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CASSAVA ROOTS: CHARACTERISTIC, UTILIZATION AND ANALYSIS METHODS

by: Sulsmono
Section of Postharvest and Food Technology
Sukamandi Research Institute for Food Crops (SURIF)
West Java, Indonesia

VISITING RESEARCHER
TRAINING AND COMMUNICATION SUPPORT PROGRAMME
CENTRO INTERNACIONAL de AGRICULTURA TROPICAL (CIAT)
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PED. EXTERIOR

INTRODUCTION

Cassava Programme CIAT has the spesific research in the Section of Cassava Utilization and it's has the fasilities of Laboratory and Scale up of cassava processing.

In the Training and Communication Support Programme which Ir. Suismono from SURIF (Sukamandi Research Institute for Food Crops), West Java-Indonesia had been conducted as Visiting Research in the Cassava Utilization Programme, about The Characteristic, Utilization and Analysis method of Cassava roots.

We wish to thank's Dr. Chritopher Wheatley as the Suvervisor for the research, Dr. Rupper Best (Leader Cassava Programme-Centro Internacional de Agricultural Tropical / CIAT) for usefull advice and thank's for financial support of the CIAT. Usefull on the Staff and Tecnical Asistence of Cassava Utilization and Servic Laboratory-CIAT.

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Author

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SECTION 1.

CHANGES OF PHYSICO-CHEMICAL THE CASSAVA ROOTS AND PRODUCTS AS AFFECTED BY VARIETY AND PLANT AGE

by : Suismono and C. Wheatley

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CHANGES OF PHYSICO-CHEMICAL THE CASSAVA ROOTS AND PRODUCTS AS AFFECTED BY VARIETY AND PLANT AGE[1]

Suismono[2] and C. Wheatley[3]

ABSTRACT

Changes of physico-chemical the cassava roots and products as affected by variety and plant age. This experiment was executed at Centro Internacional de Agricultural Tropical (CIAT), Cali-Colombia for July to December,1991. The experimental design is Randomized Complete Design (RCD), three replications with the factors : Varieties (the bitter cassava roots : M Col-1684, CM 849-1, M Ven-25 an CM 507-37 and the sweet cassava roots : CM 955-2, CMC-40 and CG 1-37) and plan ages (7, 9 and 11 months). Result of the experiment are show total and free cyanide contents at the bitter cassava roots were approximatelly three times higher than in the sweet cassava roots. Total and free cyanide content at cassava flour and by-product less 50 ppm DM basis. The amount of cyanide loss during processing (chipping and sun drying) between 7 to 20%. Optimum of dry matter, starch, fat and fiber contents are at 9 months of plant ages except at protein, total and reduce sugar contents is decrease for 7 to 11 months. Optimum viscosity at cassava flour is lower than cassava starch. After cold phase (50°C) at the cassava flour of the sweet and bitter varieties are accur retogradate if harvesting more 9 months of plant ages.

INTRODUCTION

The nutritional improtence of cassava (*Manihot esculeta* Cranz.) is primarilly a source of carbohydrate. Comparing with other food crops, cassava high caloric-yield per land unit.

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1) *Report in Visiting Researcher-Cassava Utilization of CIAT Programme, June 20 - December 20, 1991. Cali-Colombia.*
2) *and 3) Staff of Researcher from SURIF (Sukamandi Research Institute for Food Crops)-West Java Indonesia and Leader of Cassava Utilization-CIAT, Cali-Colombia.*

It has been estimated that cassava produce and average of 250,000 calories per hectar per day as compared to about 176,000 for rice, 110,000 for wheat, 200,000 for maize and 114,000 for sorghum (Cousey and Hayness, 1970). Cassava is contain very little protein or fat and it's produce the cyanide acid. The consumption of cassava product containing high levels of cyanogenic glocosides therefore constitute a serious health hazard since released from these food products will act as enzyme poisons (linamarase) and cassava roots include low-cyanide cultivar,"sweet" and high-cyanide cultivar,"bitter" (Joachim and Pandettesekere, 1944 ; Sinha and Nair, 1967 ; Rosling, 1988).

Cassava plant has'nt spesific period in which matures and repens, there is an optimum period for harvest, which varies from variety to variety. If a variety is harvested early before its optimum period, yield will be low if harvesting late, the starch and dry matter content may be low (Grace, 1977 ; Anonimous, 1983; Chock, 1985). The composition of plants may vary greatly with variety, soil, fertilizer, climate, geografical location and age of the plant (Joahim and Pandettekerese, 1944 ; Rosling, 1988).

The problem in Indonesia was some farmers and small industry levels had been suspended the time of harvesting to storage the fresh cassava roots becouse fear deteriration after harvest and to arrange fluctuate of price with to wait the high price (Suismono and Widowati, 1984 ; Wargiono and Barret, 1986). Where as, prune treatments have been affect on physiological deterioration and biological changes in cassava roots. The rating for quality attributes in terms of texture, flavour and generality were lower in roots harvested from unpruned than pruned cassava plants, while the reverse was true in color and appearence (Data et al. 1984 ; Tanaka, 1984).

Using raw material of industry levels which change in the physico-chemical characteristies of cassava roots at differ the varieties are very importance for determination the product quality, espesially the bakery product (Janssen, 1988). Colection of cassava varieties in Indonesia until 1983 were 465 varieties to include the clones from the breeding between local and new varieties (Anonimous, 1983) and less information about the physico-chemical characteristic of cassava roots (Barret and Damardjati, 1984).

This experiment was study of effect varieties (bitter and sweet cultivars) and plant age on changes physico-chemical in roots and product of cassava.

MATERIALS AND METHODS

This experiment was executed at Centro Internacional de Agricultural Tropical (CIAT), Cali-Colombia for July to December,1991. The experimental design is Randomized Complete Design (RCD), three replications with the factors : Varieties (the bitter cassava roots : M Col-1684, CM 849-1, M Ven-25 an CM 507-37 and the sweet cassava roots : CM 955-2, CMC-40 and CG 1-37) and plan ages (7, 9 and 11 months).

At the plant age of 7, 9 and 11 months was harvested seven varieties of cassava plant in the field. For a plot of each replications are contain 256 plants with size 1 m x 1 m between plants. Two lines from the border is the sampling areas. At the sampling area are harvested fifteen the plants with ramdom sampling. Assay of the yield component is the sum and weight roots of commercials, not commercials and demaged. The commercial roots in the gunny bags are bring to the laboratory used for the components analysis of cassava roots. The analysis times of the fresh cassava roots should be processed preferably on the day harvest.

Components of cassava roots are involve fresh cassava roots (in peel and parenchyme) and dry cassava product (in cassava flour and by-product) cassava roots. The parameters of analysis are total and free cyanides, moisture, dry matter, starch, total and reduce sugars and amylose contents, recovery of cassava flour, time and temperature gelatinizations and viscosity.

Preparation of fresh cassava roots are selection and cleaning of the cassava roots free dirties, soils and stalks from seven varieties. To weight approximatelly 3 kg the tubers used the assay specific gravity with the balance conected in the water and then conversed with the dry matter table (Chock and Reyes, 1985 ; Perez and Villamayor, 1984 ; Ramanujam and Lakshmi. 1984). Take three tubers and cuting of the centre part roots used the determination of cooking quality with score of the hydonic method. Approximatelly 3 g the tubers are cleaned and washed free external skin and then peeled. The peel and parenchyme are sliced into small pieces used the assay of moisture content with the weight 10 g peels and 60 g parenchyme. Too using for determination of total and free cyanide, total and reduce sugars and starch contents. Approximatelly 3 g the tuber are pelled, mixed with the blender, filtering and sedimentation which the starch yield for determination of amylose content. The slice of peel (10 g) and parenchyme (60 g) of fresh cassava are added 200 ml orthophosphoric acid contain 2.5 % ($^{v}/v$) ethanol and homogenizer with blender. Using of the enzymatic method for determined of the total and free cyanide (Cooke, 1978). The slice of peels and parenchyme of fresh cassava are dried at the freeze dryed (Model SB5 Chem-lab Instruments Ltd, Hornchurch, Essex) and milling used the determination of proximate analysis. The assay of starch content is hydrolysis with enzymatic (Batey and Ryde, 1982 and Sun-hun and Matheson. 1990). For total and reduce sugars analysis are the cupper method (Cronic and Smith, 1979). Nitrogen was determined by the semi-automatic Kjeldahl method using the Tecator System (crude protein = N 6.25) (Bradbury and Hollway, 1988), fat, fiber and ash contents by Harris method (Harris, 1970). Physical analysis at cassava flour and starch are viscosity, time and temperature gelatinize with Brabender-Viscoamylograph (Halick and Kelly, 1959 ; Shuey and Tippies, 1988).

Preparation of dry cassava was processed the fresh cassava roots became the cassava flour and by-product. By-product was include the dry peel and the fiber of the tuber centre. The step of dry cassava processing were wasing, chipping, sun drying (two days), milling and greading (separator with 65 mesh) became the cassava flour and the by-product which used the detemination of physico-chemical.

Most of the data was expressed on dry mater and analyazed for statistical significant by analysis of using the M-STAT Programme ; the standard error of the mean has been used as an estimation of the standar deviation.

RESULTS AND DISCUSSION

Production and quality

Sweet cassava (var. of CM 955-2, CMC-40, CG 1-37) and bitter cassava (var. MCol-1684, CM 849-1, M Ven-25 and CM 507-37 were harvested at 7, 9 and 11 months showed that the weight of commercial roots are increase and the weight of the commercial are decrease (Table 1). The commercial weight of the sweet cassava roots are 36.6 to 41.1 t/ha or 93 to 96 % of total production and the bitter cassava roots are 28 to 39.3 t/ha or 92 to 96 % of the total production. Fresh cassava production are highest varieties of CMC-40 (43.79 t/ha), CM 955-2 (41.6 t/ha) and CM 849-1 (40.66 t/ha) which harvested at 11 months. Appropiate number of commercial root was increase and not commercial was decrease. Deterioration levels of roots in the field are accur at varieties of CM 849-1 (2.5 to 5%) and CM 507-37 (4 to 10%), especially by fungi. Size and deteriored of roots are very importance in the quality of cassava roots. Therefore the root selection is necessared in the field. Selection are include size, deteriored and stalk of roots.

Cyanide content

Results of the statistic analysis showed varieties and plant ages significant on total and free cyanide at fresh cassava (peel and parenchyme) and dry cassava (product of cassava flour and by-product) ($P < 0.05$) (Table 2).

Total and free cyanide in the peel of bitter varieties (M Col-1684, CM 849-1, M Ven-25 and CM 507-37) are lower than the sweet varieties (CM 955-2, CMC-40 and CG 1-37). In the parenchyme, total cyanide are at the bitter variety (213 to 390 ppm DM basis) higher the sweet variety (75 to 130 ppm DM basis). Gomez and Valdivieso (1983) reported cyanide content of the parenchyme in roots of CMC-84 variety (the bitter variety) was approximately three times higher than in roots of CMC-40 variety (sweet variety). The concentration of cyanogenic glocu side is higher in the peel fraction of the tuber than in the flesh or pulps (Mata, 1986 ; Joachim and Pandettasekere, 1944). Effect of plant age on total cyanide in the peel is not significant, but in the parenchyme to decrease after 9 months old, especially bitter variety. In the peel and parenchyme, free cyanide is decrease from plant ages at 7 to 11 monts. Sinha and Nair (1967) reported in the cassava of M-4 variety the synthesis of (CN)⁻ glucoside is at its maximum during the 9 and 10 months of its growth cyanide content in the peel and parenchyme of the sweet variety is increase, where the root is harvested more of optimum plant age but at the bitter variety is decrease cyanide content (Joachim and Pandettesekere,.1944).

