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REPUBLIC OF KENYA



KENYA  
INDUSTRIAL RESEARCH ORGANIZATION

**ANNUAL REPORT**  
**1975-1976**

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INDUSTRIAL RESEARCH ORGANIZATION

ANNUAL REPORT  
1975-1976

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## DIRECTOR'S REPORT

### EXPANSION OF INDUSTRIAL RESEARCH

The first concrete step towards the implementation of the proposal to expand industrial research in East Africa was taken by the Partner States of the East African Community in June 1976 when the East African Legislative Assembly appropriated funds for the initiation of the various projects in the Partner States. At the time of writing this Report architects had been commissioned and preliminary drawings were nearing completion. Negotiations for land allocations had reached an advanced stage and given good will and financial support in the 1977/78 financial year construction of the institutes is expected to commence in October 1977.

### STAFF

Towards the end of the year under review Mr. K. E. Ekwaro returned from a six-month study tour of Canada where he gained experience in industrial chemistry under the auspices of the World Association of Industrial and Technological Research Organizations. Mr. G. W. Kulaba joined the Organization as a Research Officer Trainee (Chemist). Both Mr. Kulaba and Mr. Mndewa have joined the University of Nairobi where they are pursuing studies leading to the degree of Master of Science in Chemistry. They will rejoin the coffee processing research team at the conclusion of their studies. Mr. F.A.M.M. Kessy has joined the Organization as a Research Officer Trainee (Chemical Engineering). Efforts to recruit a qualified chemical engineer have continued and it is expected that this vacancy will be filled in the first half of 1977. At the time of writing this Report the personnel position had improved considerably at both the senior and junior levels.

### FEES FOR RESEARCH SERVICES

Fees collected for research and analytical services during the year under review amounted to Sh. 139,077/-. This figure compares with the amount of Sh. 110,413/- collected during the previous year.

### RESEARCH PROJECTS

As a follow-up to the work on coffee processing reported in the previous Annual Report, the Kenya Planters Co-operative Union Ltd. has acquired five U.V. sorting machines for the removal of "stinker" beans. It is understood that these five machines are being used for assessing the logistics of installation and operation of a much larger number of machines, which are expected to be installed in the near future. In the meantime the coffee processing research team has directed its efforts towards the problem of quality deterioration of green coffee while in transit to the consumer market overseas. This work is of utmost importance if the reputation of East Africa as a producer of high quality coffee

is to be maintained. Robusta processing research has been started, initially to determine the effects on quality of the various processing practices and of storage. The initial indications are that wet processing of robustas gives a higher quality product than dry processing. On the other hand, unlike arabicas, good conditions of storage do not appear to have a significant effect on quality of robustas.

Collaborative research effort with sorghum breeders of the East African Agriculture and Forestry Research Organization station at Serere has continued with a longterm view of producing grain of improved food value and at this stage it is gratifying to note that the efforts of the two sister research institutes of the Community, and those of national research establishments, have been recognized by the call by one of the Partner States to extend the growing of sorghum in wider areas where traditional cereals do not do well.

The study of the extrusion cooker mentioned in the previous Report has been completed and the results are reported elsewhere in this issue. The study has shown that the Brady Cooker is capable of producing acceptable protein-enriched products based on East African staples such as maize and soybeans among others, and it is understood that arrangements are on hand in one of the Partner States to have a commercial unit installed for the production of baby foods.

The various projects in industrial chemistry have been left in abeyance owing to the departure of the expatriate officer who was handling them. However, it is gratifying to note that one of them—the carbonization and briquetting of coffee husks—is likely to be exploited commercially in the near future.

The new projects outlined in the previous Report have not been started for reasons beyond the control of the Organization, namely, by the closing of the year under review one of the two Partner States concerned had not yet committed itself unequivocally to support the sisal processing research project, and because of the cumbersome tender procedure currently in use the additional laboratory facilities required for the project on the scientific assessment of coffee quality have not been started let alone completed. These facilities were expected to be ready in January 1977 but are now expected to be completed in July of that year, if all goes well.

In addition to the projects outlined above a number of others are described in detail in the reports which follow. The staff of the Organization have in one capacity or another assisted with the projects described in the report and this is hereby acknowledged.

#### VISITORS

Visitors from abroad who called at the Organization during the period under review were: Dr. A. Brnynesteyn, B.C. Research, Vancouver, Canada; Mr. Kenneth Shewmon, Meals for the Millions Foundation, Santa Monica, California; Miss Kathryn W. Shack, Meals for the Millions Foundation,

Santa Monica, California; Mr. E. Lartey, Industrial Research Institute, Accra, Ghana; Dr. S. Ristic, Yugoslav Centre for Organization and Development, Belgrade, Yugoslavia; Dr. Judson M. Harper, Colorado State University, Fort Collins, Colorado; Dr. E. R. Palmer, Tropical Products Institute, London; Dr. Cyril G. Jarman, Tropical Products Institute, London; Dr. A. Sugiura, Ministry of International Trade and Industry (MITI), Tokyo; Dr. K. Ochi, MITI, Tokyo; Dr. A. Takata, MITI, Tokyo; Dr. M.N.G.A. Khan, Commonwealth Science Council, London.

# ANALYTICAL LABORATORY REPORT

K. E. Ekwaro and H. Ssekaalo

## A. ANALYTICAL

The total number of samples submitted to the laboratory for analysis during the period under review was 93, a slight increase over the number of 85 analysed in the previous year. Continued lack of any special projects such as the one undertaken in 1973/74 on behalf of the State Mining Corporation, Tanzania, when a total of 334 samples were received for analysis, accounted for the unusually low total.

The 93 samples were of miscellaneous nature with the following being the major ones;

Minerals	31
Water	21
Oil	13

## B. INVESTIGATIONS

### *Atomic Absorption Spectrophotometry of Silicon in Silica or Silicate-Based Materials*

During the course of the previous year, it was not possible to determine silicon by atomic absorption spectrophotometry since the hollow cathode silicon lamp supplied with the instrument was found to be defective. However, we managed to receive a replacement lamp during the second half of the year under review.

Atomic absorption spectrophotometry of any element is a very attractive method especially if many samples are involved. The idea of using the method for determination of macro quantities of silicon appears even more attractive than for any other element. The reason being that the classical gravimetric method besides being indirect, is very tedious.

The main drawback to the use of the atomic absorption spectrophotometry for silicon, however, are the difficulties associated with solubilization of the silicon-containing materials. It was the purpose of this work to investigate the practicability of the two attractive methods for solubilization of the sample materials prior to their aspiration into the instrument.

There are various literature methods for treatment of sample materials for atomic absorption spectrophotometric determination of silicon. For example, lithium metaborate fusion<sup>1-4</sup>, lithium carbonate-boric acid fusion,<sup>5-6</sup> sodium-potassium carbonate-boric acid fusion<sup>7,8</sup>, sodium carbonate-sodium borate fusion<sup>9</sup>, and sodium peroxide fusion<sup>10</sup> have been employed to decompose the materials prior to their dissolution. Of recent, the decomposition of the silicon containing<sup>3</sup> materials has been done by a mixture of hydrofluoric, and nitric acids in a special designed uni-seal decomposition hydrochloric vessel<sup>11,12</sup>.

One of the two methods investigated was based on that of Burdo and Wise<sup>9</sup>. In this method the sample materials and pure silica as a reference standard, are each fused with sodium carbonate and sodium borate (the flux being intimately mixed in equal proportions). The melt is then dissolved in an acid molybdate solution to form a silico-molybdate complex. These workers<sup>9</sup> claim that this complex prevents polymerization of silica and possible flame interferences. The pure silica was able to dissolve in the proposed diluting solution. Unfortunately, the sample materials which were one calcite and two sand samples, did not completely dissolve in the diluting solution even on warming the solution. It is however, pointed out by these workers<sup>9</sup> that some cations produce insoluble molybdates in the solution environment used, pH being the main factor influencing the tendency to produce the precipitates. They further point out that acceptable results can still be obtained in the presence of precipitates by simply aspirating the solution after the precipitates settle down or filtering the precipitates before the final dilution. In our view, however, this was found to be impracticable. Coupled with this difficulty, and the fact that the high flux to sample ratio introduce undesirably high salt concentrations leading to high and fluctuating instrument background noise, it was decided not to investigate this method any further.

The second method of sample preparation was based on that of Bernas<sup>11</sup> with some modifications as described elsewhere<sup>19,10</sup>. Essentially this involves decomposing the sample material by the mixture of hydrofluoric, hydrochloric and nitric acids under pressure in a completely sealed vessel at a temperature of 105–110 C for about 40 minutes. The resulting cool mixture is then dissolved in a saturated boric acid solution. By the use of this method, it was found that the three test samples referred to above, were easily decomposed and dissolved. The pure silica used as a reference standard, was also easily solubilized.

The acetylene flow rate recommended by the Pye Unicam atomic absorption spectrophotometer manufacturers for the silicon determination was insufficient to produce a high enough flame temperature to give a positive response on this solution. Instead of the 4800 c.c./minute acetylene flow rate, a flow rate of between 5000 and 6000 c.c./minute was able to give a positive signal. After an exhaustive number of trials, the optimum instrument conditions were found to be those shown in Table 1. With these conditions, there was a linear absorbance response for the standard silicon concentration series of 0, 50, 100, 150, 200 and 250  $\mu\text{gSi/ml}$ . The linearity was maintained for two repeat readings done over a period of 5 minutes. The linearity, however, fell off negatively by an average of 5%. It is therefore recommended to calibrate the instrument approximately every 5 minutes which corresponds to a reading of ten solutions. The replicate sample readings showed good precision. More work is, however, to be done to perfect this method since a lot of saving in time and reagents is banked on it.

Table 1

*Optimum Instrumental Settings on Pye Unicam 90B Series 2 for Atomic Absorption Spectrophotometry of Silicon Using Flame Gases C<sub>2</sub>H<sub>2</sub>-N<sub>2</sub>O*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	5000
Burner height, mm	10
Slitwidth, mm	0.10
Wavelength, nm	251
Current, mA	14.5
Gain position No.	6
Disc position No.	1
Expansion position No. for 250 µg Si/ml... 0.500 absorbance units	2

*Some Aspects of Atomic Absorption Spectrophotometry of Various Metal Elements in Industrial Materials Investigated*

Attractive as it may be, atomic absorption spectrophotometry is one of the methods that need to be used with a lot of caution depending on the nature of the materials whose elements are to be determined. Thus research into the use of the method for various elements in a varied range of materials is a must if meaningful data are to be obtained. It is for this reason that this laboratory has been actively engaged in locating any problems associated with the atomic absorption spectrophotometric determination of metal cations in various industrial materials so that remedial measures to circumvent them are sought.

In locating the problems that are associated with this method, special interest has been paid to chemical interferences. Chemical interferences are derived from three main sources, viz., (i) chemical species from the flame itself; (ii) chemical species from the matrix of the sample material; and (iii) chemical species of the solubilizing medium i.e. the decomposing reagents as well as the diluting solutions. The situation is even made more complex because not only do these species occur independently of each other in the flame, but can interact with each other to produce yet more chemical entities. To highlight the complex situation that can be created from the three sources of chemical interferences let us consider a few examples in relation to how the atomic absorption signal can be affected. Kalfi and Alkemade<sup>13</sup> have found out that the dissociation energies needed for production of Ca, Sr and Ba atoms from their oxides in a carbon monoxide-nitric oxide flame are;  $D_0$  (CaO)=3.75 eV;  $D_0$  (SrO)=4.06 eV; and  $D_0$  (BaO)=5.30 eV; but production of atoms of the same elements from their hydroxides needed the following energies:  $D_0$  (CaOH)=4.44 eV;  $D_0$  (SrOH)=4.38 eV; and  $D_0$  (BaOH)=4.88 eV. Jensen and Jones found out that the principal iron-containing species in fuel-rich, premixed atmospheric

pressure lamina flame of hydrogen-oxygen, was  $\text{FeOH}$ . When molybdenum and tungsten were introduced in a hydrogen-oxygen flame containing potassium, they reacted producing the following species<sup>7</sup>:  $\text{KHM}_0\text{O}_4$ ,  $\text{K}_2\text{M}_0\text{O}_4$ ,  $\text{KHWO}_4$ , and  $\text{K}_2\text{WO}_4$ . From these examples it is evident that the population of independent atoms in the flame will be influenced to a lesser or greater extent by the nature of the chemical species present in any of the three sources outlined above. But once the nature of the interfering species is known and then circumvented, the atomic absorption spectrophotometric method, can be most rewarding.

The metal elements that have been determined by atomic absorption spectrophotometry in various materials during the course of the year have been magnesium, aluminium, calcium, manganese, iron, cobalt, copper, zinc, silver, gold, and lead.

In Table 2 to 13 are shown the optimum instrumental settings for the atomic absorption spectrophotometry of these elements in the materials using the Pye Unicam 90B Series 2 instrument. The data in these Tables are specifically intended to serve as references for future work and modifications.

Table 2

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Magnesium Using Flame Gases  $\text{C}_2\text{H}_2$ -Air*

<i>Parameter</i>	<i>Value</i>
$\text{C}_2\text{H}_2$ flow rate, c.c./min	1400
Burner height, mm	8
Slitwidth, mm	0.08
Wavelength, nm	284
Current, mA	3.6
Gain position No.	7
Disc position No.	3
Magnesium concentration range, ug/ml	0- 1.0

Table 3

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Aluminium Using Flame Gases C<sub>2</sub>H<sub>2</sub>-N<sub>2</sub>O*

Parameter	Value
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	4400
Burner height, mm	10
Slitwidth, mm	0.15
Wavelength, nm	307
Current, mA	9.5
Gain position No.	5
Disc position No.	3
Aluminium concentration range, ug/ml	0-100

Table 4

*Optimum Instrumental Settings for Absorption Spectrophotometry of Calcium Using Flame Gases C<sub>2</sub>H<sub>2</sub>-Air*

Parameter	Value
C <sup>0</sup> H <sup>0</sup> flow rate, c.c./min	1500
Burner height, mm	10
Slitwidth, mm	0.08
Wavelength, nm	418
Current, mA	9.5
Gain position No.	6
Disc position No.	2
Calcium concentration range, ug/ml	0-10

Table 5

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry Of Calcium Using Flame Gases C<sub>2</sub>H<sub>2</sub> - N<sub>2</sub>O*

Parameter	Value
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	3800
Burner height, mm	6
Slitwidth, mm	0.08
Wavelength, nm	418
Current, mA	9.5
Gain position No.	6
Disc position No.	3
Calcium concentration range, ug/ml	0-10

**Table 6**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Manganese Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.15
Wavelength, nm	278
Current, mA	11.5
Gain position No.	7
Disc position No.	3
Manganese concentration range, ug/ml	0-5

**Table 7**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Iron Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
	<b>666</b>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.10
Wavelength, nm	248
Current, mA	14.5
Gain position No.	4
Disc position No.	1
Iron concentration range, ug/ml	0-10

**Table 8**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Cobalt Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1000
Burner height, mm	10
Slitwidth, mm	0.08
Wavelength, nm	241
Current, mA	14.5
Gain position No.	6
Disc position No.	1
Cobalt concentration range, ug/ml	0-10

**Table 9**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Copper Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1000
Burner height, mm	8
Slitwidth, mm	0.08
Wavelength, nm	325
Current, mA	4.6
Gain position No.	5
Disc position No.	1
Copper concentration range, ug/ml	0-25

**Table 10**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Zinc Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.10
Wavelength, nm	214
Current, mA	9.5
Gain position No.	6
Disc position No.	1
Zinc concentration range, ug/ml	0-3.0

**Table 11**

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Silver Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

<i>Parameter</i>	<i>Value</i>
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.10
Wavelength, nm	327
Current, mA	3.6
Gain position No.	4
Disc position No.	1
Silver concentration range, ug/ml	0-8

Table 12

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Gold Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

Parameter	Value
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.15
Wavelength, nm	242
Current, mA	9.5
Gain position No.	5
Disc position No.	1
Gold concentration range, ug/ml	0-25

Table 13

*Optimum Instrumental Settings for Atomic Absorption Spectrophotometry of Lead Using Flame Gases C<sub>2</sub>H<sub>2</sub> - Air*

Parameter	Value
C <sub>2</sub> H <sub>2</sub> flow rate, c.c./min	1400
Burner height, mm	10
Slitwidth, mm	0.10
Wavelength, nm	282
Current, mA	5.0
Gain position No.	4
Disc position No.	1
Lead concentration range, ug/ml	0-10

The calibration curve for calcium based on the data in Table 4 is linear throughout the concentration range 0-10 ug Ca/ml. The curve based on the data of Table 5, however, shows a negative bias towards the higher concentrations.

