, for manufacturing cosmetic preparations such as lipstick, creams, etc. The oil should be analysed for its saturated and unsaturated fatty acids and evaluated as to the best and most economic ways of its utilization, especially because the macadamia nut is the most expensive of all edible nuts.

3. Whenever KIRDI experiments prove successful and the macadamia orchards situation improves, a feasibility study would be needed with the aim of establishing a macadamia oil-extraction factory with an annex for some cosmetics' preparations. A joint-venture with a well-known internationally firm would be highly desirable, in order to export the cosmetics' preparations and probably part of the oil, under their brand-name, which will definitely ensure a good income of foreign currency.

II - "MACADAMIA"

1/,3/,5/,6/,7/,8/

"An Important Agro-Industries Potential in Kenya

A. General Description of Macadamia Nut

Macadamia's rank amongst other nuts:

Macadamia nuts have a flavour and texture which are superior to other confectionery nuts. They are considered to be one of the finest edible nuts; and, are probably the most highly priced nuts available in the world.

World Production

The world output of macadamia kernels (1.5% moisture content) grew from about 2,700 tons in 1978 to 4,500 tons in 1980. In latter year, about 85% of the output was still accounted for by Hawaii which is the leading producer and also leads in plant-breeding and selection over other producers; but, Australia, Kenya and South Africa were rapidly increasing their shares, while Costa Rica, Guatemala and Malawi were also beginning to become significant suppliers.

In spite of the fact that Hawaii's labour and land costs are extremely high in relation to most developing countries, yet the Hawaiian industry has greatly expanded its planted area since 1979. In any case, increased supplies from other countries are expected not to create a glut on world markets that would depress prices to uneconomical levels. As about 10 years are required for a macadamia plantation to break even, the Hawaiian industry appears to be confident of high and remunerative price levels, at least until early to mid 1990's and probably well beyond that.

Prices

The international price of good quality bulk raw kernels (whole and half grades) is around US$9.00 - 10.00 per 1 Kg This price is envisaged to be more or less maintained through most of the 1980's but will probably decline somewhat in this decade and early in the 1990's and are expected to remain at a large premium over cashews, almonds and other tree-nuts, at least up to 1995

As a basis of comparison, macadamia nuts' bulk prices, f.o.b. California plants, in September 1983: for new crop, 90% "whole", were US$12.05/1 Kg, with tight supplies reported; for combination "whole/halves (approximately 70% whole)", were US$10.68/1 Kg for up to 2270 Kgs; but, over 2270 Kgs, price was US$10.46/1 Kg; "chips" however had a steady price of US$9.43/ 1 Kg. On the other hand, almond prices, f.o.b. California plants, in September 1983 also, ranged from US$3.74/1 Kg to US$3.50/1 Kg.

Uses

1) Roasted and salted kernels are used for snacks and as a nibbling food after meals.

2) Macadamia kernels give crunchiness to main dishes of meats, chicken and fish. They are also added to both fruit and vegetable salads.

3) They are incorporated into ice cream, pies, cakes and candies.

4) For the extraction of oil which is edible and is also used in some cosmetics' preparations.

Composition :[1/] Each 100 grams of macadamia nuts kernels contain:

3% water, 7.8% protein, 71.6% fat, 15.9% total carbohydrates (CHO), 1.7% ash, 48 mg calcium, 161 mg phosphorous, 2 mg iron, 264 mg potassium, 0.34 mg thiamine, 0.11 mg riboflavin, 1.3 mg niacin.

In comparison, cashew-nuts (100 gms) contain:

5.2% water, 17.2% protein, 45.7% fat, 29.3% total CHO, 2.6% ash, 38mg Ca, 373 mg P, 3.8 mg Fe, 15 mg Na, 464 mg K, 100 I.U. vitamin A, 0.43 mg thiamine, 0.25 mg riboflavin, 1.8 mg niacin.