The cyanide-yielding capacity of cassava roots is not only dependent on the genetic character of the variety grown, but also on several environmental factor (Bruijn, 1973). The envirenmental factors effecting toxic levels under cultivation conditions are still poorly understood, but harvest age has little affect on toxicity (Cooke, 1982).

After fresh cassava was processed became cassava flour and by-product to show the total and free cyanide content less 50 ppm DM basis (under of consumption standard), except total cyanide at the M Ven-25 variety. Cyanide content in cassava flour of bitter variety is higher than sweet variety. The amount of cyanide loss during processing (Chipping and sun dring) between 7 to 20% (Table 2). Paula and Range (1939) reported 85% loos of cyanide on oven drying and 50% on sun drying, while Joachim and Pandettesekere (1944) ; Uke and Dean (1983) reported lower losses 23.3 % at 60°C and 18 to 21% at 80°C. Mata (1986) showed loos of 43% and 94% on drying sweet and bitter grade cassava samples. Total cyanide in the sweet and bitter cassava are decrease during sun drying process and loss of free cyanide at block polythene are 58% (the bitter variety), 37% (the sweet variety) and at colourless polythene are 46% (the bitter variety) and 37% (the sweet variety)

(Maduagwu and Adewale, 1980). Losses of HCN for during the flesh and peel of the tuber at temperatures below 72°C above which temperature the enzyme is destroyed (Joachim and Pandel-tesekere, 1944).

Dry matter, starch, sugar contents and recovery

Dry matter content, variety and plant age are effect of significant ($P < 0.05$) on dry matter content. Dry matter of sweet varieties (var. of CM 955-2, CMC-40 and CG 1-37) are higher than the bitter varieties (var. of M Col-1684, M Ven-25 and CM 507-37), except var. CM 849-1. This case can sam at moisture content of parenchyme the sweet variety lower tha the bitter variety (Table 3). Optimum dry matter content is 9 months of the plant age. After plant age of 9 months, dry matter has decrease at at all varieties of cassava roots (Gomez and Valdivieso, 1983 ; Ramanujam and Lakshmi, 1984). Harvesting at October, water shortage curtail dry matter accumulation (Ezedinma et al,1980). Leihner (1983) reported stake dry matter increased from its initial value to a maximum before the rainy season at 8 months in var. CM 516-7 and 10 months in var. M Col 22, M Max 58 and CM 849-1). There was a marked decrease in dry matter during the rainy season. These latter changes probably reflect the plant water.

Starch content at peel and parenchyme of bitter variety are higher the sweet variety (Table 3). Seeley (1972) indicated that glucoside content of the tuber is coorrelated with the starch content, becouse bitter varieties are usually high starch yielders. There is also some relationship between starch content and palatability of the tuber. The tuber with higher starch content have less fiber content and therefore are less stringy.

After cassava was processed became the product of cassava flour and by-product which showed the starch content at cassava flour of the bitter variety higher than the sweet variety, but at by-product is the bitter variety lower the the sweet variety (Table 4). Effect of plant age on cassava content were not sinificant in the peel, decreasing after 9 months of plant age in parenchyme, optimum at 9 months in the cassava flour and increasing in by-product fo 7 to 11 months. Root starch concentration was highest at 10 month (Gomez and Valdivieso, 1983). Cock (1985) and Grace (1977) reported starch content decrease after plant age optimum were between 9 to 10 months.

Sugar content, total and reduce sugar contents of the sweet variety at peel and parenchyme are higer than the bitter variety. Total sugar content is highest in the peel and parenchyme at var. M Col-1684 each 5.61% and 2.14%, var.CMC-40 each 4.69% and 3.03%.
Ranges of the total sugar content in the parenchyme are between 1-3% (the sweet variety) and 1.67-2.14% (the bitter variety) and reduce sugar content are between 0.3-1.5% (the sweet variety) and 0.64-0.95 (the bitter variety). Total sugar in peel and parenchyme of the sweet variety were decrease for 7 to 9 month, but at the bitter variety were decrease. Reduce sugar at peel is decrease and at parenchyma is increase (Gomez and Valdivieso, 1983). Total and reduce sugar content at product of cassava flour and by-product in the bitter variety is higher than the sweet variety. Total sugar content at the sweet variety is between 0.89 to 1.43 % and at the bitter variety is between 1.03 to 1.86%. Reduce sugar content are between 0.57 to 0.92% (the sweet variety) and 0.60 to 1.1% (the bitter variety). If harvestinf at 9 month, total and reduce sugar content in the cassava flour is lowest and in by-product is decrease for 7 to 11 months.

Recovery of cassava lour, using the milling michine of Colombia Type (CIAT Modification) 1725 capasity 700 kg/h and separation at 65 mehs, which resulted the recovery of cassava flour (at the sweet and bitter variety) between 37.9 to 41.2%. If harvesting at 7 to 11 months are decrease the recovery of cassava flour.

Protein, fat, fiber and ash contents

Protein content at the peel of the bitter variety (6 to 11%) is higher the the sweet variety (6 to 7.9%) and at parenchyme of the bitter variety (2.2 to 2.7%) is lower than sweet variety (2.1 to 3.49%). Protein content at the fresh cassava (peel and parenchyme) was harvested at 7 to 11 months decreasing (Table 5). Protein content at the sweet and bitter variety were later harvested to decrease (Gomez and Valdivieso, 1983). This case at protein content in cassava flour of the bitter variety (1.98 to 2.64% is lower than the sweet variety (2.3 to 3.07%) and in by-product of the bitter variety (2.52 to 3.79% is lower the the sweet variety (2.8 tp 3.8%). Protein content in cassava flour was decrease if harvesting at 7 to 11 months (Table 6).

Fat content at fresh cassava is between 2.3 to 4.72% (in peel) and 1.5 to 2.14% (in parenchyme). The tuber contained very little fat but there was a wide distribution of fatty acids in the fats. It was found that the peel contained more fat than the pulp (Anonimous, 1981). If harvesting at 7 to 11 months at parenchyme was increasing. Fat content at cassava flour is highest at var. CMC-40 (the sweet variety) between 1.4 to 2.79% and at by-product is var. CM 507-37 (the bitter variety) 1.35 to 2.53%. Fat content optimum is harvested at 9 month (Table 5 and 6).

Fiber content, in fresh cassava were between 7.5 to 13.22% (in the peel) and 2.07 to 3.15 (in the parenchyme). Plant age at 7 to 11 months at peel is increase and at parenchyme is lowest at 9 months. In dry cassava, fiber content is between 2.4 to 2.65% (at cassava flour) lower than at by-product (3.42 to 5.80%) (Table 5 and 6), becouse by-product include from dry cassava peel an fiber of centre tuber. If harvesting at 9 monts are optimum of fiber content in cassava flour and by-product.

Amylose content and viscosity

Amylose content at the sweet variety (2.2 to 23%) is lower than the bitter variety (24 to 25%). This case have relationship with characteristic of flour viscosity and saw during gelatinization process at optimum viscosity if high amylose content is more swelling volume and accur retrogradation after cooling phase (50°C) (Table 7). Between 7 to 11 months, amylose content at the sweet variety is increase and optomum amylose content at 9 months.

Viscosity of cassava flour, time and temperatures of gelatinization at the sweet variety (24 to 28 minutes, 62 to 72°C) were higher than bitter variety (21 to 25 minutes, 60 to 67°C). If harvesting at 9 months in the sweet variety is lowest and at the bitter variety is deceasing. Times and temperatures of optimum gelatinize at sweet variety to same the bitter variety between 38 to 44 minutes and 90° C except at var. M Ven-25 is lowest (24 to 26 minutes, 65 to 75°C). Harvesting at 9 months are optimum of the times and temperatures gelatinize. The time and temperature of gelatinize is very improtence to know the characteristic of flour during gelatinization or break down of starch and swelling of starch ganule at temperature to be certain. This case can saw from colour changes of starch ganules from the white colour to transparance and optimum swelling volume of food product (Whistler et al., 1984). Effect of plant age, optimum viscosity at 7 to 11 months are increase (between 520 to 820 BU in the sweet varieties and 355 to 780 BU in the bitter varieties). If harvesting after 9 months at the sweet varieties of cassava flour are more retrograde and at the bitter varieties at 7 to 11 months accur retogradation after cooling phase (at 50°C). Bhattacharya and Southagy (1979) reported for low amylose and waxy rises but the extent of retrogradation noticed for a sample at give slurry concentration was considerably lower as reflected from the cold paste viscosity at 50°C) value and negative set back viscosity.

Viscosity of cassava starch, time and temperature of gelatinize at the sweet varieties (22 to 25.5 minutes, 61 to 63°C) are higher than at the bitter varieties (21-24 minutes, 58 to 62°C). Time and temperture gelatinize at 7 to 11 months are increase at cassava starch. Time and temperature of optimum gelatinize at the sweet varieties (27 to 31 minutes, 65 to 73°C) are higer than at the bitter varieties (25 to 29 minutes, 61 to 71°C) and plant age at 7 to 11 months is increase. Optimum viscosity at the bitter variety (1025 to 1590 BU) is higher than the sweet variety (1030 to 1130 BU) and plant age at 7 to 11 months at the sweet variety is decrease and the bitter variety is increase (Table 8). After colt phase, cassava starch of the bitter variety is more retrograde than the sweet variety for plant age at 7 to 11 months, becouse differ set back, especially at 9 months of plant age (Raja et al. 1986).

At cooking quality, the time of the fresh cassava roots at the sweet and bitter varieties are semillar between 16 to 30 menutes. More at the plant age will be increase cooking time for 7 to 11 months (Table 9). This case has been relationship with increaseing of the tuber content. Texture and performance at all varieties are very good (score = 0), except at M Ven 25 variety. M Ven variety have the amylose content highest of all varieties. Therefore during are accur the gelatinization which showed the optimum viscosity lowest and after cooking (cold phase at 50°C) are retrogradate (setback is - 400 BU at the cassava flour) (Table 7) to result in the texture very tough and performance are less like by panelis. The deterioration roots was accur at CM 955-2 and CMC 40 variety at 7 months of plant ages.

CONCLUSION

1. Selection cassava roots are very importance for indentification of tuber quality. Weight of commercial roots are highest in the sweet and bitter varieties between 92 to 96% of total production.

2. Total and free cyanide contents at the bitter cassava roots were approximatelly three times higher than in the sweet cassava roots. In the peel and parenchyme, free cyanide are decrease at 7 to 11 months. Total and free cyanide content at cassava flour and by-product less 50 ppm DM basis. The amount of cyanide loss during processing (chipping and sun drying) between 7 to 20%.

3. Optimum of dry matter, starch, fat and fiber contents are at 9 months of plant ages except at protein, total and reduce sugar contents is decrease for 7 to 11 months. Starch content in peel and parenchyme of the bitter cassava is higher than the sweet variety. Total sugar content in parenchyme (at the sweet or bitter varieties) are between 1 to 3% and reduce sugar are between 0.64 to 1.5%. Amilose content at the sweet variety is lower than the bitter variety.

Recovery of cassava flour are 37.9 to 41.2 %.

4. Optimum viscosity at cassava flour is lower tha cassava starch. After cold phase (50ºC) at the cassava flour of the sweet and bitter varieties are accur retogradate if harvest ing more 9 months of plant ages.