Ideally, it was found better to use the instrumental conditions. In Table 4 for simple matrix materials.

The main differences between the conditions in Table 4 and Table 5 are that air instead of nitrous oxide is used in the former and that a higher temperature flame is produced in the latter case. It is therefore not unreasonable to suggest that the nature of the chemical species produced from the acetylene-nitrous oxide flame interact with the calcium atoms to form molecular species which decrease the population of free calcium atoms at higher calcium concentrations.

Whereas the use of acetylene-air flame was found to give accurate results in materials of simple matrix concentration, e.g. water samples, the temperature of this flame was found to be too low to effect enough atomization of calcium atoms in complex matrix samples, e.g., clay, mineral rocks. For these more

complex materials which even needed a high concentration of the solubilizing reagent solution, the acetylene-nitrous oxide flame had to be used. Thus this example of calcium determination brings in focus once again the caution that needs to be exercised when using atomic absorption spectrophotometry. Further work will continue to improve the calcium calibration curve when acetylene-nitrous oxide flame is used in the determination. This is a problem we cannot leave without exhausting all possibilities of trying to solve it since calcium is a very important constituent in many industrial materials.

Comparative data were accumulated during the course of the year to find out the effect of determining magnesium, aluminium, calcium, manganese, and iron in the absence and presence of silicon. Clay sample materials were used for this purpose. Sample solutions prepared by removal of silicon by the classical method on one hand and by solubilizing the materials with hydrofluoric, hydrochloric and nitric acid on the other hand, were used for the study. Although work is still continuing on this investigation, a number of conclusions have already emerged. For example, the presence of silicon has negligible effect on the determination of manganese and iron. The presence of silicon, however, seems to affect the accuracy of magnesium, aluminium and calcium a great deal in some materials.

#### *The Kinagoni Lead Ore Project*

This work was undertaken after the Kenya Mining Industries Limited had requested us to look into the problem associated with the lead ore processing at Kinagoni Mines in Kilifi District of the Coast Province of Kenya in order to find out whether we could be of help in locating the nature of some of these problems. When we went there towards the end of the year under review, we were given a description of the working of their lead ore processing plant as a means of putting us in the whole picture of the problems.

The problems in their lead ore processing were concerned with two main issues. First, the Company was obliged to use sea water instead of fresh water due to the scarcity of the latter. However, efforts were being made to introduce fresh water from the neighbouring area. But the efforts were being beset by the uncertain sources of the fresh water since these are only seasonal.

The use of sea water resulted in a higher consumption of some of the reagents used in the processing of the ore. For example, laboratory experiments had shown that amylic xanthate, a reagent used as a collector for lead sulphide particles in the floatation process, was consumed to the extent of twice the amount used for fresh water.

The second issue was concerned with the fact that about 8% of the lead ore occurred in an oxidated form. This meant that the oxidated form had to be transformed into a sulphudized form, i.e. galena, PbS, before it could be separated by the floatation process. Laboratory experiments conducted at Kinagoni and Rumania had shown that sodium sulphide (for sulphudization) was used to the extent of three to five times when sea water was employed as compared to the amount used for fresh water.

Further, the chemical processes taking place during sulphidization were not only complicated by the sea water, but also by the nature of some forms of oxidated lead ore. For example, when reagents used in the process are added to sea water alone, the optimum pH (about 8.5. to 9.0) needed for the process remains constant. In the presence of some types of oxidated ore, the pH also remains constant. But when other types of the oxidated ore are present, there appears a sharp fall in pH accompanied by some colour change from black to yellow.

Sodium carbonate and silicate are other two reagents added to the mixture to be sulphidized for the purpose of controlling the pH. When the sea water is added, quite a lot of them get precipitated down due to the presence of, most probably, high concentration of alkaline earth cations in the water. Much more of these reagents have therefore also got to be used when sea water (instead of fresh wter) is used.

In view of the above facts, samples of lead ore and sea water were collected and brought to our laboratory order to obtain their detailed chemical composition.

The determination of individual constituents of the ore and sea water were started just before the end of the year. Work for the rational chemical analysis of lead in the ore was also planned to be done during the course of the coming year. By rational analysis is meant a method by which different compounds of an element are separated from each other. It is hoped that data obtained from these samples would help to elucidate some of the complex chemical reactions taking place when sea water is used to process the oxidated lead ore.

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## CERAMICS

I. M. Mbaka and R. A. Chapman

### *Kisii Stone-Report from Leeds University*

During the period under review, Miss J. Dorman, an undergraduate student at the Ceramics Department, Leeds University has been studying some properties of Kisii stone (1). A summary of the main conclusions is:-

- the unfired stone is a mixture of kaolinite, illite and muscovite
- the illite and kaolinite exhibit a preferred orientation
- after firing above 1100°C, the principal mineral is mullite, which also displays preferred orientation
- After firing at 1250°C, the modulus of rupture of the materials was about 140 MN.m.<sup>-2</sup> (21000 lb. in.<sup>-2</sup>)
- Young's modulus was  $10 \times 10^4$  MN.m<sup>-2</sup> (about  $12 \times 10^6$  lb. in.<sup>-2</sup>)
- the volume resistivity at 750°C was 10<sup>4</sup>ohm. cm (and by extrapolation, the volume resistivity at room temperature was 10<sup>13</sup>ohm.cm)
- thermal expansion coefficient of fired stone normal to the preferred orientation direction was  $3.6 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ , and parallel to preferred orientation was  $5.1 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ .

Whilst these results justified previous assumptions made at E.A. Industrial Research Organization, they also added new and potentially valuable data.

A point of particular interest concerns the anisotropy of the stone in both the natural and fired states. The practical significance attached to this is the uncommon requirement of fitting a glaze to a highly anisotropic body and the large resultant stresses which will be imposed upon the glaze/body composite at particular points on the body surface.

The permanent solution to this problem may be difficult to find.

- (1) J. F. Dorman "Properties of Kisii Soapstone as a Ceramic Material".  
Leads University 1976.

### *Kisii Stone - Electrical Insulators*

Work on this aspect of the use of Kisii stone has lapsed during the present year, largely due to the lack of interest of the other parties involved.

Only one note of practical interest can be reported—namely, that the standard glaze used at Ceramic Industries of East African Limited fitted several samples of fired stone body. The problem of glaze-body fit had hitherto been a major stumbling block and an area in which little progress had been made.

The present state of our knowledge and art concerning insulator production may be summarized as follows:-

- staywire and pin insulator shapes can be produced
- careful firing to 1250°C gives an almost impervious body
- glaze can be successfully applied to the fired body by spraying
- finished insulators have adequate flashover properties in both wet and dry conditions.

—tensile strength of the finished articles just meets the necessary standard although attention to production details should improve the margin of safety.

Thus the project seems poised ready to reach a conclusion on the next upsurge in enthusiasm.

### *Blackboard Chalk*

As reported in the previous Annual Report, the feasibility study of the economic viability of the chalk project was completed. This was after the product had been tested in a number of schools in Nyanza and Nairobi areas and found to be comparable to the chinks available on the market.

To finance the project, Kenya Industrial Estates Limited made a comprehensive study of the economics of the project and agreed to provide a loan amounting to Sh. 35,000. This loan, together with the existing capital, assessed to be Sh. 97,000, would bring the total cost of the project to Sh. 132,000/-.

It was estimated that the factory would produce about 20,000 boxes of chalk per day and make a net profit of about Sh. 20,000. Initially the factory would employ 10 people. After the employees have mastered the production techniques, the unit would expand its operations and in this way offer more employment opportunities both directly and indirectly.

As a condition for obtaining the loan from Kenya Industrial Estates, the entrepreneurs have been asked to form a legal body. In addition to this, the outstanding questions regarding the ownership of the existing building and machinery should be settled. The local authorities, as well as the Ministry of Education, were also asked to declare their willingness to assist the company in the marketing of the products. This was suggested because it was felt that the Tabaka chalk project can only survive if given Government protection. The proposed protection would give the unit a monopoly of supplying chalk to schools in Kisii District (especially primary schools which obtain their supplies from a centralized source).

### *Tanzania Brick Projects*

#### *Dodoma Clays*

Assessment of clays from several sites near Dodoma were completed in the year under review. Particular emphasis was placed on clays from Singe and Bihawana. A comprehensive report on the work carried out has been passed on to the Capital Development Authority.

As a result of this work, proposals for the construction of a multi-million shillings factory at Dodoma have been worked out. The factory is intended to manufacture building materials for the new capital at Dodoma.

#### *Clays from Pare District*

Advisory services for the improvement of the quality of bricks from Hedaru and Usangi were given after carrying out laboratory tests on clays from these areas.

The Hedaru works has remarkably increased its production and three semi-permanent kilns have been erected. This coupled with improvements in

making and drying of bricks and also the reduction in breakage has resulted in trebling the finished product.

If funds are available, it is hoped that this Organization would assist in building a more permanent kiln, both at Hedaru and Usangi.

#### *Hai Clays*

At the end of the year under review this Organization was approached by the District Development Director, Hai District of Kilimanjaro Region, with a request to test clays from Sanya Juu with a view to starting up brick works in the area.

#### *Wall Tiles*

The research on this topic was concluded in the period covered by the previous Annual Report. However, it may be added that the company, Messrs. Ceramic Industries of East Africa Ltd., has embarked upon a programme of modernisation and reorganisation within its factory to accommodate a wall tile production line.

A new Italian wall tile press is to be acquired to replace the slower and smaller existing tile press. In addition, a waterfall glazing unit is to be installed to provide automatic glaze application to the tile surface. Such a production line may produce five million tiles a year on a single shift basis.

#### *Blunger*

The Organization was approached by the Pottery section at Eastleigh Community Centre in Nairobi to design and construct a blunger.

A blunger is the technical name given in the pottery industry to a mixer used to disperse clays and other body constituents in water. In essence, a blunger comprises a mixing vessel fitted with a stirrer driven through a suitable reduction gear.

The constraints applied to the EAIRO blunger were :-

- nominal capacity of 150 litres
- electrically driven
- maximise use of second hand/scrap parts

Although the use of a concrete stirring tank would have reduced the total cost, a custom built sheet metal tank was supplied by the sponsor. This was bridged by a length of 6x3 channel section which afforded support for the electric motor and stirrer and also formed part of the housing for the reduction gear box.

The reduction gear and right-angled drive were made from parts of an old Auto Union car gear box and differential unit. Parts from this unit, including a pair of suitable gears, bearings, oil seals, crown wheel and pinion shaft, were selected, removed and cleaned. With these parts, a 12:1 reduction gear box with right-angled drive (provided by the crown wheel and pinion was constructed. The stirrer itself was made from an old lorry half-shaft.

The assembled blunger was driven through a flexible coupling by a re-conditioned 1 Hp motor.

The total cost of the blunger was about Shs. 3,000 compared with an estimated price of Shs. 7,000 for an imported machine.

The blunger is now giving satisfactory service at Eastleigh Community Centre.

### *Pozzolana*

Pozzolana and possolanic cements have been a subject of interest to this Organization for some time now. Research work into these materials started way back in 1942 but for some reason or other ceased after the war. Detailed reports of the scientific findings are however not available in the records.

### *Karima Hill Pozzolanas*

Records show that amongst the pozzolanas studied were those from Karima Hill near Othaya in Nyeri District. The deposit occupies a series of hills and the local residents have used this material as a white-wash for their houses since reportedly many decades back. The use of this material was however stopped by a Government decree in the fifties when a landslide resulted in the killing of a few dozen people in this area. The land was at the same time taken over by the Government.

This Organization was interested in this material for use as a replacement for cement in making concrete and blocks.

The reports available recommended the ratio sand: pozzolana:lime of 9:3:1. This formulation was tried but the result was unsatisfactory. The rate of setting was reportedly fast but the strength of the cubes was poor, the cubes disintegrating by mere pressure of the fingers.

Several other ratios were tried with higher proportions of both lime and pozzolana but the increase in crushing strength was only minimal. It may therefore be necessary to try pozzolanas from other sites in the same area as well as from other locations. At the same time it is proposed to investigate the use of this material first as a cement before including other aggregates to use as blocks/concrete.

### *Miscellaneous*

During the review period, a number of organizations and individuals have sought the help and advice of the Section on a variety of topics. Amongst these were:-

- Small Industries Development Organization, Arusha, on problems concerning pottery and glazing.
- Refractories Limited, Kamiti, concerning the improvement of existing refractory products.
- J.K. Mbugua, Nakuru, on polystyrene filled panels for building purposes.
- Dr. Meemeduma, Nairobi University, on the use of fired Kisii stone for tiling.
- Several individuals on kiln maintainance problems.

## CHEMICAL ENGINEERING

### F.A.M.M. Kessy

#### *The Extraction of Diosgenin From Fenugreek Seeds (Trigonella Foenum Graecum. L)*

The work on the extraction of diosgenin from fenugreek seeds (methi) was started in this Organization at the request of a pharmaceutical company in Nairobi. The company wanted us to investigate the possibility of putting up a pilot scale process plant which could later be transformed into a manufacturing unit for the extraction of isogenin.

Diosgenin is a steroidal sapogenin of considerable economic importance to the pharmaceutical industry as a starting material for the medicinally useful steroidal drugs. The group of drugs includes those which are used as anti-inflammatory agents and for the treatment of certain skin disorders, sex hormones (some of which are used as oral contraceptives) and some used in the treatment of asthma.

The present market for diosgenin is estimated to be 1,300 tonnes per annua. The main sources of the compound at present are certain wila yams which grown in Central America and the Himalays. With an increasing demand for diosgenin and the depletion of existing wild yam stocks, efforts are being made to find alternative sources for the compaound such as the spice fenugreek.

The spiece fenugreek is a legume with a growing cycle of 4-6 months. Laboratory experiments conducted here using unground seeds were based on patent specification by Roland Hardman published in December 1968. These experiments have shown that the seeds contain about 6.5% of a mixture of diosgenin/yamogenin and the fixed oil. This work was left in abeyance because the firm withdrew their request after the initial laboratory tests had been completed.

#### *Sodium Hypochlorite Bleach*

A producer of bleach solution which is normally marketed at a level of 14-15% available chlorine, was concerned about usually rapid deterioration of his product and requested the Organization to look into the cause of the problem and advise.