In other words, macadamia nut kernels content oil content, which is the main constituent,is about 1.57 as much as that of the cashew-nuts.

B. Macadamias in Kenya

At the end of 1972, approximately 3,200 hectares have been planted throughout Kenya in the form of seedling trees of Macadamia tetraphylla variety [3/]. Distribution in the different provinces and districts was as follows:

Province	District	Area planted(hectares)
Eastern	Meru	850
	Embu	352
	Machakos	419
	Kitui	2
Central	Nyeri	273
	Kirinyaga	419
	Kiambu	158
	Muranga	360
Rift Valley	Nakuru	50
	Trans Nzoia	17
Other areas		300
Total		3,200

However, the original plan was that only grafted plants using approved grafting material would be planted, with older plantings being top-worked where possible. The changeover in varieties was intended to provide a more uniform nut for processing.

The estimated production of macadamia nuts in 1972 totalled 150 metric tons. Production was expected to steadily increase, as trees of the M. integrifolia variety, planted around 1965, begin to bear nuts. Following was an estimate, made end of 1972, of the production of macadamia nuts in Kenya:[3/]

Year	Projected Yields (metric tons)
1973	500
1974	600
1975	1,200
1976	2,800
1977	3,700

(**Remark:** On the basis of 100 trees/hectare, yield in full production of 3200 hectares would be 1600 tons of nuts(=880 tons kernels)*.
Prices paid to farmers by a local processor, for macadamia nuts in the shells, based on the turn out of kernels, in 1972, was as follows:

Grade	Diameter(cms)	Price per 1 Kg usable Kernels (KShs)
1	Over 1.9	11/-
2	1.9-1.6	9/-
3	1.6-1.3	7/50
4	1.3-1.0	5/-
5	1.0-0.4	3/50

An FAO-consultant who visited Kenya in 1971[5] and reviewed the macadamia situation, has recommended the following:-

a) Seedling planting stock that was available then was more suitable for rootstock than for production of nuts for processing.

b) Young seedlings that were ready for planting, as well as young trees that were growing in the field, should be grafted or topworked as soon as possible to improve clonal varieties of M. integrifolia, the species upon which commercial nut production in the world is almost exclusively based.

c) An adequately staffed and financed research program was needed and should be initiated and carried out to encompass: variety testing, cultural practices, fertilizer studies; and, processing.

d) The economics of alternative crops such as corn, passion fruit, coffee, avocados and pyrethrum, should be considered and evaluated objectively in deciding whether or not to attempt to grow improved clonal macadamia orchards as a commercial crop in Kenya.

*According to average yield at present (5 Kg nuts/tree; and, whole nuts yield 55% kernels). Please see pages 11 + 12.

e) It is possible by careful and efficient handling and processing procedures, about 60% by weight of kernels from nuts produced by the existing (then) seedling plantings, could be utilized.

The FAO macadamia consultant (above) has also reported the following:

i) The potential production and income from existing (then) seedling plantings was only about 13% of that from comparable orchards of improved clonal varieties of M. integrifolia.

ii) He stated that "the choice of M. tetraphylla as a suitable species for orchard planting to establish a new commercial crop in Kenya was probably a mistake"; and, that "it would be risky and disastrous to continue to rely on M.tetraphylla seedlings as a source of macadamia nuts for development of a large scale commercial processing industry".

The Kenya Department of Agriculture [2/] considers the following areas suitable for growing macadamia trees:

a) All existing coffee areas.

b) All areas below the coffee areas, where the average rainfall is 1000 mm or more, or, where irrigation can be supplied.

c) The Coastal Strip.

Present Situation of Macadamias in Kenya

A meeting was held between the expert, his colleague Mr. P.M. Muraguri (Food Technologist, Agro-industries Section, Projects Planning Department, Ministry of Commerce and Industry) and an expert of the "Japanese International Cooperation Agency" who is currently carrying out research to improve and develop macadamia culture in Kenya and offer training and extension service to farmers. Results were:

1) Area cultivated with macadamia is about 4000 hectares at present.