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Table 1. Effect varieties and plant ages on the weight and number of commercial and not commercial cassava roots

Varieties	Plant ages	Weight of root per 15 plants			Yield	Number of roots per 15 plants		
		Commercial		Not Commercial		Commercial	Not Commercial	Deterioration
	(mo)	(kg)	(%)	(kg)	(t/Ha)			
CM 955-2	7	32.5	71.7	12.7	30.1	87	115	1 (0.4%)
	9	45.7	87.7	6.5	34.8	104	56	0 (0.0%)
	11	59.0	94.4	3.5	41.6	121	35	3 (1.8%)
CMC 40	7	67.2	62.2	11.0	29.1	65	70	0 (0.0%)
	9	50.5	85.4	5.7	39.4	108	50	0 (0.0%)
	11	61.7	93.9	4.0	43.7	104	34	3 (1.8%)
CG 1-37	7	35.3	91.1	3.5	25.8	93	96	1 (0.4%)
	9	54.7	88.4	7.1	41.2	128	71	0 (0.0%)
	11	55.0	96.5	2.0	37.9	119	27	1 (0.4%)
M Col 1684	7	20.0	78.4	5.5	16.9	52	34	0 (0.0%)
	9	20.0	82.4	4.2	16.1	40	31	0 (0.0%)
	11	42.0	96.5	1.5	29.0	72	19	0 (0.0%)
CM 849-1	7	33.2	80.6	8.0	27.5	84	70	4 (2.5%)
	9	51.0	89.4	6.0	38.0	109	51	10 (5.0%)
	11	59.0	96.7	2.0	40.6	133	22	8 (4.9%)
M Ven 25	7	29.2	79.0	7.7	24.6	90	90	2 (1.0%)
	9	39.5	83.8	7.5	31.0	105	70	2 (1.0%)
	11	47.0	92.1	4.0	33.9	115	40	1 (0.4%)
CM 507-37	7	19.7	79.8	5.0	16.5	80	45	14 (10 %)
	9	27.0	78.2	7.5	23.0	82	90	8 (4.0%)
	11	31.0	96.9	1.0	21.32	80	22	24 (9.0%)

Table 2. Effect of varieties and plant ages on total and free cyanide in the fresh cassava (peel and parenchyme) and dry cassava product (cassava flour and by-product)

Varieties	Plant ages (mo)	Total CN (ppm, DM basis) Peel	Total CN Paren-chyme	Total CN Cassava flour	Total CN By-product	Free CN (ppm, DM basis) Peel	Free CN Paren-chyme	Free CN Cassava flour	Free CN By-product
		(%)							
CM 955-2	7	1274.8	88.5	16.4	41.7	204.9	13.4	2.0	16.2
	9	1759.0	74.8	17.1	23.5	266.2	8.5	0.0	2.4
	11	1247.6	63.6	7.8	3.0	195.3	4.5	0.9	2.9
	mean	1440.1 b	75.9 e	13.7 ef	22.7 e	223.9 d	8.8 d	1.0 d	7.2 c
CMC 40	7	2856.1	63.8	23.6	104.4	408.9	17.9	7.9	7.7
	9	1807.7	116.0	19.9	69.1	457.2	25.9	0.0	4.9
	11	2383.1	154.8	6.6	6.2	478.3	13.0	2.1	3.8
	mean	2346.6 ab	109.1 de	16.7 e	59.9 c	449.3 b	20.0 c	3.3 bc	5.5 b
CG 1-37	7	1383.8	80.9	5.0	19.7	288.2	25.8	2.0	13.3
	9	1354.2	105.7	20.4	56.3	354.6	18.9	0.0	4.5
	11	1498.9	211.0	7.3	4.8	117.9	21.4	2.4	6.7
	mean	1410.4 b	131.3 d	10.9 f	26.8 de	267.8 cd	20.8 bc	1.4 cd	8.2 c
Col 1684	7	3552.6	385.1	29.4	73.4	450.5	78.4	3.6	6.2
	9	2712.3	351.5	115.7	235.8	400.9	39.4	4.5	3.8
	11	2618.1	298.8	16.0	8.6	580.4	54.4	3.1	3.8
	mean	2966.3 a	366.6 a	53.5 b	105.9	472.7 bc	55.5 a	3.7 b	4.6 b
CM 849-1	7	1145.0	261.9	9.5	33.6	254.6	30.3	0.3	42.4
	9	817.3	264.9	44.8	60.5	208.9	23.2	3.9	12.5
	11	1254.8	168.8	9.6	5.1	152.9	9.9	4.4	7.8
	mean	1067.7 b	232.9 b	21.3 d	33.1 d	205.1 d	20.9 bc	2.9 bcd	20.9 a
M Ven 25	7	1276.4	613.1	100.9	206.8	696.7	83.5	14.3	35.8
	9	907.4	407.4	174.6	189.5	386.2	69.7	10.5	6.3
	11	1484.6	145.0	38.1	43.6	275.5	46.5	12.3	16.9
	mean	1219.2 b	390.4 a	104.5 a	146.6 a	446.4 a	60.5 a	12.4 a	19.7 a
CM 507-37	7	1897.3	207.5	33.6	40.7	346.1	37.5	0.3	6.7
	9	1281.6	264.6	56.1	88.4	358.2	37.9	1.7	1.8
	11	1466.4	163.4	11.4	36.5	204.9	15.4	8.5	7.5
	mean	1582.0 b	213.2 c	33.7 c	55.2 c	309.3 cd	34.0 b	3.5 b	5.3 b
Mean of plant ages	7	1818.2 a	240.6 a	31.2 b	74.3 b	370.6 a	35.7 a	4.4 a	18.3 a
	9	1458.0 a	235.3 a	64.0 a	103.3 a	338.8 a	31.2 b	2.9 b	5.2 b
	11	1635.6 a	168.8 b	13.8 c	15.4 c	269.1 b	22.1 c	4.8 a	7.1 b
C.V		18.3	16.8	12.7	12.3	23.7	10.7	17.4	21.4

Mean differently superscripted down the colomn are significantly different from one another (P<0.05)

Table 3. Effect of varieties and plant ages on dry matter, moisture, starch, total and reduce sugar content in the fresh cassava (peel and parenchyma) (CIAT, December 1991)

Varieties	Plant ages (mo)	Dry matter content at Whole root	Moisture Content		Starch		Total sugar		Reduce sugar	
			Peel	Parenchyma	Peel	Parenchyma	Peel	Parenchyma	Peel	Parenchyme
		(%)								
CM 955-2	7	35.64	67.75	56.81	60.95	78.38	2.83	1.48	1.63	1.05
	9	39.26	64.40	56.11	63.19	72.38	2.05	1.31	0.94	0.13
	11	39.10	68.09	67.87	53.29	68.86	2.57	0.94	1.47	0.69
	mean	38.00 ab	66.75 d	56.93 d	59.14 c	73.21 cd	2.48 c	1.24 d	1.36 c	0.62 bc
CMC 40	7	30.60	72.47	56.39	67.29	80.24	5.32	5.60	4.22	3.52
	9	35.51	72.23	56.32	53.42	71.69	4.51	2.00	1.82	0.19
	11	33.46	74.97	63.29	48.71	75.64	4.24	1.48	1.16	0.80
	mean	33.19 c	73.22 b	58.69 bc	56.47 d	75.85	4.69 b	3.03 a	2.40 b	1.50 a
CG 1-37	7	35.02	65.89	56.74	69.06	80.40	6.37	1.97	2.51	0.29
	9	39.28	64.97	55.79	68.53	81.59	4.52	1.59	1.44	0.13
	11	38.53	67.53	58.05	64.95	79.47	2.31	1.05	0.72	0.59
	mean	37.61 ab	66.13 d	56.86 d	67.51 a	80.48	4.40 b	1.54 cd	1.55 c	0.34 c
M Col 1684	7	30.62	75.71	57.89	40.44	77.35	6.26	2.21	5.47	0.76
	9	33.72	74.83	66.55	76.80	83.87	4.02	2.69	2.94	0.46
	11	33.43	77.45	60.84	31.89	76.12	6.54	1.54	1.84	0.69
	mean	32.59 cd	75.99 a	59.76 b	49.71 e	79.48	5.61 a	2.14 b	3.42 a	0.64 bc
CM 849-1	7	34.89	64.24	58.97	64.12	78.28	3.68	2.09	1.68	0.81
	9	40.12	61.85	56.84	66.85	72.39	3.58	1.74	1.71	0.52
	11	40.16	63.01	57.78	65.71	76.32	1.34	1.18	1.02	0.77
	mean	38.39 a	63.03 e	57.86 cd	65.56 ab	75.11	2.86 c	1.67 bcd	1.47 c	0.70 bc
M Ven 25	7	33.83	69.07	57.68	65.52	78.35	1.78	1.19	1.23	0.58
	9	38.55	66.53	58.70	67.42	82.82	3.59	1.98	1.62	0.79
	11	37.93	67.26	58.78	73.55	86.99	2.20	2.90	1.44	0.96
	mean	36.77 b	67.62 cd	58.39 bc	68.83 a	82.72	2.52 c	2.02 bc	1.43 c	0.77 bc
CM 507-37	7	31.69	67.82	60.34	66.57	78.38	2.43	1.77	1.06	0.56
	9	33.75	69.67	61.68	54.28	59.77	3.31	1.94	1.76	0.92
	11	30.60	70.04	65.57	66.09	79.85	3.22	1.99	1.37	1.38
	mean	32.01 d	69.18 c	62.53 a	62.31 bc	72.66	2.98 c	1.90 bc	1.39 c	0.95 b
Mean of plant ages	7	33.18 c	68.99 a	57.83 b	61.99 a	78.77	4.10 a	2.33 a	2.55 a	1.08 a
	9	37.17 a	67.78 b	58.00 b	64.36 a	74.93	3.65 b	1.89 b	1.75 b	0.45 b
	11	36.17 b	69.76 a	60.31 a	57.74 a	77.61	3.20 c	1.58 b	1.29 c	0.84 a
c.v		2.32	2.57	3.42	5.28	7.55	18.65	16.52	14.43	13.72

Mean differently superscripted down the colomn are significantly different from one another (P<0.05)

Table 4. Effect of varieties and plant ages on Moisture content, starch, total and reduce sugar content and recovery in the dry cassava (cassava flour product and by-product/dry peel) (CIAT, December 1991)

Varieties	Plant ages (mo)	Moisture content	Starch		Total sugar		Reduce sugar		Recovery of cassava flour
			Product	By-product	Product	By-product	Product	By-product	
		(%)							
CM 955-2	7	8.12	77.00	59.07	2.11	1.97	0.65	0.72	44.73
	9	7.90	77.02	70.58	0.48	0.90	0.14	0.76	39.38
	11	6.54	77.63	84.91	1.30	0.64	0.69	0.24	33.33
	mean	7.52 bc	77.50 ab	71.52 ab	1.29 bc	1.17 d	0.49 b	0.57 b	39.15 ab
CMC 40	7	7.95	76.59	62.81	1.94	0.86	0.61	0.33	42.36
	9	7.75	77.02	76.85	0.74	1.70	0.37	1.13	48.83
	11	7.51	75.21	77.64	1.61	1.98	1.06	0.18	32.64
	mean	7.74 abc	76.27 ab	72.43 ab	1.43 b	1.51 c	0.68 a	0.54 b	41.27 a
CG 1-37	7	8.84	76.30	58.64	0.78	0.91	0.35	0.76	40.86
	9	7.79	83.01	77.72	0.31	1.39	0.26	1.18	39.06
	11	7.76	78.75	80.04	0.97	2.04	0.47	0.82	33.96
	mean	8.13 a	79.35 ab	72.13 ab	0.68 d	1.45 c	0.36 b	0.92 a	37.96 b
M Col 1684	7	7.62	76.23	59.74	1.95	2.55	0.77	1.24	45.69
	9	7.55	83.18	73.03	0.80	1.80	0.43	1.68	39.43
	11	7.11	79.38	86.25	2.81	1.75	1.30	0.40	33.14
	mean	7.43 cd	79.59 ab	73.01 a	1.86 a	2.03 b	0.83 a	1.10 a	39.42 ab
CM 849-1	7	7.53	77.72	62.38	1.21	1.73	0.34	0.62	41.12
	9	8.72	78.93	76.94	0.70	1.36	0.22	0.51	37.62
	11	7.33	77.73	75.26	1.18	1.31	0.66	0.77	35.05
	mean	7.86 ab	78.12 b	71.52 ab	1.03 c	1.46 b	0.41 b	0.63 b	37.93 b
M Ven 25	7	7.20	83.36	55.24	2.88	4.64	1.19	1.37	44.73
	9	7.91	84.83	78.24	0.55	0.66	0.26	0.41	37.94
	11	7.60	75.39	74.21	1.93	1.01	0.99	0.04	34.33
	mean	7.57 bc	81.19 a	69.23 b	1.79 a	2.10 b	0.81 a	0.60 b	39.00 ab
CM 507-37	7	7.21	81.79	56.75	1.75	3.57	1.03	1.68	48.64
	9	6.83	85.09	71.37	0.82	1.71	0.24	0.39	44.35
	11	7.13	81.69	62.56	1.93	2.33	1.19	1.21	29.10
	mean	7.06 d	82.85 a	63.56 c	1.47 b	2.54 a	0.82 a	1.09 a	40.70 a
Mean of plant ages	7	7.78 a	78.55 b	59.23 c	1.80 a	2.32 a	0.71 b	0.96 a	44.02 a
	9	7.78 a	81.30 a	74.96 b	0.63 b	1.36 b	0.27 c	0.86 a	40.94 b
	11	7.28 b	77.97 a	77.27 a	1.66 a	1.58 b	0.91 a	0.52 b	33.08 c
c.v		5.12	4.52	3.77	21.99	16.39	17.20	16.48	6.47