A qualitative analysis of the sample of the bleaching liquor was carried out and was found to contain traces of iron. The presence of metal traces like iron in contact with the bleaching solution causes it to decompose. The production plant used for manufacturing the bleach was inspected and the firms attention was drawn to a number of shotcomings of their plant and procedure.

Repairs and modifications were carried out by the firm according to our suggestions and it has been reported that the bleaching liquor is now satisfactorily stable.

### *Fuel Advisory Work*

During the year under review we were approached by a dry cleaning and laundry firm to determine the steam consumption of their work as an aid to efficient management.

Steam was raised in an oil fired boiler and supplied to the works at two pressures i.e. low and high pressure lines. The low pressure was obtained from the boiler pressure through a regulator. Each steam supply line was monitored with a steam flow meter over a period of about four weeks so as to arrive at a good estimate of the demand of the works. This demand varies with the work load of both laundry and drycleaning machinery as well as from minute to minute.

From the above observations the following recommendations were made:

- (a) A boiler size 3,000 lb/hr steam capacity should be installed. so as to meet their steam demand.
- (b) Preheating of combustion air so as to save fuel consumptions should be investigated.
- (c) Flashing of condensate returned from machines operating at high pressure should be used to provide low pressure live steam for use in the washing machines.

## FIBRE TECHNOLOGY

A.H. Bowles

Little progress has been achieved in the development of this section in spite of the selection of two suitable candidates for Research Officer (Trainee) appointments in the section. By the time of writing these appointments had not been finalized for reasons beyond the control of the Organization.

### *Textile Manufacturing Industry*

The report of the Working Party on Textiles which absorbed a considerable effort during last year was distributed to the Partner States through the Standing Committee of Officials of the East African Common Market Council. Unfortunately we have received no feed-back or substantial enquiries from the manufacturers who were the prime targets for the report. We have learned that in one partner state a committee was formed to consider the recommendations and they were categorised in three ways:

- 1) Recommendations that were already to be implemented under existing schemes.
- 2) Recommendations that deserved further consideration for implementation in the foreseeable future.
- 3) Recommendations that were rejected as impracticable or inadisable.

We are sorry that the report was considered in our absence as we believe that the thinking behind the bare substance of the report and its recommendations would have been of use to the committee.

### *Sisal Manufacturing Industry*

The research into novel methods of manufacturing sisal twines and fabrics has been delayed by the lack of funds dedicated to the project and the continued vacancy of the Research Officer (Trainee) appointments in the section. These officers were to undergo training in association with the research project in order to ensure an effective transfer of the novel technology to East Africa.

Since the monetary return on sisal growing comes overwhelmingly from the sale of the fibre and hecogenin production is merely a profitable sideline, depending upon the readily available waste from fibre decortication, it is evident that this source of hecogenin may be expected to decline as hybrid sisal represents a larger fraction of production.

### *Coir*

The F.A.O. Hard Fibres meeting brought to Nairobi Mr. C.G. Jarman of the Tropical Products Institute as the Chairman of the Advisory Working Party on Hard Fibre Research. This opportunity was taken to obtain his assistance in making a cursory survey of coir preparation and manufacture in Zanzibar as requested by the Ministry of Trade and Industry of Zanzibar.

The industry in Zanzibar is being reconstructed and produces yarn, carpets and brushes. A number of recommendations were made and a carpet loom is under construction at E.A.I.R.O. to demonstrate the manufacture of carpets of up to 1 m width.

A major problem of this industry is the amount of coir dust waste generated at the factories. This waste occupies large areas of ground that could readily be put to use. Return of the waste to the coconut groves would return to the soil the useful potash content as a fertilizer. Burning of the waste to obtain steam, or merely heat for drying processes, is rendered difficult by this same high potash content which produces a readily fusible ash. The problem of profitable disposal of coir waste has been raised at the Advisory Working Party on Hard Fibres Research and is being studied in India and Sri Lanka where its impact is so much greater.

#### *Kenya Bureau of Standards*

The Organization has been invited to participate in the Textile Industry Committee of the Kenya Bureau of Standards and expects to contribute also to the Technical Committees concerned with textiles.

#### *Absorbent Cotton Wool*

The section provided technical backing for the firm interested in installing absorbent cotton wool processing facilities in East Africa during meetings with potential suppliers. The technical characteristics of each proposed plant were discussed with particular reference to costs, site conditions and available labour for the products of interest. The feasibility and economic viability of the projected plants are under further consideration by the firm.

#### *By-Products from Sisal*

The Intergovernmental Group on Hard Fibres of the F.A.O. met in Nairobi in February and an informal meeting of the Advisory Working Party on Hard Fibres Research was convened at the same time and reported to the Intergovernmental Group.

A contribution to the Working Party's deliberations was prepared under the title of 'By-products from the Production of Sisal Fibre.' Diverse products that can be extracted from sisal waste were considered and it was noted that in spite of extensive work, at E.A.I.R.O. and elsewhere, only the extraction of hecogenin from the decorticator waste of *Agave sisalana perrine* had reached commercial viability. The extraction of a hard wax from sisal waste was noted as being probably the next most feasible product, but research is needed to develop the actual process by which it could be carried out economically.

During the collection of information about the extraction of hecogenin in East Africa it became evident that a conflict of interests had developed between the production of fibre and of hecogenin. This arises from the facts that the hybrid sisal variety 11648 developed at Mlingano is capable of yielding more fibre than *Agave sisalana*. However, the sapogenins obtainable from the hybrid consist largely of tigogenin rather than hecogenin and as yet tigogenin has no outlet on the market.

# FOOD PROCESSING TECHNOLOGY

R.O. Arunga and J.F. Okorio

## *Introduction*

The major fields of research have remained basically the same i.e. utilization of the food processing wastes, fruit, oilseeds, and cereal processing. Short-term analytical services and technical advice have also been rendered to clients on a variety of food products, including meat and milk products. In cereal processing, the emphasis has been on sorghum and finger millet. In East Africa, the acreage suitable for maize is relatively on the decrease and it is expected sorghum and millet will increasingly play an important role in traditional as well as non-traditional sorghum and millet areas. Nutritionally, most cereals only marginally satisfy protein requirements when taken together with other food items containing low amounts of protein. There have been various suggestions for cereal products fortification, restoration or enrichment. Intensive research has shown that soybeans can provide a cheap source for high-quality protein and fat. Proper processing of soybeans is necessary in order to destroy harmful enzymes and trypsin inhibitors. The project on extrusion cooking sponsored by the U.S. Agency for International Development has therefore provided a useful tool for the extension of laboratory research results into meaningful field trials. Similarly, several government agencies and companies have expressed interest in extending our findings on brewing of beer from finger millet into large scale production. The complete data on processing including machinery is now available for any party interested in pilot scale production.

## INDUSTRIAL BY-PRODUCTS

### *Bones*

Bones collected from various sources are normally steamed and milled for the production of bone meal used as animal feed or fertilizer. Local companies producing bone meal have been helped with complete analysis of the bone meal constituents. Of particular importance are the protein, calcium, phosphorus contents and bacterial counts. If used as a feed then the heat treatment should be sufficient to reduce the total bacterial count and eliminate the pathogenic species.

The by-product of the steam-rendering process contains 10–12 per cent fat. The fat contains palmitic, stearic, oleic and linoleic acids. Following a specific request, crude steam extract was hydrolysed with acid to give enough fat for making a sample of soap. Simple formulation with vegetable oils have produced reasonably good soap.

## OILSEEDS

Various Oilseeds have been analysed in the past year. A typical example is presented below. The work on soybeans is reported along with the project on the Brady Cooker.

### Tea Seeds

Tea seeds were sent by a client interested in the production of tea seed oil and animal feed. The tea seeds consisted of 64.8 per cent kernel and 34.4 per cent shell. The kernel contained the following constituents:

Constituent	Per cent
Moisture	9.1
Crude Protein (N x 6.25)	8.4
Oil (Ether Extract)	21.7
Crude Fibre	2.2
Nitrogen-free extract (by difference)	48.6
Mineral Matter	10.0

Although the cake left after oil extraction may be suitable as a feed, it has been reported that it contains a toxic saponin. Tea seed oil can be used for edible purposes after refining. The component fatty acids will be determined in due course.

### FRUIT PROCESSING

#### Cashew Apple Juice

Experiments started in the previous year have shown that the shelf-life of a pasteurised clear cashew apple juice is reasonably long. The vitamin C contents of the bottled juice have only decreased slightly after storage for one year at room temperature. Acidity of the juice has remained constant, while the colour has changed slightly to pale green, may be as a result of reactions involving residual tannins. No precipitations were observed in all the samples.

#### Results of Cashew Apple Juice Storage Experiments.

Sample No.	December 1974		Vitamin C mg/ 100g	Colour
	Acidity	per cent as Citric		
1		0.42	150	Clear
2		0.42	130	"
3		0.41	140	"
4*		0.40	160	"
	January 1976			
1		0.39	102	Clear, pale green
2		0.38	100	"
3		0.42	90	"
4*		0.40	136	Clear

\*Refrigerated Sample.

### *Cashew Apple Jam*

Ripe cashew apples were carefully washed and inspected. Black spots were removed with knives. The apples were steamed for 10 minutes under pressure and then macerated in a blender. After the adjustment of pH with citric acid to 3.3, an equal amount of sugar was added. The mixture was heated in an open pan at 80°C to obtain 65% Brix. The jam was poured hot into jars and stored at room temperature.

### *Cashew Apple-Mango Jam and Jelly*

Cashew apple puree prepared as described above was mixed with mango puree in different proportions to prepare jams and jellies. Mango puree was obtained from ripe *ngowe* varieties. The jellies were prepared by the addition of sugar and pectin to the mixed purees and concentrating to 68–70] Brix. The hot jellies were poured into clean stainless steel pans, allowed to cool and cut into appropriate sizes for packing.

# EVALUATION OF THE BRADY EXTRUSION COOKER FOR DEVELOPMENT OF PROTEIN-RICH FOODS IN EAST AFRICA

## *Introduction*

The necessity to improve and increase the use of protein in human feeding is attracting attention in East Africa. Both governmental agencies and private industry are aware of the problem and are seeking ways and means of coping with it. Volunteer organizations and bilateral assistance programmes are also strongly oriented to provide more and better proteins to the needy and in particular to infants and children. This report outlines the various test activities and developments in the field of protein-rich foods in East Africa, by use of a simple extrusion cooker.

## *Objectives*

In mid 1974 the E.A.I.R.O. and U.S.A.I.D. signed a memorandum of understanding to define in general terms the work to be performed by each party. The broad objective of EAIRO's work was to evaluate a Brady extruder cooker to assess the usefulness of this type of machine for manufacture of low-cost nutritious foods and food ingredients in East Africa. More specifically, interested parties i.e. National Milling Corporation (NMC) and Africa Basic Foods, (ABF) requested the following:—

- (a) to use locally available raw ingredients, to produce at as low cost as possible:
  - (i) a precooked weaning food.
  - (ii) foods for school-age children.

## *THE RESEARCH PROGRAM*

The following research program was drawn to fulfil the above objectives:—

### *Weaning Foods*

We aimed at a food product that would be of high protein (15 to 20%), be well cooked and of low fiber content. Consequently, we had to use dehulled seeds and put emphasis on food mixtures containing 70% cereals and 30% oilseeds. In addition other mixtures considered contained 90, 80% cereal and 10, 20% oilseeds, respectively.

### **BREAD FORTIFIERS AND ENRICHED FLOURS**

#### (a) *High Protein Breads*

Of all protein-rich foodstuffs now available, soyflour is most attractive in price and nutritional quality for fortifying wheat flour to produce high protein breads. However, soyflour can induce adverse effects on absorption, mixing and fermentation of the dough as well as on volume grain, and color of bread.

To alleviate these effects research workers in the USA have generally used additives. In pursuing this approach Dr. Tsen of Kansas State University has used SSL (Sodium Stearoyl -2 - Lactylate) to produce

acceptable breads. USAID (Dr. Paul R. Crowley) kindly sent us about 2 kilos of SSL for this research.

ABF and Kenya School Feeding Council specifically requested production of 2-3 tons of soy flour to be used in Feeding Programme in selected schools as a substitute for the currently used "SUPRO". A private enterprise has developed a protein-rich mixture under the name of "SUPRO" and the mixture consists of dried skimmed milk (15.0%) yeast (23.6%) barley flour (46.8%) salt (10.7%) and flavoring (3.8%). With 25% protein the price of the mixture is fixed for Shs. 2.00/lb.

(c) *Acceptability Studies*

We therefore planned to study the acceptance of soy flour amongst school-aged children who had been using "SUPRO" for at least one year.

EXPERIMENTAL EVALUATION

*Raw Ingredient Analyses*

Table 1. shows crude protein, moisture and fat of the food ingredients used in test runs. Protein estimation was by the Kjeldahl Method (N X 6.25).

Table 1  
*Proximate Analyses on Raw Ingredients*

<i>Ingredient</i>	<i>Moisture</i> %	<i>Proteins</i> % <sup>5a6</sup>	<i>Fat</i> %
Whole Maize	10.5	8.1	4.5
Dehulled Maize	11.2	7.3	1.0
Polished Rice	11.5	7.7	0.8
Finger millet	10.9	7.1	1.3
Whole Soybean	6.0	41.2	17.5
Dehulled Soybean	6.1	39.4	10.3
Whole Sesame	4.5	19.5	51.2
Whole Peanut	5.5	29.1	41.4

*Test Runs*

Prior to the actual runs, all test materials were cleaned through a dockage tester to remove foreign materials (stones, stalks, sand etc) and in some cases the cleaned ingredients were dehulled in a CeCoCo Rice Polisher with the setting of the discharge weight fully-in (i.e. mildest mechanical action). Percent total recoveries ranged between 91 and 95.

All test runs were made with the Brady Model 206 Crop Cooker driven by a diesel engine with a 100 HP rating. The drive speed was 650 rpm for all runs. The test runs were used to produce samples of extrusion cooked products specifically requested by identified interested parties.

The raw and ground ingredients were continuously fed into the cooker and the cooking temperature was controlled by adjusting the clearance in the discharge cone. After a cooking temperature had stabilised for more than 5 minutes, a cooked sample was taken for product evaluation. The cooker was then adjusted to produce other cooked samples at increasingly higher temperatures. Products were cooled by spreading on a paper covered concrete floor immediately after processing.

The tests conducted are outlined below and specific information on the tests may be found in Table 2.

### **General Observations on Various Test Runs**

#### *Soybean for nalations*

##### *70% Maize 30% Soybean (dehulled)*

After preliminary runs, it was found that a cooked product could be obtained at 310°F for this combination. No water additions were made. Output rates averaged 1,200 lb/hr at 650 rpm. All the material easily processed in trouble-free operations. No puffing was present at this temperature.

We produced nearly 2,000 lbs of this material for NMC in Tanzania for their acceptability studies.

*80% Maize (20% Soybean)*. This mixture gave us no problem. Cooking temperature was at 320°F and output rates averaged 1020 lb/hr. However we noticed some slight scorching at 325°F and no puffing was apparent. Another 800 lbs of this product was extruded for the National Milling Corporation of Tanzania.

*90% Maize (10% Soybean)*. Operations with this mixture were erratic and could not be stabilised to yield a uniform product. This was probably due to the degermed maize. There was considerable amount of puffing and scorching even at 310°F with 650 rpm. As a result, it was concluded that the Brady is probably not suitable for cooking this mixture without some modifications. The product appeared and tested raw.