2) About 85% of macadamias in Kenya are of the M.tetraphylla variety and 15% of the M. integrifolia. The former produces a low yield, low quality, rough-shelled nuts while the latter are superior in quality and have smooth-shelled nuts which are much preferred for processing. Very few of the existing trees are grafted.

3) It is believed that the Central Province is best-suited for macadamias.

4) Oil is extracted from macadamia nuts in Japan and is partly used in cosmetics, especially in the production of lipsticks.

5) The trunk of the macadamia tree can be used as a fire-wood and as a good source of smoke, because of its oil content.

6) It is estimated that macadamia nuts, of the Central and Eastern Provinces, of M. tetraphylla variety would contain about 65-67% oil, in comparison to M.integrifolia which contains 70-75% oil.

7) The big-scale macadamia farmers in Kenya exist in the Highlands where coffee estates are found, but, in rural areas, about 85-90% of the farmers are small-holders.

8) A flower disease (fungus) exists.

9) Fungus attacking nuts comes most probably from leaving the fallen nuts unnecessarily on the ground for long periods before they are collected.

10) Many graft-seedlings are being prepared for distribution to farmers.

11) It is recommended that new good quality high yield varieties be planted between the old low quality, low yield trees, until they start giving a nut crop and then the old trees should be cut to allow the new to develop and replace them.

12) The average yield from the existing macadamias is about 5 Kgs/tree/year. On the other hand, an existing 14 years old tree that yields about 65 Kg/year of nuts has been chosen for obtaining selected clones from it. Another one, a hybrid type, 15 years old, was found to give about 45 Kgs/year of the nuts (both from M.integrifolia variety).

13) Termites constitute a serious problem in drier areas.

14) Control of plant diseases and pests is intended for the future.

15) In Kenya, it is believed that after 12 years, macadamias reach their commercial yield.

The Macadamia Nuts Processing Factory at Thika:

- Belongs to the Kenya Nut Company Limited, which is a Kenyan/ Japanese joint-venture.

- More than 90% of its whole nuts are purchased from societies and the rest from individual farmers.

- Kirinyaga gives the higher yield of nuts.

- Process in brief: Unshelled nuts are dried in a dehydrator, then mechanically-graded to different sizes, cracked, nut-kernels are separated from the shells and then the kernels are sorted out to edible and non-edible (damaged by insects, fungus, etc) and former are graded into 3 grades:

  Grade AA: diameter 16 mm, up to 24 mm, complete, whole.

  Grade A: diameter 12-16 mm, whole & halves (50:50).

  Grade B: diameter below 12 mm & over 6mm, halves and broken (50:50)

- **Kernels constitute about 50-60% of the whole nut received, on the average.**

- Packaging for export is in 20 Kg. net aluminium-foil, raw, under vacuum (gross about 21 Kg. weight). Most of the export is to Japan. But, some are vacuum-packed in 2 Kg.& ½Kg. aluminium-foil packages for local market beside the ½ Kg. and 1 Kg. roasted kernels in polybags.

- It was noticed, by the UNIDO-expert and his colleague Mr. Muraguri, during a visit to the factory, that a significant quantity of whole nuts was spread over the floor in the reception room as a result of partly-open or torn bags; and, the quantity seen that day of "moldy" and insect-infected kernels was also rather significant.

- Most of the workers are casual and a few only are permanent. Present operations are considered to be labour-intensive.

Conclusion:

From the above, it appears that new macadamia seedlings, grafted with good quality, high yielding clones of the M. integrifolia variety, should be planted between the low quality, low yielding old macadamia trees (most of which are of the M. tetraphylla variety); and, as soon as they yield a commercial crop, the old trees should be cut. That seems the only alternative left for Kenya, in order to assure its place amongst the competitive macadamia nut producing and exporting countries. In this regard, good management and the utilization of the best agricultural practices with regards to spacing, protection from strong winds, application of the right fertilizers, insecticides, pesticides, etc., should be followed in order to obtain high quality macadamia nuts and high yielding trees.