Mean differently superscripted down the colomn are significantly different from one another (P<0.05)

Table 5. Effect of varieties and plant ages on protein, fat, fiber and ash content in the fresh cassava (peel and parenchyma) (CIAT, December 1991)

Varieties	Plant ages (mo)	Crude Protein		Fat		Fiber		Ash	
		Peel	Parenchyma	Peel	Parenchyma	Peel	Parenchyma	Peel	Parenchyma
		(%)							
CM 955-2	7	8.98	4.25	3.03	1.98	11.98	2.74	3.74	1.91
	9	7.81	3.38	3.24	1.95	11.05	2.30	3.62	1.60
	11	6.94	2.85	3.39	2.06	12.58	2.96	2.09	0.82
	mean	7.91 b	3.49 a	3.22 c	1.99 ab	11.87 ab	2.74 b	3.15 b	1.44 c
CMC 40	7	7.34	2.48	5.16	1.39	5.23	2.38	3.91	2.44
	9	5.24	2.21	4.50	1.60	13.93	2.91	3.74	2.04
	11	6.70	1.86	4.50	2.13	14.66	2.62	2.84	1.14
	mean	6.43 bc	2.18 c	4.72 a	1.70 abc	11.29 b	2.63 b	3.50 b	1.87 a
CG 1-37	7	7.08	2.68	2.92	1.47	10.18	2.44	1.54	1.97
	9	6.99	2.50	2.44	1.29	7.63	2.25	2.18	1.78
	11	6.94	1.92	3.77	1.74	6.18	1.52	1.19	0.95
	mean	7.00 cd	2.37 c	3.04 cd	1.50 bc	7.99 cd	2.07 c	1.63 c	1.56 bc
M Col 1684	7	10.50	2.17	2.47	1.90	7.43	3.55	5.46	2.42
	9	12.48	2.68	4.84	1.23	14.10	2.85	5.07	2.22
	11	10.26	1.74	4.59	1.94	18.15	3.05	4.17	1.22
	mean	11.08 a	2.20 c	3.96 b	1.69 abc	13.22 a	3.15 a	4.90 a	1.95 a
CM 849-1	7	7.49	3.73	2.14	1.18	9.45	2.69	2.68	2.16
	9	7.29	2.68	2.34	2.30	9.63	2.40	2.74	1.76
	11	5.53	1.92	2.83	2.18	9.32	2.67	1.51	1.04
	mean	6.44 d	2.77 b	2.43 d	1.76 ab	9.46 c	2.58 b	2.31 c	1.65 b
M Ven 25	7	9.73	3.44	2.29	2.09	7.44	2.77	3.22	1.95
	9	8.80	2.50	3.99	2.18	6.85	2.43	3.31	1.92
	11	6.16	1.57	3.26	2.15	8.21	2.44	2.39	1.03
	mean	8.23 b	2.50 bc	3.18 c	2.14 a	7.50 d	2.54 b	2.97 b	1.63 b
CM 507-37	7	7.63	2.50	2.87	1.30	6.81	2.90	2.58	2.18
	9	9.09	2.80	2.97	1.30	9.91	2.85	3.93	2.22
	11	6.06	1.92	1.80	1.03	8.50	2.87	2.14	1.32
	mean	7.59 bc	2.41 c	2.34 d	1.21 c	8.40 cd	2.87 ab	2.88 b	1.91 a
Mean of plant ages	7	8.39 a	3.03 a	2.98 b	1.61 a	8.36 b	2.77 a	3.30 a	2.15 a
	9	8.10 a	2.68 b	3.47 a	1.63 a	10.15 a	2.57 a	3.51 a	1.93 b
	11	6.94 b	1.97 c	3.44 a	1.89 a	11.08 a	2.59 a	2.33 b	1.07 c
c.v		8.54	12.87	18.98	11.77	13.07	14.39	18.54	10.52

Mean differently superscripted down the colomn are significantly different from one another (P<0.05)

Table 6. Effect of varieties and plant ages on protein, fat, fiber and ash content in the fresh cassava (peel and parenchyma) (CIAT, December 1991)

Varieties	Plant ages (mo)	Crude Protein		Fat		Fiber		Ash	
		Product	By-product	Product	By-product	Product	By-product	Product	By-product
		(%)							
CM 955-2	7	3.84	4.14	1.63	1.99	2.46	4.52	1.58	1.90
	9	2.92	4.02	2.07	1.52	2.30	4.99	1.38	1.80
	11	2.45	3.44	1.22	2.27	2.06	3.67	0.46	1.72
	mean	3.07 a	3.86 a	1.64 bc	1.93 abc	2.27 bcd	4.39 c	1.14 d	1.80 b
CMC 40	7	3.32	3.20	2.00	1.56	2.00	4.26	1.72	1.96
	9	2.50	2.89	4.78	1.55	2.59	4.37	1.66	1.96
	11	1.57	2.33	1.59	2.01	2.57	3.38	0.67	0.96
	mean	2.46 c	2.80 e	2.79 a	1.79 bc	2.38 abc	4.00 cd	1.35 b	1.62 c
CG 1-37	7	2.73	3.09	2.26	1.04	2.08	3.22	1.70	1.95
	9	2.33	3.20	2.07	1.01	2.28	4.60	1.44	1.66
	11	1.86	2.68	1.70	2.00	1.85	2.95	0.56	0.94
	mean	2.31 cd	2.99 cd	2.01 b	1.35 c	2.07 cd	3.59 de	1.23 bc	1.52 c
M Col 1684	7	2.56	3.79	2.74	2.90	2.91	5.18	1.95	2.26
	9	2.50	4.60	1.64	2.49	2.95	7.57	1.82	2.12
	11	1.92	2.97	2.01	1.69	2.11	4.66	0.76	1.78
	mean	2.33 cd	3.79 ab	2.13 b	2.36 ab	2.65	5.80 a	1.51 a	2.05 a
CM 849-1	7	3.09	3.67	3.24	1.61	2.58	3.46	1.74	2.02
	9	2.74	3.84	1.34	2.00	2.15	4.19	1.49	1.91
	11	2.09	2.62	1.87	1.57	1.40	3.31	0.53	0.86
	mean	2.64 b	3.38 c	2.15 b	1.73 bc	2.04 d	3.65 de	1.25 bc	1.60 c
M Ven 25	7	2.56	2.27	1.61	1.43	2.63	3.37	1.68	1.91
	9	2.21	3.49	1.35	1.70	2.19	3.74	1.44	1.64
	11	1.16	1.80	1.23	1.59	1.73	3.16	0.54	0.81
	mean	1.98 e	2.52 de	1.40 c	1.57 c	2.18 bcd	3.42 e	1.22 cd	1.45 c
CM 507-37	7	2.44	3.73	1.68	1.44	3.07	5.21	1.94	2.26
	9	2.33	4.26	2.17	2.86	2.36	5.39	1.81	2.16
	11	1.86	2.91	1.50	3.29	1.76	4.68	0.88	1.13
	mean	2.21 d	3.63 b	1.78 bc	2.53 a	2.46 ab	5.09 b	1.54 a	1.85 b
Mean of plant ages	7	2.93 a	3.41 b	2.17 a	1.71 a	2.53 a	4.17 b	1.76 b	2.04 a
	9	2.50 b	3.56 a	2.20 a	1.87 a	2.40 a	4.98 a	1.58 b	1.89 b
	11	1.84 c	2.68 c	1.59 b	2.06 a	1.95 b	3.69 c	0.63 c	1.17 c
C.V		6.54	12.21	13.67	14.17	10.48	10.76	8.39	10.46

Mean differently superscripted down the colomn are significantly different from one another ($P<0.05$)

Table 7. Effect varieties and plant ages on amylose content, times and temperatures gelatinization and viscosity of cassava flour (CIAT, December 1991)

Plant ages/ Varieties	Amylose content (%)	Gelatinization Time (min)	Gelatinization Temperarute (°C)	Optimum Gelatinized Time (min)	Optimum Gelatinized Temperature (°C)	Viscosity Optimum (BU)	Viscosity At 50°C (BU)	Viscosity Set back (BU)
7 months :								
CM 955-2	23.02	28	72	44	90	520	540	20
CMC 40	21.43	26	67	42	90	725	740	15
CG 1-37	21.54	24	62	43	90	680	580	-100
M Col 1684	22.12	22	61	42	90	640	620	- 20
CM 849-1	24.19	21	60	41	90	640	580	- 40
M Ven 25	23.78	23	62	26	70	340	50	-290
CM 507-37	24.44	22	61	33	89	550	350	-200
mean	22.93 a							
9 months :								
CM 955-2	22.02	24	62	38	90	600	500	-100
CMC 40	24.30	24	62	42	90	790	720	- 70
CG 1-37	24.54	24	62	44	90	780	690	- 90
M Col 1684	26.02	24	62	43	90	750	760	10
CM 849-1	25.90	25	67	43	90	720	660	- 60
M Ven 25	26.05	23	62	28	75	440	40	-400
CM 507-37	26.30	26	67	42	90	760	620	-160
mean	25.02 a							
11 months :								
CM 955-2	23.43	27	65	44	90	720	640	- 80
CMC 40	24.94	27	65	44	90	795	680	-115
CG i-37	25.02	26	64	43	90	820	600	-220
M Col 1684	24.51	24	67	43	90	780	680	-100
CM 849-1	24.79	24	67	42	90	720	560	-140
M Ven 25	25.28	23	62	24	65	355	15	-340
CM 507-37	24.25	23	62	42	90	780	570	-210
mean	24.60 a							
c.v	5.98							

Mean differently superscripted down the colomn are significantly different from one another ($P<0.05$)

Table 8. Effect varieties and plant ages on times and temperatures gelatinization and viscosity of cassava starch (CIAT, December 1991)