*100% Soybean (dehulled)*: Soybeans processed easily and at 260°F or above was found to be adequately cooked. About 100 lbs of soy-flour was produced for bread fortification experiments. Also another 3,000lbs was produced for ABF, which was used in School feeding trials in Kenya.

### **Peanut Formulations**

#### *75% Maize 25% Peanut (Crushed)*

We had no problem with this run. However, the product was denser and this was probably due to suppression of puffing by higher oil content in peanuts. Some free oil was noted. Output rates averaged 960 lbs/hr.

#### *85% Rice 15% Peanut (rushed)*

No trouble during operation. Temperature and output were stabilised. The product was good and well puffed.

Table 2

## Input and Extruder Characteristics

Proportion of Ingredients						Ground/Unground	G or U	Water Added (GPH)	Feed Auger Setting	Cone Clearance (turns out)	RPM	Horse power	Output Rate (lbs/hr)	Temperature
Cereals			Legumes											
Sample Number	Maize	Rice	Soybean	Peanut	Sesame									
1	70		30			G	0	2.0	2.0	650	100	1200	310	
2	80		20			G	0	2.0	1.9	650	100	1020	320	
3	-	-	100			U	0	2.0	2.5	650	100	1140	290	
4	75			25		G	0	2.0	2.2	650	100	960	300	
5		85		15		G	0	2.0	1.8	650	100	1090	320	
6	75				25	-	-	-	-	-	-	-	-	
7	90	-	-	-	10	-	-	-	-	-	-	-	-	
8		60		40		G	0	2.0	1.7	650	100	1300	310	
9	80				20	-	-	-	-	-	-	-	-	
10		50			50	G	0	2.0	2.2	650	100	1380	315	

COMMENTS Although the most delicious product was produced in sesame formulation, the runs had to be abandoned because of plugging. Product was "delicately porous" and had ability to simply dissolve in ones month; could prove smashing SNACK

### Sesame Formulations

70% Maize: 30% Sesame

Operations with sesame were erratic. There was uncontrollable puffing. However, the product pieces which managed to come through had an exceptionally pleasant taste. The product simply dissolved into ones mouth on tasting!

#### Product Analyses:

The extruded products were analysed for protein, fat and moisture. Their values are given in Table 3.

Table 3

*Proximate Analyses for Cooked Products*

<i>Product</i>	<i>Moisture</i> %	<i>Fat</i> %	<i>Protein</i> % (a)
70% Maize : 30% Soy	5.0	8.7	16.9
80% Maize : 20% Soy	6.9	7.1	16.2
90% Maize : 10% Soy	9.0	4.0	9.5
100% Soy	4.0	21.0	35.3
80% Maize : 20% Sesame	7.0	9.0	12.8
90% Maize : 10% Sesame	7.0	11.0	10.7
60% Rice : 40% Soy	6.0	14.0	21.4
50% Rice : 50% Soy	5.0	10.0	20.4

(a) Protein is %N x 6.25

*Product Use Tests*

As for the potential applications for the extruded products, soy flour lent itself to application in two areas viz (1) as an enrichment agent in bread (2) as a replacement for the expensive "SUPRO" marketed in East Africa.

*High-Protein Bread from Wheat Flour Fortified with Full-Fat Soy Flour Extruded From the Brady Crop Cooker*

These baking tests were carried out at the Wheat Quality Control laboratories of the Ministry of Agriculture at Njoro, Kenya.

*Abstract*

Fortifying wheat flour with full-fat soy-flour in making bread can raise protein content, balance essential amino acids, and increase bread's calorific value. Such fortification can adversely affect baking quality of wheat flour.

Sodium stearoyl-2-lactylate (SSL) could increase the stability of dough containing 8% soy flour. The effect was enhanced with increased additions of SSL (0.25 to 3.0%). The breads with 4% to 24% soy flour exhibited a small loaf volume. When 1.0% SSL was added acceptable bread resulted from wheat fortified with soy flour up to 16%.

Protein malnutrition, a serious problem of people whose diets consist mainly of cereal or starchy food, has aroused keen interest in fortifying breads or other products with protein-rich foods. Of all the protein-rich additives now available, soy flour is most attractive in price and nutritional quality. Soy flour has been extensively studied and generally recommended as a bread fortificant. However, in many poverty areas where diets are deficient in both protein and calories, full-fat soy flour can become an ideal supplement because of its high protein and fat content. Furthermore, to produce full-fat soy flour, simple and low cost equipment like the Brady Crop Cooker can be set up and run in Africa.

Many workers, notably Finney et. al. (1), Pomeranz e.al.(2), and Tsen et.al. (3) have shown that adding glycolipids and dough conditioners improve baking performance of flours fortified with soy products, mostly defatted soy flour.

Bookwalter et.al. (4) used extrusion-cooked, full-fat soy flour in high-protein bread. They found that loaf volume decreased less with extruded products than with non-extruded, full-fat soy flour.

Our study, part of a research program on low extrusion cooker for production of low cost nutritious foods, was undertaken to examine dough and baking properties of wheat flour fortified with full-fat soy flour and their changes with the added sodium stearoyl-1 lactylate (SSL).

## Materials and Methods

### Materials

Wheat flour was milled by a commercial mill for home-baking. Although this is a weak wheat flour it is the most available. The full-fat soyflour was cooked in the Brady at 260°F. Their proximate analyses were:

Flours	Moisture	Protein a	Fat
Wheat flour	11.0	10.8	-
Full fat Soyflour	4.0	35.0	21.0

- (a) Protein content is  $\%N \times 6.25$  for Soy and  
 $\%N \times 5.7$  for wheat flour.

### Farinograms

Farinograms were obtained by the constant-dough weight methods, using 50 grams of sample (5).

### Baking Test

The "Remix" Baking Test (6) was used. The method requires no skilled punching, detects extreme strength more readily and discriminates more widely between strong and weak flours.

### Formula

Flour (14% mb)	100.0 g
Water (distilled)	Variable
Yeast	1.2 ADY (25 ml)
Sugar	2.5 g
Salt	1.0 g
Potassium Bromate	1.5 mg %
Phosphate	0.1 g
Malt	0.3 g

### Procedure

- (1) Mix ingredients for 2.0 minutes in a mixer (National mfg Co., Linco In, Neb)
- (2) Ferment for 140 minutes at 30°C.
- (3) Ferment for 25 minutes (recovery time).
- (4) Sheet and mould.
- (5) Proof for 55 minutes at 30°C (86°F).
- (6) Bake 25 minutes at 430°F.

### Results and Discussion

#### *Rheological Properties of Doughs Fortified with Various Percentages of Full-fat Soy Flour and Treated with and without 1.0% SSL*

#### *Farinograms*

Table 4 shows changes in absorption, developing, time, and stability of doughs of wheat flour fortified with 0 to 24% soyflour with and without SSL added.

Absorption of the fortified flour dough increased slightly as full-fat soy flour was increased. Dough peak time was 5.00 min for wheat flour dough and 6.50 min for dough fortified with 24% soy flour. Despite the different percentages of fortified soy flour, changes in peak among fortified doughs were extremely little. Surprisingly dough stability increased with increased levels of soy, probably due to lecithin in full-fat soy flour. . .

Adding 1.0% SSL did not affect absorption, but could delay dough development and increase dough stability of wheat flour fortified with soy flour.

Table 4

*Farinographic Characteristics of Wheat Flour Fortified with Indicated Percentages of Full-Fat Soy-Flour and SSL*

Full Fat Soy Flour %	NIL				1.0% SSL		
	Protein %	Absorption %	Peak Time Min.	Stability Min.	Absorption %	Peak Time Min.	Stability Min.
0	12.8	58.0	5.00	7.5	56.8	2.0	14.0
4	13.5	57.4	6.00	8.0	56.8	9.25	15.5
8	14.4	57.2	5.50	8.5	—	8.0	17.0
12	15.9	58.0	4.50	9.0	55.6	10.0	17.5
16	16.8	59.0	5.50	9.5	57.0	10.0	17.0
20	18.4	59.2	6.00	11.5	57.4	10.0	17.0
24	20.6	60.2	6.50	13.0	59.2	9.25	17.0

Protein is N% x 6.25

To substantiate that SSL could increase mixing stability of dough containing soy flour, additional tests were made to examine effects of SSL added at 0.25, 0.50, 1.00, 1.5, 2.0, 2.5 and 3.0% SSL on doughs containing 8% full-fat soy flour. That both dough developing time and stability increased as SSL increased confirmed the dough strengthening effect of SSL for soy fortified dough (Table 5).

#### *Effect of Different Percentages of Full-fat Soy Flour on Baking Quality*

To explore how much full-fat soy flour could be used, we fortified wheat flour with 4, 8, 12, 16, 20 and 24% soy flour and evaluated their baking performances. The "Remix" Baking Test (6) was employed.

Table 6 shows adverse effects of full-fat soy flour on loaf volume of finished bread: loaf volume decreased progressively with the soy flour increments.

The improving effect of SSL was obvious. Without 1% SSL, all finished breads supplemented with 8 to 24% soy flour had small loaf volumes. However with 1% SSL, breads made from wheat flour fortified with soy flour upto 16% had acceptable specific volumes.

Table 7 gives other alveographic data and the alveograms are given together with farinograms.

#### *ACCEPTABILITY STUDIES ON SOYFLOUR AS A SUBSTITUTE FOR "SUPRO" IN KENYA SCHOOL LUNCH PROGRAM*

##### *(1) General*

An extensive survey on feeding habits and nutritional state in Kenya was performed by Bohdal and co-workers in 1968. Its recommendations led to the introduction of school lunches. Directives were given as to the composition of the meals and the quantities to be supplied.

The school feeding programme is supervised by the Kenya National School Feeding Council. The Executive Officer is responsible for its organization. He is assisted by field officers who distribute the food over the schools in the district, and collect the money paid for it by the parents.

The parents pay 13 Kenya Shillings a term per child i.e. c.2 US cents a day (July 1976). Although this contribution appears reasonable there are many parents who cannot afford this expense in addition to the school fees in Standards 5 and 6. During the second term of 1976 over 42,666 children were involved in the programme. So far no systematic evaluation of the effects of the programme had been carried out. The National School Feeding Council needs hard figures to demonstrate the usefulness of the school lunches and to acquire the government's financial support for an extension of the program to areas where it is most needed.

Table 5

*Farinographic Characteristics of Wheat Flour Fortified with 8% Full-flour and Treated with Indicated Percentages of SSL*

<i>Full-fat Soy flour</i>	<i>SSL %</i>	<i>Absorption %</i>	<i>Peak Time Min.</i>	<i>Stability Min</i>
0	0	58.0	5.0	7.50
8	0	57.2	5.5	8.5
8	0.25	—	6.6	10.0
8	0.50	56.2	5.25	12.0
8	1.00	—	8.0	17.0
8	1.50	55.8	7.75	18.75
8	2.0	55.0	13.25	19.00
8	2.5	55.0	17.75	18.75
8	3.0	53.4	16.25	18.75

Table 6

*Effects on Baking Quality of Fortifying Wheat Flour with Indicated Percentages of Full-fat Soy-Flour and SSL*

<i>Soy flour %</i>	<i>SSL %</i>	<i>Absorption 1 %</i>	<i>Volume CCS</i>	<i>Volume CC/g</i>
0	0	58.0	560	4.3
4	0	57.4	490	3.4
8	0	57.2	500	3.8
12	0	58.0	450	3.5
16	0	59.0	420	3.2
20	0	59.2	430	2.9
24	0	60.0	370	2.9
0	1.00	56.8	640	5.1
4	1.00	56.8	625	4.9
8	1.00	—	—	—
12	1.00	55.6	570	4.5
16	1.00	57.0	560	4.3
20	1.00	57.4	510	4.0
24	1.00	59.2	480	3.8
8	0	57.4	500	3.8
8	0.25	—	—	—
8	0.50	56.2	560	4.4
8	1.00	56.0	575	4.5
8	1.50	55.8	530	4.2
8	2.00	55.0	530	3.4
8	2.50	55.0	530	3.4
8	3.00	53.4	430	2.9

Table 7

## Farinographic &amp; Alveographic Characteristics

Soy Flour %	SSL %	Protein Percent	Farinograph					Alveograph			Loaf Volume
			Abspt. Percent	Peak Time	Stabi- lity	Tolerance	Stabi- lity	Strength	L/P		
0	0	12.8	58.0	5.00	7.50	60	100.8	43.5	1.05	560	
4	0	13.5	57.4	6.00	8.00	55	108.0	33.7	0.55	490	
8	0	14.4	57.2	5.50	8.50	55	122.4	31.2	0.40	500	
12	0	15.9	58.0	4.50	9.00	30	133.2	29.0	0.28	450	
16	0	16.8	59.0	5.50	9.50	35	140.4	32.2	0.26	420	
20	0	18.4	59.2	6.00	11.50	35	153.6	31.0	0.21	430	
24	0	20.6	60.0	6.50	13.00	25	148.8	40.6	0.78	370	
0	0.25	12.7	58.0	1.50	8.75	20	93.6	31.8	0.97	550	
0	0.5	12.2	58.2	1.75	3.00	40	91.2	47.3	1.23	615	
0	1.0	12.5	56.8	2.00	14.00	40	94.8	44.2	1.21	640	
0	1.5	12.1	58.0	1.50	3.75	55	110.4	44.2	0.92	603	
0	2.0	12.1	56.8	1.50	3.00	60	112.8	41.6	0.69	573	
0	2.5	12.1	56.0	1.25	1.75	85	103.2	39.0	0.77	590	
0	3.0	11.6	56.8	1.50	1.50	120	123.6	34.0	0.42	550	
4	0.25	13.2	56.8	9.25	15.50	25	114.0	43.3	0.68	630	
4	1.0	13.1	-	6.50	10.00	60	128.4	32.5	0.34	-	
8	0.5	14.3	56.2	5.75	12.00	35	122.4	0.38	0.38	560	
8	1.0	14.0	-	8.00	17.00	35	122.4	31.8	0.10	-	
8	1.5	14.0	55.8	7.75	18.75	35	116.4	32.5	0.43	570	
8	2.0	14.1	55.0	13.25	19.00	30	128.4	35.1	0.37	550	
8	2.5	14.0	55.0	10.25	18.75	20	129.6	30.6	0.36	530	

(2) *Background Information*

The school feeding program is concentrated in the Eastern Province (see Table below). Chiefly owing to communication problems and poverty it does not yet cover some areas in which malnutrition is assumed to be highly prevalent (e.g. the North-Eastern Province).

Number of children registered in the school feeding program per province; 2nd term 1976

Province	Number
Central Province	11,016
Eastern Province	20,604
Rift Valley Province	2,348
Western Province	8,284
Nyanza Province	414
TOTAL:	42,666

The program is uniform i.e. all the schools receive the same kind of food inspite of regional differences as to food habits. The main food items include beans and maize, supplemented with "SUPRO", an industrial product composed of barley flour (47%) yeast (24%) and dried skim milk (15%).