Moreover, the proper harvesting and post-harvest operations should be followed; and, processing should be done under most optimum conditions.

C. "Processing of Macadamia Nuts" [4/, 5/, 6/]

Following are the details of the basic method of processing:

- Harvested nuts, which contain about 30% moisture in the husk alone and about 20-25% in the rest of the nut, should not be left in boxes to "sweat", otherwise a rapid rise in temperature will occur, resulting in deterioration, plus the susceptibility to molding, especially in case of nuts which have cracks or openings in the shell. But, if it is necessary to hold the fresh nuts for some time, then nuts should be spread on wire-mesh trays, layer not exceeding 7.5 cm in depth, protected from rain, raked over regularly; and, air-dried in the shade for 10 days to two weeks, before marketing.

Dehusking:

- As soon as the nuts arrive to the processing plant, their outer green husks should be removed as quickly as possible, preferably within 24 hours after harvesting. However, some people prefer dehusking the nuts soon after they drop to the ground.

  Husks are used as mulch for the soil; and, some tried utilizing the dried material as animal feed after mixing it with pineapple peels and molasses.

Dehydration:

- Is the most critical step in processing macadamia nuts. Moisture in the kernels should be reduced to 1.5% as soon as possible, if flavour deterioration is to be avoided. Meanwhile, drying causes the kernel to shrink away from the shell, thus facilitating decortication afterwards.

- The initial drying teperature of about 38°C is recommended, otherwise if exceeded initially, browning reactions would occur on cooking the nuts. Drying of the nuts should not exceed 46°C, for about 72 hours, or until moisture content is 1.5%.

- After nuts are dried, they may be stored in sacks or bins where they will keep satisfactorily under dry, well-ventilated conditions for at least 4-5 months.

Cracking the nuts:

- Shell of rough-shell varieties is thinner than that of the smooth-shell type, and thus are easier to crack.

- It is necessary to grade the nuts into a number of sizes, in order that each cracking-machine will crack nuts of uniform size. Cracking is accomplished by passing them through steel drums, kernels being separated from shells by a combination of sieving and air-blasing. Moreover, kernels which adhere to the shells are separated by hand.

- Another method of processing has the cracking following the size-grading.

Quality Grading:

(a) Flotation method:

- Kernels are sorted to remove pieces of shells and damaged kernels, then latter are graded into Grade 1 (having a minimum oil content of 67.5%), Grade 2; and, Grade 3, or inferior quality, kernels.

- Commercial grading is based on the fact that plump, smooth-surfaced, light-coloured kernels, have a high oil content and low specific gravity; and, as the oil content decreases, kernels become heavier, darker and less mild in flavour.

- Grading is simply done by using specific gravity solutions. Grade 1 kernels will float on tap water at room temperature and a specific gravity of 1.0. Grade 2 kernels, with specific gravity between 1.0 and 1.25, which are usually sold to confectionery and bakery trade, will float on a 4% brine (sodium chloride) solution. In addition, kernels that will sink will be of Grade 3 (inferior quality) and should be discarded. However, during grading, kernels absorb up to 8-10% moisture. This is removed by dehydration before further processing.

(b) Other:

"nuts" are size-graded mechanically prior to cracking, removing shells and sorting the kernels into three grades: AA, A, B grades, as used at present in the macadamia nut processing plant at Thika.

Roasting the kernels:

- To obtain maximum shelf-life, a satisfactory time/temperature roasting relationship, accompanied by the use of latest packaging techniques, must be used.

Methods of roasting:

(a) Dry roasting:

- The unusually high oil content of above 70% for Grade 1 nuts, makes them adaptable to dry roasting. A heat of 135°C for 40-50 minutes produces the most desirable rate for dry roasting. Frequent stirring of the nuts is necessary to prevent scorching.