Plant ages/ Varieties	Gelatinization		Optimum Gelatinized		Viscosity		
	Time (min)	Temperarute (°C)	Time (min)	Temperature (°C)	Optimum (BU)	At 50°C (BU)	Set back (BU)
7 months :							
CM 955-2	22.5	62.3	27	65	1070	575	- 475
CMC 40	22.0	61.5	27	65	1070	600	- 470
CG 1-37	24.0	62.3	28	67	1115	860	- 255
M Col 1684	21.0	58.2	25	61	1190	810	- 380
CM 849-1	22.0	60.8	27	68	1080	910	- 120
M Ven 25	21.5	61.0	25	68	1075	440	- 635
CM 507-37	19.8	58.2	25	68	1480	940	- 540
9 months :							
CM 955-2	22.5	62.8	27	65	1065	800	- 265
CMC 40	23.5	61.5	30	73	1035	850	- 185
CG 1-37	25.0	62.9	29	70	1130	840	- 290
M Col 1684	23.7	58.7	27	64	1240	750	- 490
CM 849-1	23.5	60.6	29	69	1180	870	- 310
M Ven 25	24.0	61.0	28	71	1025	180	- 845
CM 507-37	21.5	60.5	26	65	1370	860	- 510
11 months :							
CM 955-2	25.5	63.0	30	71	1050	780	- 270
CMC 40	24.0	62.3	31	72	1030	800	- 230
CG i-37	24.5	63.6	27	72	1040	550	- 490
M Col 1684	21.0	60.2	25	65	1530	790	- 740
CM 849-1	24.0	60.5	28	67	1430	880	- 550
M Ven 25	23.7	62.5	29	70	1175	250	- 925
CM 507-37	21.5	61.6	25	65	1590	415	-1175

Table 9. Eating quality of the fresh cassava roots as affected by varieties and plant ages

Varieties	Plant ages (mo)	Cooking times (min)	Texture	Perfor-mance	Fiber	Taste			Deterio-ration
						Bitter	Medium	Sweet	
CMC 955-2	7	18	0.3	0.6	1.0	0.0	0.0	0.0	0.3
	9	16	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	20	0.3	0.3	0.3	0.3	0.0	0.0	0.0
CMC 40	7	18	0.6	0.6	0.6	0.0	0.0	0.0	0.3
	9	20	0.0	0.6	0.6	0.0	0.0	0.0	0.0
	11	20	1.0	0.6	0.0	0.3	0.0	0.0	0.0
CG 1-37	7	18	0.3	0.3	0.6	0.6	0.6	0.0	0.0
	9	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11	30	3.0	3.0	0.0	3.0	0.0	0.0	0.0
MCol 1684	7	22	0.0	0.0	1.0	3.0	1.6	0.0	0.0
	9	25	0.0	0.0	1.0	3.0	2.6	0.0	0.0
	11	20	0.0	0.0	1.0	2.0	2.0	0.0	0.0
CM 849-1	7	19	1.0	1.0	1.0	1.3	1.3	0.0	0.0
	9	21	0.0	0.0	0.6	2.0	1.6	0.0	0.0
	11	20	0.0	0.0	0.0	2.0	2.0	0.0	0.3
M Ven 25	7	18	3.0	3.0	0.0	3.0	2.0	0.0	0.0
	9	30	3.0	3.0	0.0	3.0	3.0	0.0	0.0
	11	30	3.0	3.0	0.0	3.0	3.0	0.0	0.0
CM 507-37	7	18	0.0	0.3	1.0	1.0	0.3	0.0	0.0
	9	20	0.0	0.0	1.0	3.0	3.0	0.0	0.0
	11	18	0.0	0.0	0.0	2.0	1.0	0.0	0.0

Score : 0- very good; 1- good ; 2- medium and 3- not good.

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SECTION 2.

PHYSICO-CHEMICAL OF THE KRUPUK PRODUCT ON SOME OF THE FORMULATES OF CASSAVA COMPOSITE FLOUR

by : Suismono and C. Wheatley

PHYSICO-CHEMICAL OF THE KRUPUK PRODUCT ON SOME OF THE FORMULATES OF CASSAVA COMPOSITE FLOURS[1)]

Suismono[2)] and C. Wheatley[3)]

ABSTRACT

Physico-chemical of the Krupuk product on sum of the formulates of Cassava composite flours. The materials are the cassava flour and strarch variety of "Paralek" (Local variety from Karawang West Java-Indonesia). This experiment was executed in Laboratory of Chemistry SURIF-Indonesia and Laboratory of Cassava Utilization CIAT-Colombia with experimental design Randomized Completely Design (RCD), 3 replications and the factors are the formulates of composite flours as cassava flour (CF) : cassava starch (CS), eachs : 0:100 , 25:75 , 50:50 , 75:25 and 100:0. Composite flour was made the Krupuk products and the observation data are the chemical(moisture content, cyanide, starch, sugar, protein, fat, fiber and ash content), physical (viscosity, times and temperatures gelatinization, surface expention rate and hardness) and organoleptic test (aroma, taste, colour,stickiness and performance) of the Krupuk products. The results are cyanide content very low (2-32,9 ppm) after steamed. The larger adding of cassava flour (until 75 percent the cassava flour) at the formulate of cassava composite flour are increase the sugar, fiber, protein, fat and ash content, but denaturated starch during the Krupuk process and more liked by panelis.

INTRODUCTION

Cassava (*Manihot esculenta* Cranzt.) is a source of carbohydrate and can processed become cassava flour, cassava starch and cassava composite flour, using for food products. Thermoplastic extrution is one of the promosing technologies for the future

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1) Report in Visiting Researcher-Cassava Utilization of CIAT Programme, June 20 - December 20, 1991. Cali-Colombia.

2) and 3) are each Staff of Researcher from SURIF (Sukamandi Research Institute for Food Crops)-West Java Indonesia and Leader of Cassava Utilization-CIAT, Cali-Colombia.

of cassava. It's capable of gelatinizing starch granules in pure cassava flour, reorienting the amylose and amylopectine molecules to from network which posseses viscoelastic properties semilar to those provided by wheat gluten. It can be used for the production of various convernience products such as snacks, breakfast cereals, baby food etc. and to give a provitable in the industry levels (El-Dash and Chang,1988).

Krupuk is food product in Indonesia and it's one of the extrution product. This product are called "Chicharritos"-YUPI in Colombia and "Ca-charon" in Philippines (Aurea, 1987). Krupuk product in Indunesia was consumpted to the complement food or snack. Sum of small industries are produce the kind of the Krupuk products 28,739 manufactories and production are 229,127,698 kg on 1987 (Table 1) (Madetten, 1989). The raw materials of krupuk from fresh cassava, cassava starch and flours are eachs 0.2 tons, 26.6 tons and 0.18 tons (Table 2) (CBS, 1989).

Appropriate the cassava utilization program in Indonesia is using cassava flour for food products, then the trials of this experiment are cassava composite flours for made the krupuk. Changes in the nutrient of the cassava products produced by cooking may be convieniently into those changes brought about by heat and those due to the effect of water and steam, or fat and oil (Bradbury et al., 1987). During the preparation of the krupuk, changes of colour, taste and texture varied depending on the formulate of the cassava composite flours used. This experiment were studied the changes of physico-chemical at the Krupuk product by the effect of the composite flour formulates.

MATERIALS AND METHODS

This experiment executed on April - September 1991. Cassava roots used "Paralek" variety (Local variety from Karawang-West Java-Indonesia) and harvested at 11 months the plant age.

Processing of cassava flours, cassava starch and the Krupuk products made in Chemist Laboratory-SURIF (Sukamandi Research Institute for Food Crops)-Indonesia and the analysis of physico-chemical in the Laboratory of Cassava Utilizarion-CIAT (Centro Internacional de Agricultura Tropical) Cali-Colombia. Experimental design is Randomized Completele Design (RCD), three replications and the factors are the formulate of composite flours from cassava flour (CF) : cassava starch (CS), eachs : (0:100) , (25:75) , (50:50), (75:25) and (100:0).

The steps of cassava flour process was peeling, washing, chipping, pressing, drying and milling. In the step of pressing produced the water and the starch (Figure 1). Procedure of Krupuk processing was mixer with the blender all the spices involve the shallots 20 g, the garlic 10 g, the salt 20 g and the sugar 25 g. The composite flours of 200 g with the trials formulate added the egg (two dinner spooks) and the water 400 ml as little as until texture the pasta compact and elastic and then packed with banana leaf and steamed at 100°C during 90 minutes. Making cold overnight at room temperature. Slicing with the dense size 2-3 mm to the sun dryer (± 2 days) until moisture content 10-12 percents. Then the krupuks were fried on oil at temperature 100-150°C so volume Krupuk larger than before baked (Figure 2).

Chemical composition of cassava flour, starch and krupuk products were analysed as total and free cyanide with hydrilysis of enzimatic methods (Coock, 1978), amylose content (Sun-hun and Matheson, 1990), total and reduce sugars (Cronic and Smith, 1979) and starch content with modifikasi hydrolisis acid and enzymatic methods (Batey and Ryde, 1982). Nitrogen was determined by the semi-automatic Kjeldahl method using the Tecator System (crude protein = N x 6.25) (Bradbury and Holloway, 1988), fat, fibre and ash by Harris method (Harris, 1970). Physical analysis as cassava flour and starch are vicosity and the temperature of gelatination with Brabender-Viscoamylograph (Halick and Kelly, 1959), and krupuk products are hardness (with Penetrometer) and spisific volume. Organoleptic test (aroma, taste, texture, performace and likeness) with hedonic method (Aurea, 1988).

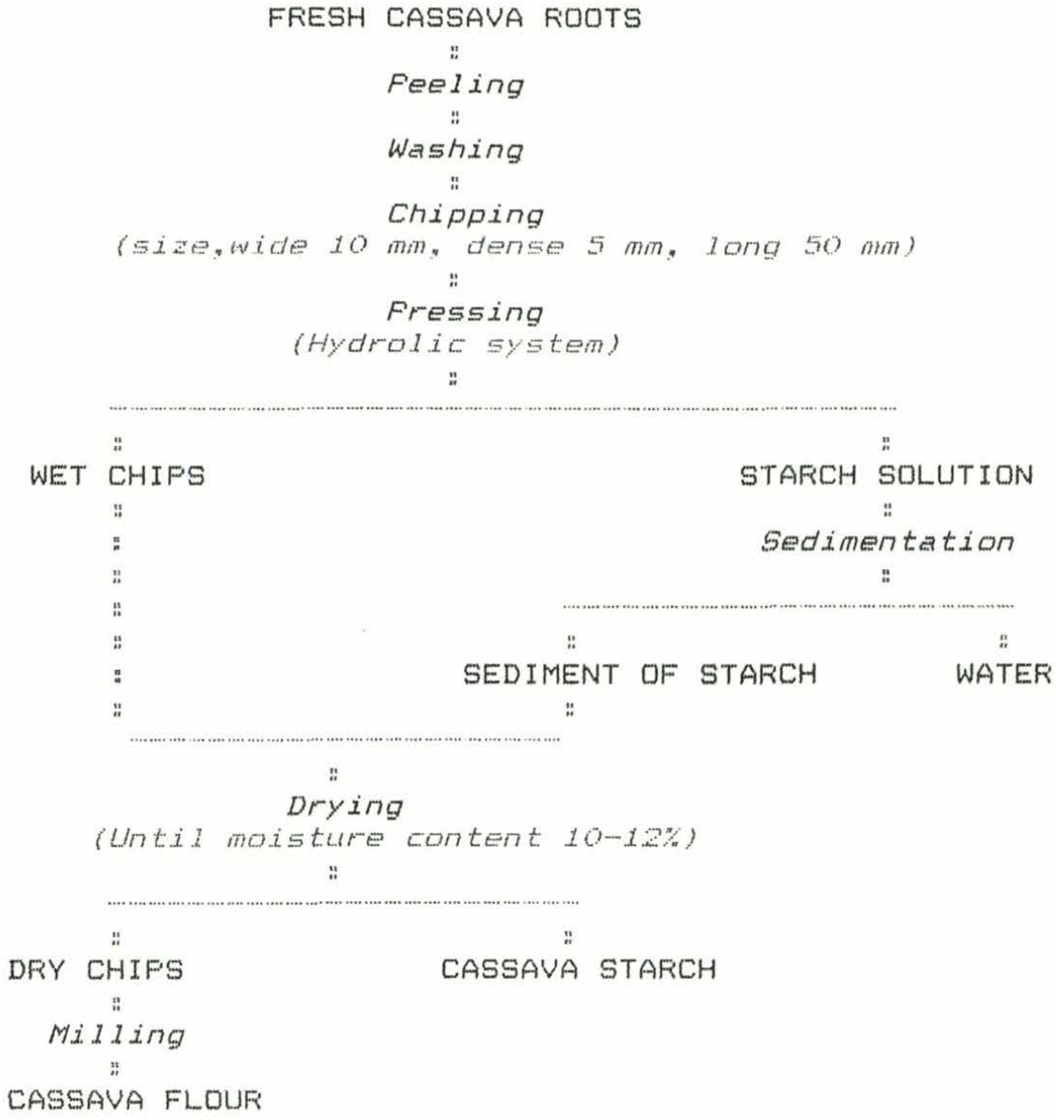


Figure 1. The steps of cassava flour processing
(CIAT, September,1991)

```
                    Preparation
                         :
                         v
        ----------------------------------------------------
        :                                                  :
        v                                                  v
      Mixing                                             Mixing the spices
       - the formulates of composite flour                 :
         (Cassava flour and starch)                        :
       - the spices  <--------------------------------------
       - the water
       - the egg
        :
        v
      PASTA
        :
        v
      Packaging ( with banana leaf)
        :
        v
      Steam (110ºC, 90 minutes)
        :
        v
       Cold (room temperature, 12 hours)
        :
        v
     Slicing
        :
        v
     Drying
        :
        v
     Frying
        :
        v
     KRUPUK
```