The nutrient content is shown in the Table below:

*Nutrient content of the School Meal*

	Maize (28g)	Beans (84g)	Supro (7g)	Total (119g)
Energy kcal	91	280	18	389
Protein (g)	2.5	20.5	18	389
Protein (g)	2.5	20.5	1.7	24.7
Fat (g)	1.2	1.3	0.1	2.6
Carbohydrate (g)	18	47	3	67
Fiber (g)	0.5	3.4	0.9	4.8
Water (g)	3	8	8	19
Calcium (mg)	3	99	15	117
Iron (mg)	0.7	6.8	0.3	0.3
Vitamin A (mg)	0.012	0.002	0	0.014
Thiamin (mg)	0.09	0.40	0.01	0.50
Riboflavin (mg)	0.04	0.17	0.14	0.35
Niacin (mg)	0.5	1.7	0.8	3.0
Ascorbic acid (mg)	0	0	0	0

As it is distributed at present the lunch consists of three ounces (84 g) of beans, one ounce (28 g) of maize and a quarter of an ounce (7 g) of supro. Its

energy value is less than 400 kcals. It provides 25 g of protein, whilst its supplies of iron, thiamin, riboflavin and niacin are sufficient for the total daily requirement. As far as vitamin A and ascorbic acid are concerned, however, it is highly deficient.

(3) *Selection of Target Area*

In consultation with the executive officer of the National School Feeding program (NSFP), Mr. Otieno, a limited number of districts were pre-selected. This selection was made on the basis of the numbers of children who had been participating for at least two terms. Visits were made to Nyeri and Machakos districts in order to investigate the possibilities for a comparative study. The age span from 7 to 12 years was chosen because during this period growth is fairly steady.

(4) *School Feeding in Practice*

Nearly 15 schools were visited to demonstrate the use of full fat-*soy flour* in place of "SUPRO". All schools employed at least one cook, sometimes two. Fire wood was used as a fuel, a nearby river provided the water. Maize and beans were cooked together, in big iron drums. Cooking time was at least three hours. Supro was sometimes added half an hour before cooking was finished. Instead of Supro, we added equal amounts of *soy flour* half an hour before cooking was finished. After food was prepared, portions were served out in aluminium bowls as the children passed by.

(5) *Questionnaire:*

A questionnaire composed of six questions was submitted to the children and kitchen staff in order to get some information on their opinion about the new food (full fat *soy flour*) in comparison with the usual "SUPRO". A brief explanation in the local language was given to facilitate the answering of questions. The younger children were however interviewed, on the assumption that they would encounter insurmountable difficulties in filling in these forms themselves. As a matter of fact even children from standard 7 (older children) demonstrated their inability to do so by copying the answers of their fellow pupils. It was obvious therefore that the results of these trials had very little value.

We immediately modified the questionnaire to 2 basic questions that required YES/NO answers by the vote. The questions and their answers are presented below:-

QUESTION 1: Do you like the taste?

QUESTION 2: Is the amount of food enough for you?

Both questions reflect the appreciation of the new ingredient (*soy flour*) in the school lunch. The table below summarizes the results.

*Appreciation of School Lunch Containing Soy Flour*

TASTE		AMOUNT	
Appreciation	No. of children	Appreciation	No. of children
Positive	681	Insufficient	381
Negative	207	Too much	207
Unknown	57	Unknown	357

Through an oversight two possible answers concerning the taste were omitted from the form, viz. "indifferent" and "do not know". In considering the table above it should be borne in mind that the answers might be influenced by fear of repercussions. Anonymous files would therefore be preferable.

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## CEREAL PROCESSING

### Joatham Kapasi-Kakama

The year under review saw continued work on breeder's samples. Grain polishing tests were performed on the 1975 season Serere samples for relating kernel size and kernel pericarp thickness to the pearling performance. Grain pearling was also performed on 26 samples obtained from the Crop Science Department of the University of Dar es Salaam at Morogoro to evaluate the effect of weathering on the pearling performance of the grain.

Red flinty sorghums obtained from Serere at the beginning of 1976 were evaluated for their pearling performance.

Nitrogen results on the remaining 39 samples of the 79 Serere samples are reported.

### EXPERIMENTAL MILLING

#### *1975 EAAFRO Samples*

Seventy four of the 79 white sorghum samples which had been obtained from Serere at the beginning of 1975 were tested in the grain polisher. 1.5 kg of clean grain from each sample was polished at a predetermined optimum setting. The resulting grain was weighed and inspected for the degree of pearling effected. Those samples which appeared unsatisfactory were reran through the polisher irrespective of the yield obtained. On this basis 47 samples required a rerun.

The results in Tables 1 and 2 show the effect of kernel size and kernel pericarp thickness on the yield and quality of the pearled products. The samples designated large (L) had mean kernel weights of 30 mg or more, those designated intermediate (I) had mean kernel weight ranges of 25 to 30 mg, and the small types (S) had mean kernel weights of less than 25 mg.

For kernel pericarp thickness, samples were classified as thick (Tk), thin (Tn) or intermediate thickness (In) depending upon the impression obtained after scraping a number of kernels from each sample.

The quality score of the final product was based on the attractiveness of the product. Those with scores of A were most attractive followed by those with scores of B, C, etc.

In Table 1, 14 of the 15 samples with large kernels had second yields of 80% or more and product quality scores of at least a B. On the other hand 11 out of 27 samples classified as small had second yields of 80% or more and product quality scores of at least a B, while 3 of the 5 samples with grains of intermediate kernel size had yields of 80% or more and product quality scores of at least a B.

In the same table, 20 of the 24 samples with thin pericarps and 4 of the 8 samples with pericarps of intermediate thickness had yields of at least 80% and product quality scores of at least a B. Similar yields and quality scores could only be observed in 5 of the 15 samples with thick pericarps.

Thus, the indication is that, other characteristics being similar, grain with large kernels and thin pericarps will give the best pearling performance while grain with small kernels and/or thick pericarps will most likely give poorer results.

The same conclusion may be arrived at by considering the results in Table 2. The 27 samples in this table required only one run through the polisher to give reasonably debranned products. Here, all of the 9 samples with large kernels gave yields of 80% or more and quality scores of B or better. Similar observations were recorded in 9 of the 15 samples with small size and 1 of the 3 samples with intermediate size.

Table 1  
*The Effect of Kernel and Pericarp Thickness on the Yield and Quality of Pearled Sorghum - Part 1*

Sample	First Yield	Second Yield	Final Quality	Kernel	Pericarp
38-75	96.0	90.0	B	L	Tn
13-75	98.0	86.7	A	L	Tn
69-75	96.3	86.3	B	L	Tn
60-75	92.3	85.3	A	L	Tn
9-75	93.3	85.0	A	L	Tn
54-75	93.3	84.7	A	L	Tn
40-75	93.7	84.0	A	L	Tn
49-75	93.7	84.0	A	I	Tn
76-75	93.3	84.0	A	S	Tn
16-75	92.0	83.7	A	L	Tn
26-75	90.5	83.0	A	S	Tn
14-75	85.0	82.7	B	L	In
21-75	93.7	82.3	A	I	Tk
73-75	91.7	82.3	A	L	Tn
30-75	93.0	82.0	A	S	In
4-75	91.7	81.7	A	S	Tn
28-75	91.3	81.7	A	S	Tk
51-75	92.3	81.7	A	S	In
68-75	92.3	81.7	A	L	Tn
32-75	92.3	81.3	A	L	Tn
44-75	91.0	81.3	A	I	Tk
72-75	93.3	81.3	A	L	Tn
61-75	92.0	81.0	A	L	Tn
75-75	91.7	81.0	C	S	Tk
8-75	92.3	80.7	A	S	Tk
47-75	91.3	80.7	A	S	Tk
24-75	88.5	80.5	C	S	Tk
62-75	91.7	80.3	A	S	Tn
27-75	87.5	80.0	A	S	In
17-75	92.0	79.7	B	S	Tn
50-75	90.0	79.7	C	S	Tn

Table 1—Continued

Sample %	First Yield %	Second Yield Quality	Final Product	Kernel Size (a)	Pericarp Type (b)
1-75	90.	79.0	B	S	In
45-75	90.7	78.7	B	S	Tk
31-75	86.7	78.3	B	L	Tn
12-75	90.0	77.7	B	I	In
41-75	93.5	77.5	B	S	In
15-75	88.7	77.3	C	S	In
11-75	85.0	75.0	C	S	Tn
66-75	85.3	74.7	C	I	Tn
36-75	85.3	74.3	C	S	Tn
55-75	81.5	74.0	B	S	Tk
78-75	83.3	71.7	B	S	Tk
18-75	77.5	70.0	C	S	Tk
65-75	84.3	65.0	C	S	Tk
5-75	88.7	64.7	C	S	Tk
57-75	75.7	63.7	C	S	Tk
19-75	72.7	60.3	C	S	Tk

(a) L ± Large  
I ± Intermediate  
S ± Small

(b) Tn ± Thin  
In ± Intermediate  
Tk ± Thick

Regarding the pericarp type, all of the 12 samples with thin pericarps, 6 of the 8 samples of intermediate pericarp thickness and 2 of the 7 samples with thick pericarps had yields of 80% or more and product quality scores of B or better.

#### 1975 Morogoro Samples

The 27 sorghum samples in this group were chalky white with thick pericarps. Except for 6 of the, they had been affected in one way or another by wet weather during their maturing stage. Thus they provided excellent material for observing the effect of weathering on the yield and quality of the pearled product.

They were run through the polisher using the same procedure as mentioned in the previous section. 26 of the 27 samples required a second polishing to appear reasonably debranned.

The results for this experiment are given in Table 3. Fifteen per cent of the weathered sorghums gave yields of at least 70% and a final product quality of B. All the 6 unweathered sorghums gave yields of 70% or more and product scores of at least a B. There were no A scores for any of the weathered sorghums while one of the unweathered sorghums gave a yield of 79.3% and a score of A. Another unweathered sorghum did not require a second polishing after giving a product yield of 88.0% and a score of B.

**Table 2**

*The effect of Kernel Size and Pericarp Thickness on the Yield and Quality of Perled Sorghum - Part 2*

Sample	Yield %	Product Quality	Kernel Size (a)	Pericarp Type (b)
33-75	90.0	B	S	In
63-75	89.7	B	L	Tn
52-75	89.3	A	L	Tn
35-75	88.7	A	L	Tn
2-75	88.0	A	S	Tn
58-75	88.0	A	L	Tn
25-75	87.7	A	S	In
39-75	87.7	B	S	Tn
6-75	87.0	C	S	Tk
6-75	87.0	C	S	Tk
53-75	84.7	A	S	In
37-75	84.3	A	L	Tn
74-75	84.3	A	L	Tn
3-75	83.7	A	L	Tn
59-75	83.5	C	S	Tn
7-75	83.3	A	S	Tk
70-75	83.0	A	S	In
10-75	82.0	A	L	In
67-75	81.5	A	S	Tk
29-75	81.0	A	S	In
48-75	81.0	A	L	Tn
71-75	80.3	A	I	Tn
77-75	80.0	C	S	Tk
79-75	80.0	C	I	Tk
22-75	77.0	B	S	Tk
42-75	72.0	B	S	In
56-75	66.0	C	S	In
23-75	62.5	B	I	Tk

(a) L ± Large  
I ± Intermediate  
S ± Small

(b) Tn ± Thin  
In ± Intermediate  
Tk ± Thick

These observations indicate that weathering adversely affects the pearling performance of sorghum grain.

*1976 EAAFRO Samples*

All the 40 samples used in this test had red pericarps varying from lighter shades to deeper ones. Endosperm texture ratings (ETR) were intermediate and mean kernel weight values ranged between 22 and 31 mg, with approximately 95% of the samples having values of 29 mg or less. They did not possess pig-

mented undercoat. They were used to relate pearling performance to pericarp pigmentation. Pearling was carried out using the procedure already discussed in a previous section in this report. The results are shown in Table 4.

The figures in the column marked "Pericarp Colour", were arbitrarily chosen to represent the visual response to the colour intensity of the pericarp. The quality "1" denotes the lightest shade while "4" denotes the deepest colour intensity.

Of the 40 sorghums examined, 2 were classed "1", 21 classed "2", 15 classed "3", and 2 classed "4". Thus classes 2 and 3 dominated the group.

Second yields of at least 70% were observed in all of class 1, approximately 67% of class 2, approximately 87% of class 3, and none of class 4. The quality of those with yields of at least 70% was A for all of calss 1, approximately 29%

*The Effect of Weathering on the Yield and Quality of Pearled Sorghum*

<i>Sample</i>	<i>First Yield %</i>	<i>Second Yield %</i>	<i>Final Product Quality</i>	<i>Whether Weathered*</i>
85-75	88.0	—	B	—
91-75	91.3	83.0	B	W
89-75	90.7	82.0	B	—
104-75	86.5	80.5	C	W
83-75	87.0	80.0	B	—
82-75	90.7	79.3	C	W
93-75	91.0	79.3	A	—
100-75	92.0	79.3	B	—
105-75	90.6	78.8	C	W
92-75	88.7	78.3	B	—
97-75	89.0	76.7	B	—
88-75	86.7	76.3	C	W
98-75	95.0	74.0	C	W
99-75	88.3	71.3	C	W
102-74	88.3	71.3	B	W
103-75	90.0	70.7	B	W
106-75	83.6	69.4	C	W
96-75	88.3	69.3	C	W
80-75	85.0	67.0	B	W
81-75	82.7	67.0	B	W
84-75	80.3	67.0	B	W
95-75	84.7	66.3	C	W
87-75	86.0	66.0	B	W
86-75	74.0	65.5	C	W
94-75	88.3	65.0	C	W
101-75	81.7	64.0	D	W
90-75	75.0	60.0	C	W

\* W ± Weathered

Table 4

*The Effect of Pericarp Colour on the Yield and Quality of Perled Sorghum*

Sample	Pericarp Colour	First Yield %	Second Yield %	Final Product Quality	ETR* 1-5 scale
117-76	2	88.0	78.0	D	3.1
122-76	1	85.0	76.7	A	3.1
139-76	3	85.3	76.3	B	2.8
124-76	2	84.3	75.3	B	3.1
137-76	2	81.7	75.3	B	3.1
138-76	2	84.3	75.3	B	3.2
106-76	3	89.6	75.2	B	2.9
104-76	2	82.0	75.0	C	2.9
109-76	3	85.3	75.0	B	2.9
121-76	3	78.7	75.0	A	3.1
129-76	2	82.7	74.7	B	3.0
118-76	2	81.3	74.3	A	3.0
102-76	2	83.6	74.0	D	3.2
126-76	1	82.0	74.0	A	3.0
130-76	2	84.0	74.0	A	2.9
112-76	2	84.7	73.7	A	3.2
119-76	3	87.4	73.4	A	3.0
114-76	3	82.0	73.0	A	3.0
140-76	3	83.3	73.0	A	3.0
12 -76	2	80.3	72.7	B	3.0
127-76	3	89.3	72.3	B	2.9
116-76	3	81.3	72.0	A	3.2
136-76	3	88.0	72.0	C	3.0
115-76	2	79.4	71.5	A	3.0
120-76	3	82.0	71.3	B	3.1
132-76	2	83.7	70.8	A	3.1
128-76	3	84.7	70.7	B	3.1
108-76	3	79.7	69.6	D	3.1
125-76	3	84.7	69.5	B	3.0
107-76	2	78.3	69.3	D	3.1
105-76	2	86.7	68.5	B	3.0
134-76	3	85.7	68.0	C	2.8
103-76	4	83.3	67.5	B	3.0
111-76	2	83.7	66.3	C	3.0
113-76	2	81.6	66.0	C	3.0
101-76	2	75.7	65.3	D	2.6
131-76	4	78.7	64.0	B	3.0
135-76	2	74.3	60.5	C	3.2
110-76	3	80.7	60.3	B	2.9
133-76	2	78.3	60.3	D	3.1

\* ETR ± Endosperm Texture Rating

of class 2, approximately 27% of class 3, and none of class 4; B for approximately 25% of class 2, approximately 47% of class 3, and none of class 4.