- Grade 2 nuts dry out severely and become dull if they are dry roasted.

(b) Deep frying:

- A refined coconut oil, prepared especially for nuts and containing a suitable antioxidant, is recommended for macadamia nuts. A batch of kernels is placed in stainless steel wire-baskets and lowered into a stainless steel vat containing the oil and thermostatically controlled at cooking-temperature.

- In Hawaii, oil-frying at 135°C for 12-15 minutes has been found most satisfactory for all grades of M.integrifolia kernels. A higher temperature causes uneven cooking; and, a lower temperature produces oil-soaked nuts. But, for M. tetraphylla, 127°C is used for about 12 minutes.

- Care must be taken to remove particles of kernels which tend to darken the oil and reduce its effective life.

- It is estimated that 49.2 litres of oil are required for every 454 Kgs of macadamia kernels. Heat is increased as each new charge is added, so that the cold kernels will not reduce the optimum frying-temperature.

- When cooking is completed, kernels are removed from the oil, drained, centrifuged to remove excess oil and cooled rapidly by air.

Salting:

- Nuts to be salted should be lukewarm to cool.

- An adhesive is applied before salting:

  a) For oven-roasted kernels, a 15% solution of gum arabic.

  b) For oil-fried kernels, a special fat which melts at about 32°C.

- Kernels are sprayed and stirred, and the salt is applied immediately. A special grade of salt, finely ground (as for popcorn); and, free from impurities, is used.

- The adhesive solidifies on the kernel's surface at room temperature and holds the salt grains.

N.B: Some kernels are roasted but not salted, for use in chocolate and toffee covered confectionery.

Packaging:

- Because cooked kernels absorb moisture readily, packaging should be done as soon as the kernels are salted and cooled.

- Vacuum-packing in glass jars, tins, or, aluminium-foil, is most recommended, followed by cold storage.

- The use of inert gases, such as nitrogen and carbon dioxide, appears to have little advantage over vacuum-packing and cold storage.

- Macadamia kernels can also be packed in polyethylene bags; and, in an aluminium-foil cup, about 7.5 cm in diameter, with vegetable parchment on the bottom. Each cup could hold about 18-20 gm, or, about a dozen of finely-salted kernels. Latter type is packed mainly for distribution to airliners' passengers.

Storage:

- Storage life of M. tetraphylla is considerably less than M. integrifolia, under same storage conditions.

- The influence of moisture and temperature on the stability of roasted macadamia kernels is similar to that of raw kernels.

- For storage of three months or more, the moisture should not exceed 1% in the kernels.

- To maintain good colour and flavour in vacuum-packed raw kernels for 18 months:

  i) Room temperature is satisfactory for 1.4% moisture.
  ii) 1.7°C is required for 2.3% moisture.
  iii) -17.8°C is necessary for 4.3 moisture.

- Light apparently has no effect on stability of raw or roasted macadamia kernels.

- Roasted kernels maintain quality better than raw kernels.

- Flavour deterioration closely parallels darkening of the kernels.

- Kernel stability increases with decreasing moisture down to 1%; and, decreases with increasing storage temperatures.

Deterioration:

- While raw and roasted macadamia kernels have a long storage life as compared with other high oil content nuts, yet they do deteriorate slowly.

- Deterioration in <u>flavour</u> may be due to:

  a) Absorption of cold storage odours.
  b) Development of rancidity.
  c) A gradual loss of the delicate nutty flavour.

- Deterioration in <u>texture</u> of the kernels:

  i) First, as a loss of crispness and slight mealiness.
  ii) In time, kernel loses all resemblance to its original texture and becomes either tough or soggy.

- Deterioration in <u>colour</u> : will be evident as an almost black colour when affected kernels are cooked, on the contrary to fresh kernels which remain bright when cooked.

Annex

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