Figure 2. Procedure of the krupuk processing
(CIAT, September,1991)

RESUTS AND DISCUSSION

Chemical composition of Krupuk

1.Cyanide content

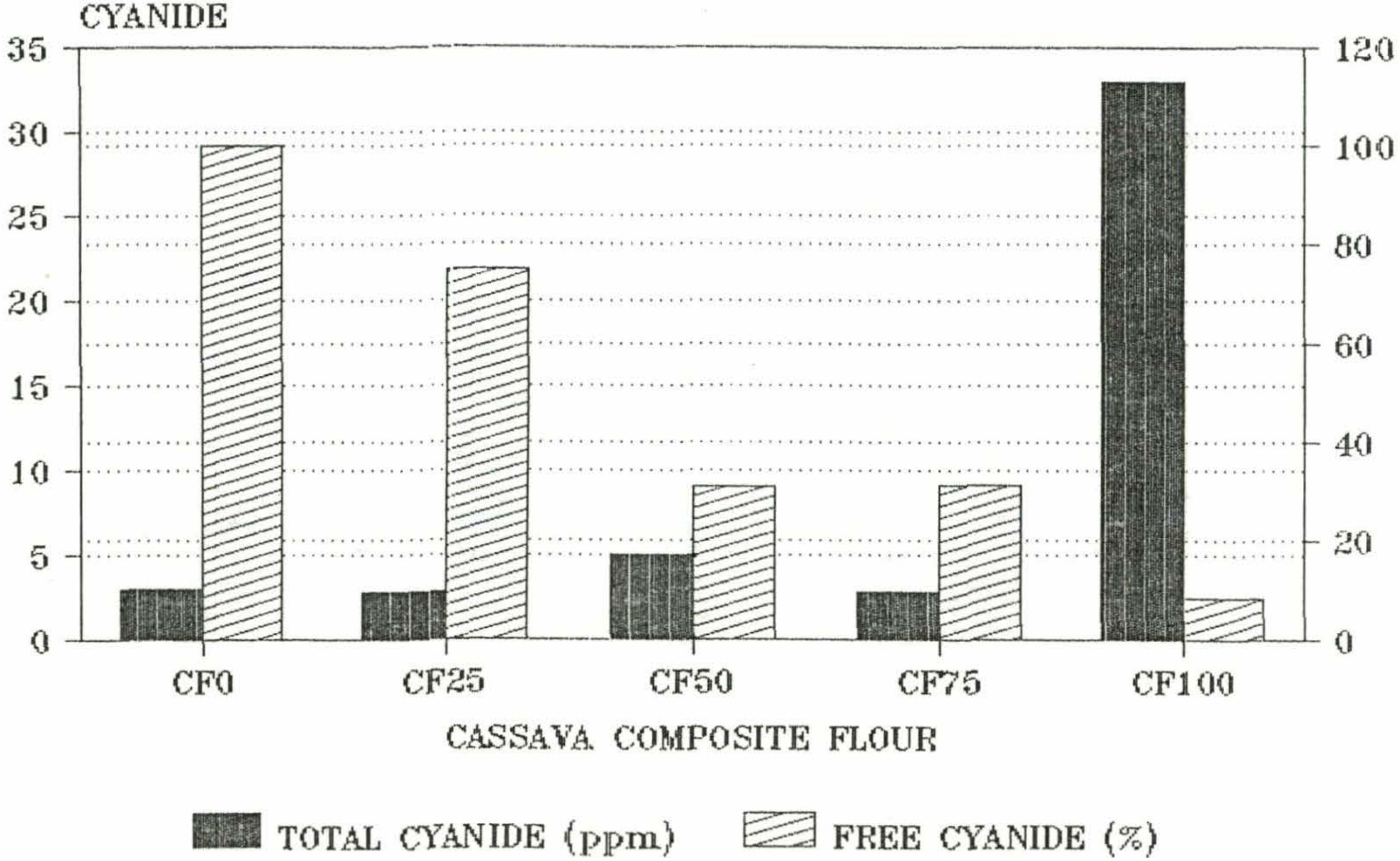
Cassava "Parelek" variety is contain the total cyanide in the cassava flour (CF) 35.66 ppm and in the cassava starch (CS) 3.55 ppm. If to due, we were mixed to become the composite flour and made the krupuk product, so the total cyanide content in the composite flours with the formulates (CF:CS) as 0:100 , 25:75 , ppm, 50 , 75:25 and 100:0 are each 2.93 ppm, 2.75 ppm, 2.81 ppm and 32.98 ppm. Total cyanide of the Krupuk is lower than cassava flour and starch, especially if mixed with cassava flours less 75% (Figure 3). During processing of the cassava flour was reduced the total cyanide content (Aurea, 1988).

Free cyanide content in the Krupuk were increase if the formulates of the cassava composite flour fewer than cassava starch. Free cyanide content with the formulates CF:CS as 0:100 , 25:75 , 50:50 , 75:25 and 100:0 are each 100% , 74.9% , 31.0% , 30.09% and 8.2% (% free CN from total cyanide). Free cyanide in the Krupuk are 0.87 - 4.71 ppm lower than in the cassava flour 5.76 ppm (Figure 3). During the Krupuk processing was evaporated the water by heating and together losses cyanide content (Aurea, 1988). On the cooking process are steam or boiling and baking to reduce the cyanide content (Troug Van Den,1988).

b. Carbohydrate content

Starch and sugar are component of carbohydrate. Starch content in the Krupuk on each formulates were increase which comparted in the cassava flour 70% and cassava starch 93%. Between the formulates of the composite flour so much larger of the cassava flour were added, then starch content in the Krupuk to decrease. The formulates of the composite flour FC:CS as 0:100 , 25:75 , 50:50 , 75:25 and 100:0 are contain the starch content

TOTAL AND FREE CYANIDE OF THE KRUPUK BEFORE FRYING



each 100%, 8.6%, 67%, 77% and 60% (Table 1). During the cooking processes (Steamed) were gelatinized to proceed, visible at changes of the total and reduce sugar content. Total sugar content were increase with added the cassava flour and optimum at the formulate CF:CS=50:50 is 5.07%. Too the reduce sugar are lowest at the formulate CF:CS=50:50 0.60% (Table 1). Brabury et al (1987) reported the total sugar was increase from 34.5 g per kg sample (uncooking) to 98.5 g per kg (boiled) and 104.4 g per kg (steamed) becouse during the cooking were gelatinized and denaturated starch by heat and the water. After boiling increase the water content 10-40 g per kg sample and 20 g per kg after steamed, but to decrease after baking become 70-90 g per kg. Cheftel at al (1985), on baking process was reduced sugar content in relationship with the millar reaction. At the extrution process, for the cooking was gelatinized by heat and the water which amylopectin at the paste retrogradate and the puffing process after baking (Kawabata, 1984).

Table 1. Starch and sugar content on the Krupuk and the raw materials (Cassava flour and Cassava starch)

Formulates of composite flours	Moisture content (%)	Starch content (%)	Sugar content Total (%)	Sugar content Reduce (%)
Krupuk :				
(CF) : (CS)				
0 : 100	8.04	100	4.50	0.77
25 : 75	7.86	87	2.28	0.62
50 : 50	8.10	67	5.07	0.60
75 : 25	7.59	77	4.67	0.71
100 : 0	6.72	60	2.60	0.68
Raw materials :				
Cassava flours (CF)	8.12	70	0.20	0.04
Cassava starch (CS)	9.80	93	0.36	0.20