Since there were very few samples in these classes 1 and 4, the observations about the pearling behaviour of samples in these classes cannot be relied on to reach a fair conclusion. However, they seem to suggest that sorghums with lighter pigmented pericarps are likely to give a better pearling performance than those with pericarps of deeper pigmentation. The sorghums with pericarps of intermediate pigmentation will give performances lying in between the two extreme classes.

#### ANALYSIS OF BREEDERS' SAMPLES

Moisture and nitrogen determinations were completed on the remaining 39 of the 79 Serere samples delivered at the beginning of 1975. The nitrogen, endosperm texture ratings and mean kernel weights for the samples are shown in Table 5.

As observed in the Annual Report for 1974-1975, the mean kernel weights ranged from 16 mg to 34 mg for all the 79 samples with approximately 86% of them greater than 20 mg. The endosperm texture rating values for approximately 84% of the samples were 3.0 to 4.6 indicating that the textures were of intermediate nature.

The dry basis crude protein values for all the 79 ranged from 10.3% to 14.1% with approximately 84% of them having values of 11.0% or more. The protein values appeared to be related to the kernel size. The higher protein values were observed in samples with smaller grains (mean kernel weight less than 30 mg) while the lower protein values were observed in the samples with larger grains. Moisture, nitrogen and ash determinations were commenced on the 1976 Serere samples and their pearled products. This was done in order to evaluate the effect of pearling on the ash and nitrogen values of the red flinty sorghums. The complete results will be discussed in the next Annual Report.

Table 5

Protein, Endosperm Texture Rating and Mean Kernel Weight Values of Some Sorghum Lines

Sample	Nitrogen (N) % db	Protein % (N $\times$ 6.25)db*	Endosperm Texture Rating 1-5 scale	Mean Kernel Wt. mg
41-75	2.08	13.0	3.0	22
42-75	2.06	12.9	3.4	19
43-75	2.14	13.4	3.2	18
44-75	1.99	12.4	3.1	27
45-75	1.94	12.1	3.8	19
46-75	1.81	11.3	3.8	32.
47-75	1.94	12.1	3.8	24
48-75	1.79	11.2	3.3	30
49-75	1.87	11.7	3.4	26
50-75	1.79	11.2	3.2	23
51-75	1.92	12.0	3.9	23
52-75	1.69	10.6	3.0	31
53-75	1.99	12.4	3.7	20
54-75	1.77	11.1	3.5	33
55-75	1.85	11.6	2.9	20
56-75	2.10	13.1	2.3	23
57-75	1.92	12.0	2.7	22
58-75	1.68	10.5	3.9	31
59-75	1.87	11.7	3.0	21
60-75	1.82	11.4	3.4	33
61-75	1.73	10.8	3.0	31
62-75	1.82	11.4	3.0	32
63-75	1.69	10.6	2.8	33
64-75	1.85	11.6	1.8	22
65-75	1.73	10.8	2.7	19
66-75	1.84	11.5	3.1	26
67-75	2.26	14.1	3.7	19
68-75	1.91	11.9	3.2	33
69-75	1.84	11.5	3.7	32
70-75	1.87	11.7	4.2	16
71-75	1.81	11.3	3.7	25
72-75	1.77	11.1	3.4	33
73-75	1.73	10.8	3.9	31
74-75	1.69	10.6	3.2	33
75-75	1.89	11.8	2.8	22
76-75	1.85	11.6	2.2	32
77-75	1.71	10.7	3.7	20
78-75	1.75	10.9	3.2	22
79-75	1.87	11.7	2.9	25

\*db...dry basis

## COFFEE PROCESSING RESEARCH

A. Gibson and B.A. Mwingira

### *Introduction*

This year a considerable amount of effort has been employed in the practical consolidation of studies carried out in previous years. In this respect, most of the projects covered can be considered as "on-going" or as "rejuvenated by force of circumstance."

The choice of covering materials for drying parchment coffee falls into both categories since normal circumstances would require a continuing search for cheaper and more suitable material. But, when the principally used material is suddenly withdrawn from the market, a much more urgent search project has to be initiated.

The major variation from reports of previous years has been the amount of research work carried out on the robusta coffees. This work has involved studying the basic parameters which govern good storage conditions, following reports that clean robusta coffee was deteriorating in quality during storage. Results from the initial work have indicated that the important storage parameters for robusta coffees are basically identical to those already found for the arabica coffees. Of equal importance, a by-product of this work on robusta coffee has indicated that it is possible to remove off-flavoured robusta coffee beans in a similar manner to that employed for the arabic beans if the robusta coffee is fully wet-processed. The problems of excessive coating found in the dry-processed robusta coffees are no longer apparent following wet-processing.

A further project which can be considered to be new, involved a study of potential quality deterioration when green coffee is transported from a producer country in East Africa to a destination in Europe. Previously the dictum had always been followed that the responsibility for coffee once it had been sold on the East African auctions was solely that of the purchaser. It has now been accepted that the producer country should accept a basic responsibility for produce bearing its name until such produce arrives at its final destination. The purpose of the study project was to try and define those areas of transportation and intermediary storage which could give rise to potential quality deterioration and to then inform and advise the coffee shippers accordingly.

The first of these transportation trials was carried out on a commercial outturn of 605 bags being despatched from Nairobi, Kenya to Hamburg, Germany during the latter half of May 1976. Control bags of coffee were shipped by air freight to Hamburg whilst the rest of the consignment was freighted in the normal manner by rail to Mombasa and then by sea to Hamburg. Detailed results of this and subsequent trials will be given in later Annual Reports.

Environmental control for both the drying of parchment coffee and the studied during the year. This work has been carried out using arabica coffees storage and conditioning of parchment and green coffee has been extensively

but, if the initial results derived from the robusta coffee storage studies continue to hold, the conclusions derived from the environmental control studies should also be applicable to the robusta coffees.

A continuing problem associated with coffee storage is the determination of the moisture content of the finished product. The desired moisture content for prolonged storage without appreciable quality loss is now generally accepted as lying between 10 and 10.5%. The accurate laboratory method of moisture determination is tedious and time consuming and is therefore not suitable for determining rapidly changing moisture contents in commercial quantities of coffee.

The need for rapid moisture determination was the major incentive for the development of various mechanical moisture meters. All such moisture meters require calibrating for the particular product which is to be measured, if any degree of accuracy or reproducibility is to be obtained.

Unfortunately, the market availability of moisture meters is not static. The EAIRO is continually having to calibrate and assess the suitability of new moisture meters to replace those which for a variety of reasons have been withdrawn from the market. A review is given of this work in the following detailed text.

An ever increasing problem in the estates sector of the East African Coffee industry is the ever decreasing efficiency of picking the crop. One possible solution to this problem requires the use of a highly efficient mechanical picking machine; no such machine is currently available. The alternative solution is to use a machine capable of selectively sorting the very heterogeneous coffee cherry obtained by unselective manual picking.

Trials were carried out on a machine which claimed to have the necessary throughput capacity and efficiency. These initial trials appeared to be very promising and showed a distinct quality difference between coffees derived from "acceptable" cherry and machine "reject" cherry. The current recommendation for optimum coffee processing and quality still stresses the necessity of selective coffee cherry picking.

The work on "stinkers" which was reported upon in the previous Annual Report is still being expanded with the final objective of being able to control, in part, the causative factors in the field; factors which cause multiplication in the factory processing and finally the removal of residual off-flavoured beans from all types of coffee during the final milling.

The Coffee Processing Research Section continued to be active in the dissemination of the practical benefits of the information derived from their work.

Preparations for the forthcoming research project on "A Scientific Assessment of Coffee Quality" have continued; this project is due to commence in the first half of 1977.

## COVERING MATERIALS FOR PARCHMENT COFFEE

Coffee drying is the most important stage in coffee processing for producing the optimum quality characteristics of the final green and roast coffee. It should be noted that during the early stages of drying, coffees should not be overheated by direct exposure to sunlight. When sunlight is absolutely necessary (between approximately 30% and 23% moisture content) the coffee may have to be covered when the temperatures are high so as to prevent overheating.

It is well known that the process of coffee drying is irreversible, that is to say, once water is introduced during the drying stages, the end product will not have a good cup-liquor. With these facts in mind, we know that covering parchment coffee at times during the course of drying is very essential. Firstly, it prevents overheating of the coffee and subsequent cracking of the parchment when the temperatures are very high and, secondly it prevents rain from coming into contact with coffee which may spoil and lower the quality of coffee.

Recently it was claimed that the traditionally used imported material for covering coffee e.g. Nylex P.V.C. sheets was no longer available. Subsequently, EAIRO had the task of finding an alternative material which could replace the imported material. Two locally made yellow polythene materials were offered for testing, to find out if they were suitable for covering coffee.

### *Experimental Aims*

1. To test their suitability for covering drying parchment coffee and whether the locally made materials were as good as the recommended imported materials e.g. Nylex P.V.C.
2. To find out the degree of Ultraviolet transmission of these materials.
3. To carry out practical tests of heat build-up when using these materials for covering coffee.

### *Experimental*

There were four types of materials to be tested.

- (a) The Nylex P.V.C. material which is imported from Australia.
- (b) The transparent P.V.C. material which is imported from France.
- (c) The Yellow polythene material which is locally made in East Africa.
- (d) The Yellow polythene (improved) material which is also locally made in East Africa.

It is very important that the materials for covering parchment coffee should be U.V. stabilized, otherwise rapid deterioration of the plastic occurs. Moreover, U.V. light should not be transmitted otherwise a "greenhouse effect" is produced. Consequently the four materials were tested to see how much U.V. light could be filtered out by these materials. The four plastic films were scanned using the SP.800 U.V. spectrophotometer.

### *Results*

The imported Nylex P.V.C. film did not transmit any of the U.V. light nor visible light of less than 450 millimicrons. The material is therefore a one hundred per cent filter of Ultraviolet light.

The imported transparent film did transmit approximately (80%) of the visible light of less than 450 millimicrons and, approximately 4% of U.V. light above 332 millimicrons.

The locally made yellow polythene material did transmit (about 10%) of both short and long wave U.V. plus visible light of less than 450 millimicrons. The yellow polythene film (improved) showed a transmittance of U.V. light and visible light of less than 450 millimicrons. Therefore, the yellow polythene (improved) material is also a one hundred per cent U.V. filter.

Another experiment was carried out to find out how much heat build-up would be produced under partially sealed conditions using the four types of materials as sunlight transmission windows.

Four identical boxes with open tops were filled with parchment coffee. Each box contained a thermocouple immersed to a standard depth in the parchment coffee. The four boxes were then separately sealed with the four plastic materials and were then kept overnight at constant temperature so that each box would register the same temperature before the experiment started.

All four boxes were simultaneously exposed to standard sunlight. The readings were monitored at intervals and some of the readings are given below.

*Time Weather Conditions Temperature Readings (°C)*

<i>Time</i>	<i>Weather conditons</i>	<i>Nylex P.V.C. Film</i>	<i>Transp. P.V.C. Film</i>	<i>Yellow Polly. Film</i>	<i>Yellow Polly. Film (Improved)</i>
9.30 a.m.	Sunny	24°C	24°C	24°C	24°C
10.30 a.m.	Sunny	27.5°C	28.5°C	27.5°C	26°C
11.30 a.m.	Sunny	32.5°C	36°C	33.5°C	31°C
12.30 a.m.	Sunny	36°C	40°C	37°C	34°C
2 p.m.	Sunny	39.5°C	43°C	40.5°C	37°C
3 p.m.	40°C	40°C	43.5°C	41°C	37°C
4 p.m.	Sunny	40°C	42°C	40°C	36.5°C
9.30 a.m.	Slightly Cloudy	34°C	24.5°C	24.5°C	24°C
10.30 a.m.	"	27.5°C	27.5°C	28°C	27°C
11.30 a.m.	Sunny with scattered clouds	37°C	37.5°C	37.5°C	35.5°C
		38.5°C	38.5°C	39°C	37°C
12.30 noon	"	39°C	39°C	39°C	37.5°C
2 p.m.	"	38.5°C	39.5°C	39°C	37.5°C
3 p.m.	"	38°C	38°C	38.5°C	37°C
4 p.m.	"	24.5°C	24.5°C	24.5°C	24°C
8.30 a.m.	Cloudy	26.5°C	27°C	27°C	25.5°C
9.30 a.m.	"	27.5°C	27.5°C	28°C	26.5°C
10.30 a.m.	"	29°C	29°C	30°C	28°C
11.30 a.m.	"	36°C	36.5°C	37°C	33°C
12.30 noon	"	37°C	37°C	37.5°C	34°C
2 p.m.	"	37°C	36.5°C	37°C	34°C
3 p.m.	"	36°C	36.5°C	36.5°C	33.5°C
4 p.m.	"	36°C	36.5°C	36.5°C	33.5°C
4 p.m.	"	36°C	36.5°C	36.5°C	33.5°C

## CONCLUSIONS

As far as the transmission exercise is concerned, we can deduce that the imported nylax P.V.C. material, which has been recommended in East Africa for covering coffee, has similar, although slightly inferior characteristics to the yellow polythene material, (improved) which is being manufactured here in East Africa, neither gives any appreciable transmission of U.V. light. Consequently this locally made material could act as a substitute for the imported nylax material. The durability of the yellow polythene material has still to be investigated.

The Yellow polythene and the imported transparent materials are not very good filters of U.V. light. The imported transparent material is however superior to the Yellow polythene as far as U.V. filtration is concerned.

As far as heat build-up under partially sealed conditions is concerned the nylax and the yellow polythene (improved) materials show fairly low temperature compared to the remainder. The yellow polythene (improved) material has the lowest temperatures recorded at any time compared to the remaining three materials.

This exercise showed that covering coffee in a sealed form causes a considerable degree of heating; this is very detrimental to coffee. The best way is to cover coffee only when it is really necessary, when it is raining and when it is very hot. The alternative measure would be to build tents over the drying tables. This would help to create ventilation and consequently the cooling effect would be of advantage since there would be no heat build-up in the coffee on the drying tables.

Further work will be carried out on this topic.

## COFFEE STORAGE – ROBUSTA COFFEE

In view of the impending need to store robusta coffee in "Clean" form (long-term storage) a need made evident in 1975, simple initial experiments were organised at the East African Industrial Research Organization prior to a more extensive research programme. The first of these experiments was aimed at demonstrating the differences in the effect upon coffee quality of a range of storage treatments.

Knowing that coffee loses quality during storage, it remains to be established under what conditions the deterioration of coffee quality is minimal. Consequently robusta coffee was processed and collected in Uganda by staff from the EAIRO for storage trials. The types of coffee which were processed in Uganda were as follows:

- (i) "Clean" robusta coffee from "Kiboko"
- (ii) "Clean" robusta coffee, wet processed
- (iii) Parchment robusta coffee, wet processed

Previously one bulk supply of "Clean" robusta coffee from "Kiboko" had been brought from Bukoba in Tanzania; this lot was also included in this particular exercise.

The four different types of coffee were stored as replicates in atmospheric air and carbon dioxide (CO<sub>2</sub>) in sealed Kilner jars under three different temperature conditions.