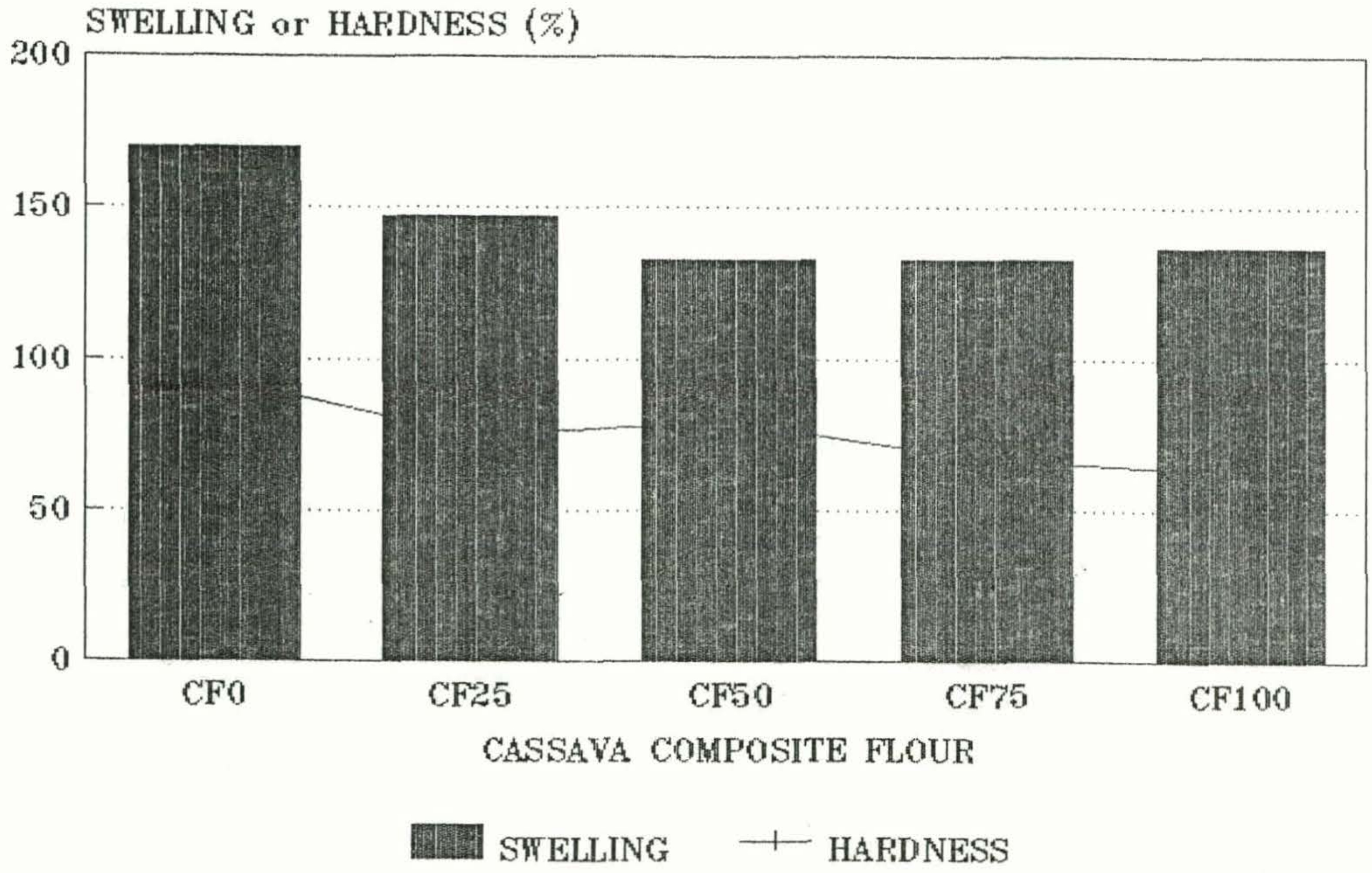
c Proximate analysis

Proximate are involve protein, fat, fiber and ash comtents. Protein content at the cassava flour and starch are each 1.22% and 0.87% lower than at the Krupuk products 1.57 to 2.62%. Ash content at the cassava flour and starch are each 0.66% and 1.42% lower then at the Krupuk 3.54 to 5.70% (Table 2). Protein and ash content at the Krupuk were increase with added the cassava flour on the formulates of composite flours. Protein content at the formulates CF:CS as .:100, 25:75, 50:50, 75:25 and 100:0 are each 1.57%, 1.75%, 1.92%, 2.27% and 2.62%. So the ash contents are 3.54%, 3.74%, 3.28%, 5.18% and 5.7%. May be a few the mixing of cassava flour (larger cassava starch) gelatinized very quicly becouse the time of gelatinization at cassava starch shorter than cassava flour (Figure 4), so to decrease protein and ash contents. Effect heat can be denaturate protein for cooking (Cheftel et al, 1985). Ash content was decrease becouse reducing the minerals (K, Na, P and S) by boiled, and Sodium (Na) by steamed (Bradbury et al, 1987).

Table 2. Kadar protein, fat, fiber and ash pada beberapa formula krupuk

Formulates of composite flours	Protein (%)	Fat (%)	Fiber (%)	Ash (%)
Krupuk :				
(CF) : (CS)				
0 : 100	1.57	1.00	0.05	3.54
25 : 75	1.75	1.06	0.09	3.74
50 : 50	1.92	0.06	1.55	3.28
75 : 25	2.27	1.26	1.63	5.18
100 : 0	2.62	1.23	2.05	5.70
Raw materials :				
Cassava flours (CF)	1.22	1.27	2.57	1.42
Cassava starch (CS)	0.87	1.69	0.04	0.66

SWELLING AND HARDNESS OF THE KRUPUK AFTER FRYING



Fat and fiber contents were increase with added cassava flours in the formulates of coposite flour (Table 2). Effect of cooking can be denaturate the starch content and can be increase fiber content (Brabury et al., 1987).

Physical Characteristics

a. *Viscosity*

Viscosity is relationship between swelling power and the Brabender pasting curves. Therefore, both swelling power and viscograph curves are usually determinated (Miller et al, 1973). Adding the cassava flour at the formulate of the Krupuk was need the time of gelatinization 27 minutes at the paste longer than the cassava starch 23.5 minutes. Temperatures of gelatinization increase 60.5°C to 67°C, the time of the optimum gelatinization 27 to 42.5 minutes and temperature 66.8°C to 90°C, but the optimum viscisity decrease from 1740 BU to 720 BU (Table 3 and Figure 4).

Setback viscosity indicate after colling at 50°C for 30 minutes which characteristics of the paste will stabilizer and tendency to retrograder (Mazurs et al, 1957 ; Aurea, 1988 ; Whistler et al. 1984). After cooling at 50°C, the viscosity increase at all formulates becouse the starch is not compact in the granule (Richana and Damarjati, 1989) or between the starch moleciles have been the inclination to assosiate (Lee et al, 1957 and Leach et al, 1959). Between the formulates, after cooling at 50°C and setback viscosity increase until CF75 each 480 BU and -170BU. The symbol of negative (-) indicate that after at 50°C for 20 minutes still the soft of the paste (Samson et al, 1990).

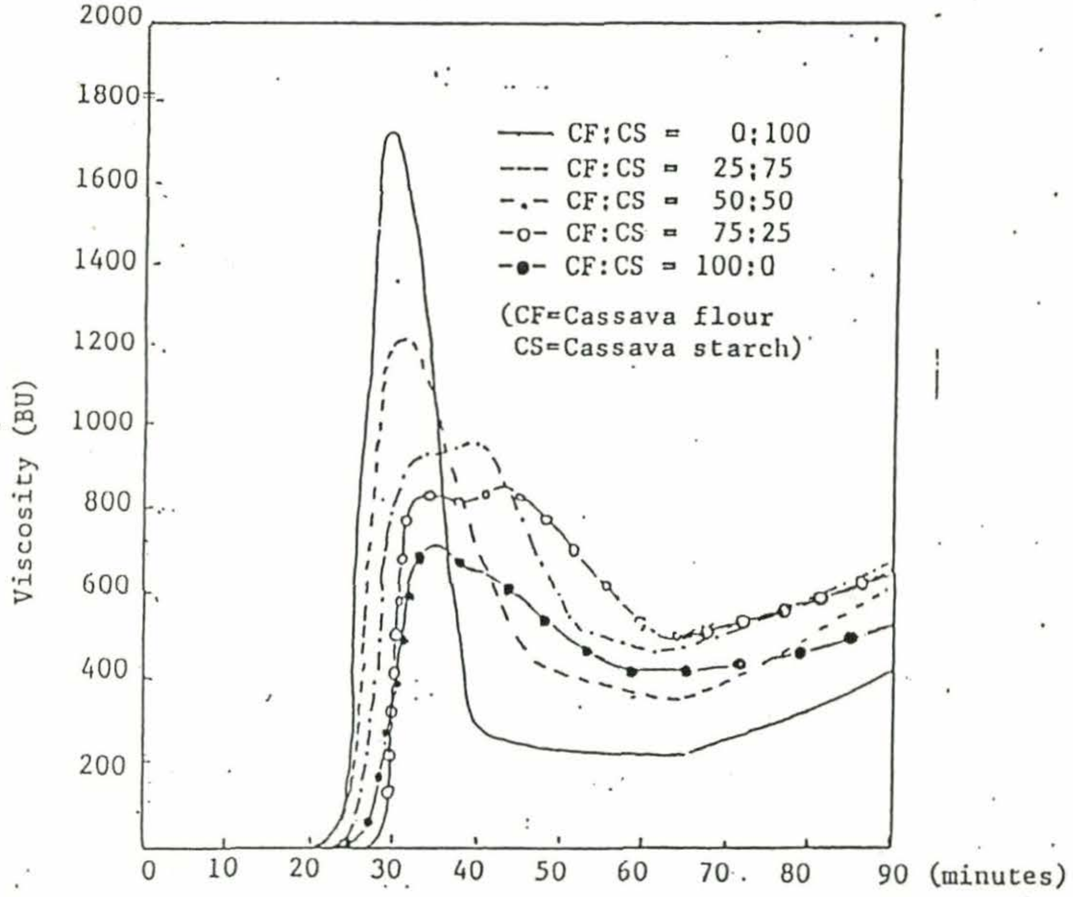


Figure 4. Viscosity of the Cassava composite flours at some formulates for the Krupuk products

b. Spesific volume and hardness of the Krupuk

After frying all the Krupuk was swell 130% to 190% (1.5 times) and between the formulates with added the cassava flours are little or no relation swelling. The formulates CF0 to CF 25 147% to 170% and CF50 to CF 100 about 130 % (Table 3)

Table 3. Swelling and hardness of the Krupuk at before and after baking

Formulate of the Krupuk (CF :CS)	Spesific volume (0 cm)			Hardness		
	Before frying	After frying	(%)	Before frying	After frying	(%)
0 : 100	12.0	20.5	170	137	129	94
25 : 75	12.2	18.0	147	177	133	75
50 : 50	14.4	19.2	133	289	229	79
25 : 75	16.3	21.2	133	314	213	67
100 : 0	7.8	10.6	137	342	216	63
Type 1	15.0	28.5	190	338	226	58
2	9.5	17.0	178	274	165	60
3	16.0	27.5	171	498	233	46

[1] measure with Penetromete

Type 1,2 and 3 are the Krupuk product from industry levels in Indonesia materials each : types 1 and 3 (100% cassava starch) and type 2 (75% cassava starch and 25% the shrimp).

Swelling of the Krupuk were decrease with added the cassava flour at the composite flour comparted the cassava starch, be-couse amylose content lager. These is visible at increasing the viscosity of the cassava starch paste for cooling at 50°C and setback viscosity more stability, therefore after frying the Krupuk volume of cassava starch are sweller than at cassava starch. Endang (1985) reported after the gelatinize process by heat and water, so the characteristics of starch to form the power tissue ("micel"). After frying, the tisuues can be swell and the starch more stability (Endang, 1985). Aurea (1985) reported at the fried cassava chip, the surface expansion is positively correlated with maximum paste viscosity, which is obtained the increase in structural viscosity caused by the swollen starch granules is conterbalanced by thedecrease in viscosity resulting from desintegration and solubilisation of the starch. Cassava strach in flour with hight maximum viscosity apparently swells more before a major portion is converted to fragments during continuous heating. It seems that the more swollen the starch granules during steaming of the dough, the greather was the expansion of the dried chips frying. Cassava starch is mostly made up of starchj and when suspension of starch is heated, the water molocules enter the starch granules overcoming the associative forces within the granules and starch granules swell out many times their own volume (Leach *et al.* 1959).

Between the formulates CFO to CF100, the hardness of the Krupuk increase with added the cassava flour at the trials after and before baking aech 137g - 342g per 10 mm and 129g - 216 g per mm. But after baking the harness of the Krupuk were decrease at all the formulates from CFO to CF100 were 94% to 63% (Table 3).

c. Organoleptic test of the Krupuk

Organoleptic test were executed by tens panelis on the colour, aroma, taste, texture and performance at the Krupuk products before and after frying.

Before frying, with added the cassava flour at the composite flour, the Krupuk colour was light brown, texture less compact, hardness decrease and performance was less like. Until the formulates CF 75 is indicate the panelis still like (Table 5).

After frying, between the parameters the panelis more like the colour and taste of the Krupuk. Until the formulates CF75 is the panelis still like the colour, aroma, taste and performance the Krupuk (Table 6). Changes of the color is a probable couse for the the formation of browning products between the sugars and theamino acids during steaming of the cassava dough. As the degree of darkness of the steamed dough increased and the fried chips became darker (Aurea, 1988). It seems at the formulate CF50 which the colour less like (Table 6) and total sugar content highest (5.07 %) (Table 1).

Table 5. Organoleptis test of the *Krupuk before frying*

Formulate of the Krupuk	Colour	Texture	Stickiness	Performance
(CF :CS)				
0 : 100	4.6	5.0	4.6	2.6
25 : 75	2.3	5.0	4.6	2.3
50 : 50	2.0	5.0	4.6	2.3
75 : 25	3.6	4.6	4.6	2.6
100 : 0	5.0	3.6	3.6	2.3
Type 1	3.5	5.0	5.0	2.5
2	4.5	4.5	4.5	2.5
3	1.5	5.0	5.0	2.5
4	5.0	5.0	5.0	2.5

Type 1,2 and 3 are the Krupuk product from industry levels materials each : types 1 and 3 (100% cassava starch) and type 2 (75% cassava starch and 25% the *shrimp*) *from* Indonesia and type 4 "Chicarritos"-YUPI product from Colombia. Score : 5.0-4.6 very like, 4.5-3.6 like, 3.5-2.6 medium, 2.5-1.6 less like and 1.5-0.0 no like.