- (a) One lot (both in CO<sub>2</sub> and Air) was stored in the oven at 30°C.
- (b) The other lot (both in CO<sub>2</sub> and Air) was stored at Room temperature around 20°C.
- (c) The final lot (both in CO<sub>2</sub> and Air) was stored in the cold room at 5 to 10°C.

### *Experimental*

Three sacks of robusta coffee which were brought from Uganda and one sack of robusta coffee which was brought from Tanzania were kept in the cold-room. The coffee from Uganda had been prepared by the standard factory procedures. Robusta coffee had been picked, sun-dried and turned into "Kiboko". Wet-processed robusta coffee involved a two-stage fermentation step and conventional sun-drying. Before the experiments commenced the coffee was divided amongst the following treatments.

- (1) "Clean" robusta coffee - "Kiboko" - was divided into two lots. One lot was sealed into three Kilner jars in ordinary air. One Kilner jar was kept in an oven at 30°C and the final one was kept in the cold room. The other lot was also sealed into three Kilner jars in carbon dioxide. The three Kilner jars were subjected to the same treatment as above.
- (2) "Clean" robusta coffee, wet processed, was divided into two lots. One lot was sealed into three Kilner jars in atmospheric air. The three Kilner jars were subjected to the same treatment as in experiment number one. The other lot was also sealed into three Kilner jars in carbon dioxide. The three Kilner jars had the same treatment as above.
- (3) Parchment robusta coffee, wet processed, was divided into two lots. One sealed into Kilner jars in atmospheric air and the other lot sealed into Kilner jars in carbon dioxide. The two lots were subjected to the same treatment as in the above experiments.
- (4) "Clean" robusta coffee, "Kiboko" from Bukoba, was also divided into two lots. One lot was sealed into Kilner jars in atmospheric air and the other lot in carbon dioxide. The two lots were also subjected to the same treatment as in the rest of the experiments.

Samples of coffee from these Kilner jars were taken at intervals for liquoring purposes and some of the liquoring reports are tabled below.

### **Results and Discussions**

*Experiment 1*-As it is shown on the tables "Clean" robusta coffee-"Kiboko"-generally was described as "harsh robusta flavour", odd pale beans being heavily coated with silver-skin and this tendency seemed to worsen as the coffee was being stored. Cold storage tended to maintain the quality of the first liquoring report. As time passed by, storage at 30° C seemed to deteriorate very much faster than the rest. But there was no great difference in the liquor of coffee stored in atmospheric air and carbon dioxide.

LIQUORING REPORTS FROM TWO LIQUORING CENTRES

Key to Samples

AIW	-	"Clean"	robusta	coffee	-	"Kiboko"	(Uganda)	-	Air at 30°C.
AIC	-	"	"	"	"	"	"	-	Air cold room.
AIR	-	"	"	"	"	"	"	-	Air in room temperature.
CIW	-	"	"	"	"	"	"	-	CO <sub>2</sub> - at 30°C.
CIC	-	"	"	"	"	"	"	-	CO <sub>2</sub> cold room.
CIR	-	"	"	"	"	"	"	-	CO <sub>2</sub> room temperature.
A2W	-	"Clean"	robusta	coffee	-	wet processed	(Uganda)	-	Air at 30°C.
A2C	-	"	"	"	"	"	"	-	Air Cold Room.
A2R	-	"	"	"	"	"	"	-	Air Room Temperature.
C2W	-	"	"	"	"	"	"	-	CO <sub>2</sub> - at 30°C.
C2C	-	"	"	"	"	"	"	-	Cold Room.
C2R	-	"	"	"	"	"	"	-	Room Temperature.
A3W	-	Parchment	robusts	coffee	-	wet procesed	(Uganda)	-	Air at 30°C.
A3C	-	"	"	"	"	"	"	-	Air-Cold Room.
A3R	-	"	"	"	"	"	"	-	Air - Room Temperature.
C3W	-	"	"	"	"	"	"	-	CO <sub>2</sub> - at 30°C.
C3C	-	"	"	"	"	"	"	-	CO <sub>2</sub> - Cold Rooms.
C3R	-	"	"	"	"	"	"	-	CO <sub>2</sub> Room Temperature.
A4W	-	"Clean"	robusta	coffee	-	"Kiboko"	(Bukoba)	-	Air - at 30°C.
A4C	-	"	"	"	"	"	"	-	Air - Cold Room.
A4R	-	"	"	"	"	"	"	-	Air - Room Temperature.
C4W	-	"	"	"	"	"	"	-	CO <sub>2</sub> at 30°C.
C4C	-	"	"	"	"	"	"	-	CO <sub>2</sub> Cold Room.
C4R	-	"	"	"	"	"	"	-	CO <sub>2</sub> - Room Temperature.

Key to Liquoring Centres

T - Tanganyika Coffee Board

E - Edm. Schluter & Co (K) Ltd.

In Table 1 (T) Liquoring results were received on 23rd February, 1976.  
Samples were used before experimentation.

Table 1 (T)

Sample	Raw Quality	Roast Quality	Liquor Quality
A1	Mixed medium size, brownish colour <i>Fair Robusta</i>	soft, odd pale – <i>About Fair</i>	<i>Harsh Robusta Flavour</i>
A2	Mixed medium size Greenish colour, <i>Fair to good Robusta</i>	Softish, odd pale <i>Fair</i>	Light acidity, "medium body" <i>Good Clean Robusta Flavour</i>
A3	Mixed medium cold size, Greenish colour <i>Fully Fair Robusta</i>	Soft  <i>Fair</i>	Light acidity "medium" body. <i>Mild Clean Robusta Flavour</i>
A4	Mixed faded <i>About Fair</i>	Softish <i>About Fair</i>	<i>Harsh Robusta Flavour</i>

Table 2 (T)

Liquoring Reports Received in May 1976

Sample	Raw Quality	Roast Quality	Liquor Quality
A1W	Brown silver skinned heavily coated	Very soft, odd pales	Light medium body & acidity
A1W	Brown silver skinned heavily coated <i>About Fair</i>	Very soft, odd pales <i>About Fair</i>	Light medium body & acidity <i>Poor/Fair Robusta Flavour</i>
A1C	Healthier Colour, Light brown <i>Fair</i>	Soft, mixed pale <i>About Fair</i>	Light medium body & acidity – <i>About Fair Robusta Flavour</i>
A1R	Polish brown, better than A1W, slightly lower to A1C.	Soft, mixed and odd pale <i>About Fair</i>	Light medium body & acidity – <i>About Fair Robusta Flavour</i>
C1W	Greenish Brownish  <i>Fair</i>	Soft, very mixed  <i>About Fair</i>	Light acidity, light medium body, slightly nasty <i>Poor/Fair</i>

Table 2 (T)—Continued

C1C	Greenish Brownish <i>Fair</i>	Soft and mixed <i>About Fair</i>	<i>Poor/Fair</i>
C1R	Greenish Brownish <i>Fair</i>	Softish, odd semi-pale — <i>About Fair</i>	
A2W	Mixed Greenish <i>Fully Fair</i>	Mixed, odd pale	Light medium. Acidity clean cup— <i>Fully Fair</i>
A2C	Mixed Greenish/ Brownish <i>Fully Fair</i>	Odd pale	<i>Fully Fair</i>
A2R	Pale Greenish Brownish <i>Fully Fair</i>	Fairly even <i>Fully Fair</i>	<i>Fully Fair</i>
C2W	Greenish <i>Fully Fair</i>	Fairly even <i>Fully Fair</i>	<i>Fully Fair</i>
<i>Sample</i>	<i>Raw Quality</i>	<i>Roast Quality</i>	<i>Liquor Quality</i>
C2C	Greenish colour <i>Fully Fair</i>	Fairly even <i>Fully Fair</i>	Clean Cup <i>Fully Fair</i>
C2R	Greenish colour <i>Fully Fair</i>	Fairly even <i>Fully Fair</i>	Light Medium Clean Cup <i>Fully Fair</i>
A3W	Greenish Brownish Fresher in appearance <i>Fair</i>	Soft, odd pale <i>Fair</i>	Light medium—Acidity & Body, cleanish <i>Fair</i>
A3C	Greenish Brownish <i>Fair</i>	Softish — <i>Fair</i>	<i>Fair</i>
A3R	Greenish Brownish <i>Fair</i>	Soft and Mixed <i>About Fair</i>	<i>Fair</i>
C3W	Greenish Brown Colour — <i>Fair</i>	Mixed soft <i>About Fair</i>	<i>Fair</i>
C3C	Greenish Brown Colour — <i>Fair</i>	Soft and Mixed <i>Fair</i>	<i>Fair</i>
C3R	Greenish Brown Colour <i>Fair</i>	Soft and Mixed <i>About Fair</i>	Light medium acidity and Body, cleanish <i>Fair</i>
A4W	Brown Colour <i>About Fair</i>	Soft and Very Mixed <i>Poor/Fair</i>	Light acidity, light body, woody <i>Poor/Fair</i>

Table 2 (T)– Continued

A4C	Brownish Colour Faded <i>About Fair</i>	Soft and very mixed <i>Poor/Fair</i>	<i>Poor/Fair</i>	
A4R	Brownish Colour Faded <i>About Fair</i>	Softish <i>Fair</i>	<i>Poor/Fair</i>	
C4W	Brownish Colour Faded  <i>Fair</i>	Small mixed &  <i>About Fair</i>	Light acidity, light medium Body, slightly woody <i>Poor/Fair</i>	
C3C	Greenish Brown Colour– <i>Fair</i>	Soft and Mixed <i>Fair</i>	<i>Fair</i>	
C3R	Greenish Brown Colou <i>Fair</i>	Soft and Mixed <i>About Fair</i>	Light medium acidity and Body, cleanish <i>Fair</i>	
A4W	Brown Colour <i>About Fair</i>	Soft & Very Mixed <i>Poor/Fair</i>	Light acidity, light body, <i>Poor/Fair</i>	
A4R	Brownish Colour Faded <i>About Fair</i>	Soft and very mixed <i>Poor/Fair</i>	<i>Poor/Fair</i>	
A4R	Brownish Colour Faded <i>About Fair</i>	Softish <i>Fair</i>	<i>Poor/Fair</i>	
C4W	Brownish Colour Faded <i>Fiar</i>	Small mixed &  <i>About Fair</i>	Light acidity, light medium Body, slightly woody <i>Poor/Fair</i>	
	<i>Sample</i>	<i>Raw Quality</i>	<i>Roast Quality</i>	<i>Liquor Quality</i>
C4C	Brownish Colour faded, <i>Fair</i>	very mixed, very soft, <i>Poor/Fair</i>	<i>Poor/Fair</i>	
C4R	Brownish Colour faded, <i>Fair</i>	Mixed and Soft <i>Fair</i>	Light acidity, light medium body, slightly woody – <i>Poor/Fair</i>	

Table 3 (E)

*Liquoring Report Received in December 1976*

<i>Sample</i>	<i>Raw Quality</i>	<i>Roast Quality</i>	<i>Liquor Quality</i>	<i>U.V. Sorting</i>
A1W	Brownish colour Full silver skin	Slightly irregular Uneven, some pales <i>Fair*</i>	Harsh common <i>Fair</i>	Not amenable to U.V. sorting
A1R	Light Greyish Colour	Irregular Uneven many pales <i>Poor/Fair*</i>	Harsh Unclean Common <i>Poor/Fair</i>	„ „ „

Table 3 (E)—Continued

C1W	Light Greyish Colour	Irregular Uneven Few pales <i>Fair*</i>	<i>Fair/Food</i>	„
C1R	Light greyish Brownish – greenish	Irregular Uneven <i>Fair*</i>	Unclean harsh—common <i>Poor/Fair</i>	„ „
A2W	Light–grey greenish colour	Irregular <i>Fair*</i>	Uncleanish harsh <i>Fair</i>	Stinkers detected
A2R	Light – grey greenish colour polished look	Regular Even no pales <i>Fair/Good*</i>	clean – good tough of acidity <i>Fair/Good</i> <i>Fair/Good</i>	„
C2W	Yellowish	Regular Even with odd pales <i>Fair</i>	Neutral, slightly harsh, <i>Fair/Good</i>	„ „
C2R	Light–green and greyish beans	many pales <i>Poor/Fair</i>	Uncleanish <i>Fair</i>	„ „
A3W	Light–green and Greyish beans	Irregular, some pales <i>Fair</i>	Slightly harsh <i>Fair/Good</i>	„
A3W	Very light green yellowish colour	Irregular, some pales <i>Fair</i>	Very slightly harsh <i>Fair/Good</i>	„ „
A3R	Very light green yellowish colour	Irregular, some pales <i>Fair</i>	Very slightly harsh, <i>Fair/Good</i>	„
C3W	Very light greenish	Irregular some pales <i>Fair</i>	Very slightly harsh, <i>Fair/Good</i>	„ „
C3W	Very light greenish	Irregular some pales <i>Fair</i>	Very slightly harsh, <i>Fair/Good</i>	„ „
C3R	Very light green colour	Slightly irregular Uneven some pales <i>Fair</i>	Slightly harsh, <i>Fair/Good</i>	„
A4W	Regular light Brownish Full silver skin	Irregular Uneven some <i>Fair*</i>	harsh Unclean <i>Fair</i> <i>Fair</i>	Not amenable to U.V. Sorting
A4R	Regular Brownish Colour, Full silver skin	Irregular Uneven, some few pales <i>Fair*</i>	Medium still clean <i>Fair</i>	„ „
C4W	Regular light Brown colour Full silver skin	Irregular Uneven, some few pales <i>Fair*</i>	Medium strong slightly harsh, <i>Fair</i>	„ „
C4R	Regular light Brown colour Full silver skin	Irregular Uneven some pales <i>Fair</i>	medium still <i>Fair</i>	„ „

*Experiment 2* – “Clean” robusta coffee, wet processed, generally was described as “Good Clean Robusta Flavour” in most of the liquoring reports so far received. In raw, roast and liquor, coffee stored in a cold room was referred to as very fair but coffee stored at 30°C and room temperature was referred to as being “About Fair”. No marked differences was noticeable between coffee stored in carbon dioxide and atmospheric air, but occasionally coffee stored in carbon dioxide was superior compared to coffee stored in atmospheric air.

*Experiment 4* – “Clean” robusta coffee “Kiboko” from Bukoba in most of the liquoring reports was described as “harsh robusta flavour”. As far as raw, roast and liquor was concerned the coffee which was stored in the three different conditions showed hardly any difference and were described as ‘poor/fair’ in all cases. No difference could be seen between coffee stored in atmospheric air and carbon dioxide. This could be attributed to the fact that the coffee which was utilised was in a very poor condition—quality wise—hence storage of such coffee, however ideal the method might have been, could not improved the cup but instead it only made matters worse.

#### *Conclusion*

This exercise has indicated that ‘wet processed’ robusta coffee has a better “Robusta Flavour” than “Clean Kiboko”. Although most of the robusta coffee in East Africa is dry processed, it would be advisable if robusta coffee was wet processed. This would pay as far as revenue is concerned because a farmer would be getting more per kilo of coffee than he is now getting from the same kilo of dry-processed robusta coffee.

As far as the storage of coffee in atmospheric air or carbon dioxide is concerned no marked difference in quality has been noticed, but storage in carbon dioxide on some occasions has been shown to be better than storage in ordinary air. More work will have to be done on this line with normal good coffee.

We have noted that storage of coffee at low temperatures seems to maintain its quality without any drastic changes taking place, but this trend cannot be observed when the coffee is of poor standard. As it is shown from the tables, coffee which had a poor cup from the start showed no difference in quality under different conditions of storage. Consequently we can summarise by saying that storage of coffee is meaningless if the inherent quality of the coffee is poor.

#### STORAGE AND TRANSPORTATION OF GREEN COFFEE

Storage work carried out previously by the EAIRO and the Kenya Coffee Storage Project concentrated mainly on parchment and prehulled coffee. But preliminary laboratory work at that time indicated that clean green coffee deteriorated more rapidly than either of the other forms under any given set of storage conditions.

Subsequent to the normal milling and grading exercises at the KPCU Mills in Nairobi and the TCCC Mills in Moshi, all East African Mild Arabica coffee is in the clean form.

Quality deterioration of this green coffee prior to auction is obviously undesirable since its potential value is lowered before sale.

This facet of potential quality deterioration is clearly the responsibility of the producing Coffee Marketing Board. However, subsequent to auction, ownership of the coffee changes and the new owner becomes liable for any quality deterioration.

Prior to the inception of the present storage transportation research project the East African producer country had abdicated any further interest in the coffee once that coffee had been sold on auction. Following prolonged discussions, it was finally agreed that the producer country had a long-term vested interest in maintaining the quality of its produce up to the time of delivery to the final consumer even though it may have ceased to have any immediate financial interest in any particular consignment.

Having arrived at this decision, the next major problem was the absence of any clear information regarding the aspects of current transportation practices which might be considered to be deleterious.

The current research project was started to fill in those gaps in our knowledge of quality deterioration related to transportation and intermediate storage.

It was soon realised that the simplest way to acquire the necessary information was to commence with a quantity of green coffee of known quality in Nairobi and monitor any changes in quality at intermediate points en route to Europe. However, the aforementioned question of ownership of the coffee was rapidly seen to be the first major problem which had to be solved.

If a large commercial quantity of coffee belonging to the original growers or to the Coffee Board of Kenya was shipped to Europe as a research trial, how would the coffee be disposed of and how would payment be made?

This almost insuperable problem was solved by the kind assistance of Mr. J. Lydall of Cetco Ltd., Nairobi and Mr. H. Gottschalk of Tchibo Ltd., Hamburg, who not only offered to allow one of their commercial shipments to be used as the material for the trial, but also stated their willingness to participate in the sampling and liltoring in Nairobi and Hamburg, respectively.

Accordingly a consignment of 605 bags of Std. 3 green coffee was chosen to be despatched, with all of the appropriate controls, in the latter half of May or early part of June 1976.

Three bags were shipped by air freight to Hamburg to act as overall controls for any quality deterioration found to occur during normal sea freighting. The remaining controls were designed to study any quality deterioration occurring within the railway wagon en route to Mombasa; any deterioration whilst in transit in Mombasa and finally any deterioration in the ships hold whilst travelling by sea to Hamburg, Germany.

Detailed results from this project will be given in the next Annual Report.

#### MOISTURE METERS

The introduction to this Annual Report reviewed in brief the factors governing the desirability of having an electronic moisture meter capable of rapidly and accurately measuring the moisture content of coffee.

No single commercially available moisture meter can be considered as suitable for measuring the moisture content of coffee under any given set of conditions.

The major dichotomy arises in the environment in which the moisture meter is to be used, whether it is to be a static and mains-operated model, or a battery operated portable model. Both types are available and very rarely a model capable of both types of power operation.

However, in our opinion, only about two of the commercially available static models fulfil the necessary requirements and only one of the portable models (now no longer commercially available) fulfils the same requirements.

Most of the unsuitable meters fail in that they do not have any suitable means of compensating for the difference in ambient temperature and that of the sample being measured. Others, whilst appearing to have temperature compensating facilities, are equally unsuitable since the temperature being compensated for is that of the meter and not of the sample being measured.

The absence of a suitable temperature compensating system can give rise to errors of moisture content as high as 2%.

If the temperature of the sample is higher than that of the meter or ambient conditions, this error will always be higher than the correct figure. This is the situation normally encountered when using moisture meters for field purposes to assess the moisture content of drying coffee in either mechanical driers or conditioners, or on sun-drying tables. However, a similar effect is often noted with static moisture meters used at reception stores or mills in East Africa where incoming parchment coffee will often be at higher temperature than the ambient conditions of the static moisture meter.

The converse situation will apply where the temperature of the sample is lower than that of the moisture meter; the measured moisture content will always be lower than the factual value.

Many of the commercially available moisture meters claim an accuracy varying between  $\pm 0.05\%$  and  $\pm 0.25\%$ . Without adequate temperature compensation these claims are obviously meaningless since the final figure, accurately read and sometimes even mechanically printed out, may be in error by  $\pm 2\%$ .

This temperature compensating error is completely divorced from the original calibration of the meter for the particular product being measured. Such calibrations are traditionally carried out at 20°C which means in effect that a meter with no temperature compensating facilities will only give accurate readings when used in an air-conditioned environment of 20°C and that every sample measured is also at 20°C. Under any other circumstance the readings taken will be grossly in error.

A second common failing with most of the commercially available moisture meters relates to the size of the sample chamber. In most cases this is too small to accept the approved weight of coffee, particularly when this is either parchment, buni or Kiboko. The reason for this failing is not difficult to find. Nearly all of these meters were originally designed for the cereal crops such as rice, wheat, barley oats, etc., etc., all of which occupy a smaller volume for a given

weight than the much larger grain size of coffee. In consequence, the calibration of certain meters requires the use of a smaller standard weight of coffee than recommended for optimum accuracy and performance.

With the above criticisms in mind an attempt will shortly be made to design and manufacture a moisture meter specifically for coffee, in either the buni, parchment or clean forms.

#### THE MECHANICAL SORTING OF COFFEE BERRY

Traditionally, the hand-picking of East African arabica coffee berries was always carried out in a very selective manner. Teams of pickers would be instructed to pick only uniformly ripe and red berries and would normally repeat cyclic picking of the same blocks of coffee trees every ten to fourteen days. Subsequent further hand-sorting prior, to pulping ensured an even greater selectivity in coffee berry harvesting practices.

Intensive farming practices on the coffee estates in recent years have resulted in far higher yields and this, combined with a static or declining pool of "pickers", has made it difficult, if not impossible, to continue the policy of selective picking.

In the cooperative coffee sector, selective berry picking is still mandatory since the individual farmer is paid differing rates dependant on the qualities of berry which he delivers to the cooperative processing factory.

The current situation, with a 75,000 tonne Kenya clean coffee crop, is that selective picking in the Cooperative sector is the norm whilst selective picking in the Estates sector is the exception rather than the rule.

By 1980 Kenya hopes to be producing at least 100,000 tonnes of clean coffee partially by increased planting and partially by more intensive farming practices. Much of this increased yield can be expected to revolve around the Estates sector and therefore exacerbate still further the present selective picking problems.

If unselective or "strip" picking becomes an economic necessity in the Estates sector, it will then be advisable to have an alternative mechanical method available for separating coffee berries into various quality categories.

Several years ago a machine was tested at the Brooke-Bond Liebig coffee factory at Kibubuti. For many reasons this machine was found to be completely unsatisfactory in mechanical efficiency of separation and the tests were abandoned even before any final coffee quality trials were carried out.

On the 22nd March, 1976 a partially modified olive sorting machine was tested to assess its suitability for separating freshly picked coffee cherry into two major fractions—desirable and underable.

Desirable cherry was provisionally defined as being a uniform red colour whilst the undesirable cherries would consist of green, under-ripe, yellow drought affected, very dark red overripe and black "buni" or C.B.D. damaged cherry.

Only one such test was carried out at Cerec Estate, Solai. The absence of further quantities of coffee cherry at this particular period of the Kenya coffee season precluded the possibility of further tests until the latter half of 1976.

### *Experimental Aims*

1. To assess the machines mechanical ability to separate coffee berries into two predetermined categories—desirable and undesirable.
2. To carry out controlled fully-wet processing of the two categories of cherry and to assess all possible differences in quality which may arise.

### *Experiments*

1. The coffee berry sorting equipment was set up and operated by one of the senior technicians from Gunson's Sortex, London.
2. Approximately 500 kg of coffee berry supplied by Ceres Estates, Solai from their end-of-season picking was used for the exercise.
3. A rough estimate was made of the percentage rejects compared to the percentage of accepts.
4. Approximately equal volumes of both accept and reject coffee berries were subsequently carefully pulped and graded, rapidly fermented using Ultrazyme 100 and, following careful washing and under water soaking, were carefully sun-dried at Teremuka Estate. Solai

Each parchment coffee sample received identical and controlled processing conditions.

5. The six fully dry parchment coffee samples were subsequently delivered to the E.A. Industrial Research Organization and, following hand milling, grading and sorting exercises, the AB grades were submitted for liqoring tests to Mr. J. Lydall, Cetco, Nairobi.

### *Results*

1. *Percentage of Machine Rejects*

The machine rejected approximately 10% of the coffee berries presented for sorting. For convenience the resulting portions were subsequently referred to as "Yellow" (rejects) and "Red" (accepts).

2. *Processing Results*

The weights given below do not represent the total berry weights involved in the sorting exercise. They are representative samples used purely for processing and quality assessments.

	<i>Red</i>	<i>Yellow</i>
wt. of Berry (kg)	11.82	11.14
wt. of Dry parchment "First" (g)	1718.2 (93.6%)	1932.1 (94.8%)
wt. of Dry parchment "Seconds" (g)	30.5 (1.7%)	27.2 (11.3%)
wt. of Dry parchment "Lights" (g)	87.4 (4.8%)	78.6 (33.9%)
(Moisture Content 10.5%).		
wt. of green beans "First" (g)	1376.3 (95.2%)	1531.2 (96.1%)
wt. of green beans "Seconds" (g)	23.4 (11.6%)	19.4 (1.2%)
wt. of green beans "Lights" (g)	46.3 (3.2%)	42.6 (22.7%)

### *Percentage Milling Losses*

Firsts	19.9%	20.7%
Seconds	19.9%	20.7%
Seconds	23.3%	28.7%
Lights	47.0%	45.8%

### 3. Grading Results

The size grading exercises were carried out only on the green beans "First", since the small quantities of "Seconds" and "Lights" would have made the exercise meaningless.

<i>Grade</i>	<i>AA</i>	<i>AB</i>	<i>C</i>
Weight (g)	17.8	540.9	817.5
%	1.3	39.3	59.4
b) U.V. Assessment			
Normal wt (g)	16.8	535.7	809.7
Normal %	94.4	99.0	99.0
"Stinkers" wt (g)	<i>AA</i>	<i>AB</i>	<i>C</i>
	1.0	5.2	7.8
"Stinkers" %	5.6	1.0	1.0

Total percentage of "Stinkers" in Red Firsts  $\pm 1.0\%$

*Yellow Firsts*  
Total Weight 1531.2 g

a) <i>Size Grading</i>			
<i>Grade</i>	<i>AA</i>	<i>AB</i>	<i>C</i>
Weight (g)	14.8	389.2	1127.2
%	1.0	25.4	73.6
U.V. Assessment			
Normal wt (g)	14.8	388.2	1124.7
Normal %	100.0	99.7	99.88
"Stinkers wt (g) NIL		1.0	2.5
"Stinkers wt (g) NIL	NIL	0.3	0.2

Total percentage of "Stinkers" in Yellow Firsts  $\pm 0.2\%$

### 4. Liqueuring Reports

Samples of AB Size of both "Red" and "Yellow" were sorted under manual U.V. to identify the presence of any obvious potential "off-flavoured" green beans. These samples were submitted for liquoring with comparable samples which had not been U.V. sorted. A numerical summary of the liquoring reports is given below.

<i>Sample</i>	<i>Raw</i>	<i>Roast</i>	<i>Liqor</i>	<i>Overall classification</i>
Red-sorted	2,0,2	1,0,2	2+,2+,4+	3
Red-unsorted	2,0,3+	1+,0,2	2,2+,4	3-
Yellow-sorted	2,0,3	1+,0,3 s	2+,2+,4	4
Yellow-unsorted	2,0,4+	1+,0,4+	2,2,5+	5+

## Discussion of Results

### 1. *Efficiency of Mechanical Separation*

The machine, in unmodified form, was not capable of giving a 100% accuracy of separation since it occasionally "missed" coffee berries which should have been rejected and vice versa. This phenomenon was expected due primarily to the multiple belt feed system being designed for objects larger than coffee berries, namely "olives". The resultant dispersion of samples through the optical viewing and rejection system give rise to the noted lowering of efficiency.

In spite of this occasionally gross error, the machine performed with surprising efficiency. It was obvious that the optical problems associated with "wet-feed" systems had been satisfactorily solved. These optical problems were primarily responsible for the premature termination of the previous mechanical coffee berry sorting tests.

### 2. *Processing Results*

Only marginal differences were noted in red and yellow when studied for comparable dry parchment coffee yield, green bean coffee yield, and percentage milling losses. This was possibly a reflection more of the nature of the coffee used in this single trial than of the efficiency of the machine. The "end of season" nature of the starting material could not have been expected to give clear cut differences at this stage of the operations.

### 3. *Grading and Sorting*

The low percentage of AA size coffee beans in both red firsts and yellow firsts was to be expected. Traditionally, the Solai coffees have always tended to be small even during the peak picking season. The coffee berry used in the trial was rather drought affected as well as being the end of the season crop and could have been expected to give the observed low percentage distribution of AA and BB sizes. A normal main season Solai coffee crop would consist primarily of AB size green coffee.

The observed differences between AB and C sizes, when comparing red firsts and yellow firsts, was striking vindication of the need for specific coffee berry selection either by selective hand-picking or by the mechanical means employed. The higher percentage of C sizes in over-ripe and particularly under-ripe drought-affected coffee could have been predicted on the grounds of immaturity or available nutrient deficiency. However, this was one of the first cases, to the E.A.I.R.O.'s knowledge, that such a clear cut distinction had been experimentally observed.

The results derived from the U.V. hand-sorting exercise carried out prior to submission of samples for liquoring assessment showed that the red mature coffee berry contained a higher percentage of defective beans than the rejected "yellow". These results should be viewed with suspicion until a larger number of trials have been carried out.

### 4. *Liquoring Reports*

A study of the detailed liquoring reports showed that a consistent difference was observed between similarly treated red and yellow samples in almost all

aspects of liquoring. "Yellow" coffee was one standard lower than "red" coffee in composite raw and roast qualities; a half standard lower in composite liquor quality and one standard lower in overall classification. In samples of similar treatment, these observed differences were mainly attributable to the much higher proportion of pales and softs in the roast of "Yellow" compared to "Red" and the subsequent influence that these defectives had upon the liquor flavour characteristics.

Any future trials should consider the possibility that these "pales" and "softs" originate from "yellow" and "green" berries respectively and that a future commercial machine should be capable of selectively removing these berries from "red" berry at virtually 100% efficiency.

### **Conclusions**

On the basis of the single test carried out in the Solai region in March 1976, the machine tested demonstrated its ability to perform a coffee berry sorting exercise with commercially significant efficiency. The modifications suggested would have to be carried out before the machine was subjected to testing over a full commercial coffee season. Quality trials carried out on the coffee sorted by the machine justify the assertion that selective coffee berry sorting or picking definitely influences the quality of the final commercial green coffee.

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