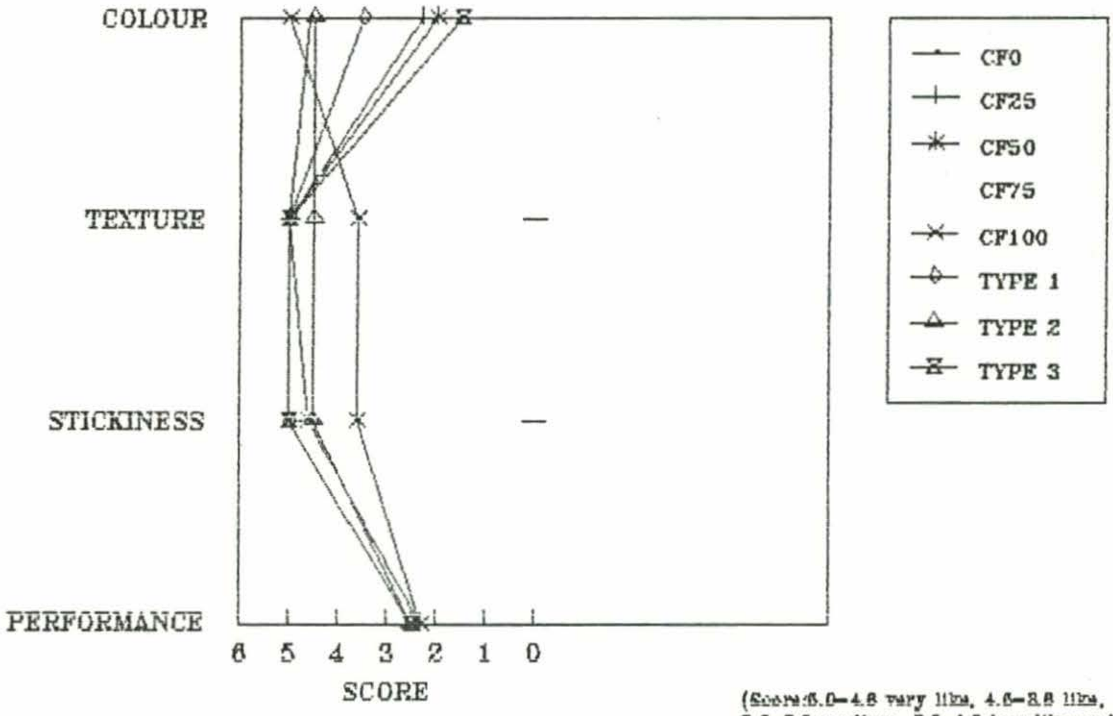
Table 6. Organoleptis test of the krupuk after frying

Formulate of the Krupuk	Colour	Aroma	Taste	Texture	Performance
(CF :CS)					
0 : 100	3.8	2.4	3.2	2.8	2.3
25 : 75	3.4	2.4	3.2	2.8	2.6
50 : 50	2.8	2.4	3.2	2.8	2.6
75 : 25	3.4	2.8	3.4	2.6	3.6
100 : 0	3.0	2.8	2.8	2.6	3.0
Type 1	4.2	3.7	4.2	2.7	2.6
2	4.2	3.7	3.5	2.7	2.0
3	4.2	3.2	4.0	3.0	2.6
4	3.5	3.5	3.7	3.0	2.6

Type 1,2 and 3 are the Krupuk products from industry levels materials each : types 1 and 3 (100% cassava starch) and type 2 (75% cassava starch and 25% the shrimp) from Indonesia and type 4 "Chicharritos"-YUPI product from Colombia. Score: 5.0-4.6 very like, 4.5-3.6 like, 3.5-2.6 medium, 2.5-1.6 less like and 1.5-0.0 no like.

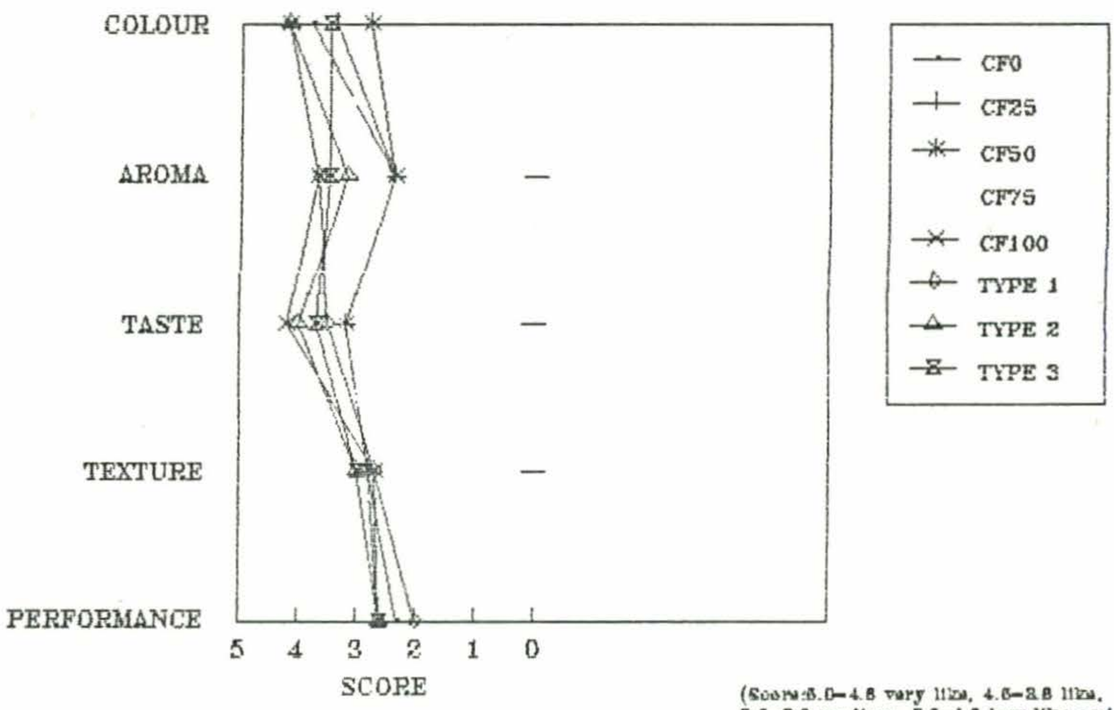
ORGANOLEPTIC TEST OF THE KRUPUK

BEFORE FRYING



(Score:5.0–4.6 very like, 4.5–3.6 like, 3.5–2.6 medium, 2.5–1.6 less like and 1.5–0.0 no like)

AFTER FRYING



(Score:5.0–4.6 very like, 4.5–3.6 like, 3.5–2.6 medium, 2.5–1.6 less like and 1.5–0.0 no like)

CONCLUSSION

1. After steaming, total cyanide at the Krupuk is 2 to 32.9 ppm (< 50 ppm can humman consumption) and starch content was denaturated during steam (still 77 percents with added 75 percents the cassava flours). It seems by to increase the total sugar and fiber contents. Protein, fat and ash content are increase too.

2. All the formulates of Krupuk products, during the gelatinization needed the times 23 to 27 minutes, temperatures between 60.5 to 67ºC. The larger adding of cassva flours are decrease the peak viscosity and retrograded the Krupuk after fied (still 147 percents swelling of the Krupuk with added 25 percents cassava flours).

3. Adding the cassava flour are resulted the Krupuk pruducts more liked by panelis.

ACKNOWLEDGEMENTS

We wish to thank Dr. Chistopper Wheatley as the Superviser for the research, Dr.Rupper Best Leader Cassava Programm in Centro Internacional de Agricultura Tropical (CIAT) for usefull advice and thanks for financial Support of the CIAT. Usefull advice on Staff and Technical Assistence of Cassava Utilization and Service Laboratory-CIAT.

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Table 1. The Small Industries of the Krupuk kind produces on eights province, Indonesia, 1987.

Provinces	Sum of manufacturer (units)	Labours	Production (Kg)	Value of production (Rp)	Value of invetation (Rp)
South Sumatra	1.253	4.798	9.226.690	7.496.687,-	596.207,-
West Java	2.117	15.321	81.210.220	60.908.415,-	1.848.480,-
Central Java	9.973	48.552	51.465.374	46.318.837,-	6.236.350,-
Jogya	666	1.996	5.847.010	4.092.907,-	483.306,-
East Java	8.803	30.566	74.553.638	72.689.798,-	5.504.750,-
West Kalimantan	116	318	571.380	559.953,-	65.615,-
N.T.B	773	3.032	5.775.716	1.732.715,-	112.670,-
South Sulawesi	38	229	477.670	358.253,-	168.324,-
Totals	23.739	104.722	229.127.698	194.157.565,-	15.015.629,-

Souce : Madhetten (1989). (Eqv. 1 $ US = Rp.1.850,- on October 1989).

Table 2. Production of the Krupuk from some of the cassava product in Industry manufacturer in Indonesia, 1988

Cassava products	Production of the Krupuk (x 1,000 ton)
Fresh roots	0.20
Tapioca starch	26.60
Gaplek flour	0.18
Totals	27.00

Source : CBS (1989).

Table 3. Pasting characteristic of Cassava composite flour (65 mesh particle size) for the Krupuk product

Formulates of the Krupuk (CF : CS)	Times of gelatinization (min.)	Pasting temperature (°C)	Peak viscosity/ temperature (BU/°C) (p)	Viscosity at 90°C (BU) (h)	Viscosity at 50°C (BU) (c)	Break down (p-h)	Setback viscosity (c-p)
0 : 100	23.5	60.5	1740/66	300	410	1440	-1330
25 : 75	23.2	61.5	1205/67	425	625	780	- 580
50 : 50	24.0	62.4	980/86	460	690	520	- 290
75 : 25	27.0	67.0	850/90	480	680	370	- 170
100: 0	25.0	65.5	720/85	375	530	375	- 190

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SECTION 3.

STUDY OF COMPARISON ON THE RESEARCH OF CASSAVA POSTHARVEST BY CASSAVA UTILIZATION CIAT AND SURIF PROGRAMME

by: Sulsmono

REPORT

STUDY OF COMPARISON ON THE RESEARCH OF CASSAVA POSTHARVEST BY CASSAVA UTILIZATION-CIAT AND SURIF[1)]

Suismono[2)]

CIAT (Centro International de Agriculture Tropical), Cali-Colombia
SURIF (Sukamandi Research Institute for Food Crops), West Java-Indonesia

INTRODUCTION

Cassava (*Manihot esculenta Crantz.*) is the fourth most important source of calories for people in the tropics, after rice, sugar and maize (Cock,1982). Cassava has importamnt function as a famine food in areas where food security is low.

Colombia and Indonesia is a country in the tropic areas to produce the cassava. Central of cassava production in Colombia are the Atlantic Cost Region, to include four provinces (departemento) as Atlantico, Bolivar, Cordoba and Sucre. Location of pilot plan of Cassava processing program-CIAT is in Chinu, Sincelejo-Sucre (Figure 1 and 2). Central of cassava production in Indonesia are five provinces, to includeas East Java, Central Java, West Java, Lampung, NTT, D.I Yogyakarta and South Sumatra. Location of Pilot plan of Cassava processing-SURIF are in three provinces as Central Java, West Java and East Java.

This report is a study of comparison of cassava postharvest, especially Pilot plan of Cassava Agro-industry System during Visiting Researcher June - Decembre, 1991 in Section of Cassava Utilization-CIAT, Cali-Colombia by Researcher Staff from SURIF (Ir.Suismono) and visiting to the pilot plan area in Sicelejo on Octobre 16-19, 1991 together the staff of Cassava Utilization-CIAT (Dr.Carlos Ostertag and Lisimaco Alonso).

---

1) Report on Visiting to Pilot plan the Cassava flaur Agro-industry of CIAT Programm in Chinu-Sincelejo,Atlantic Cost Colombia at October 16-19.1991.

2) Researcher Staff of SURIF -West Java, Indonesia

FIGURE 1.

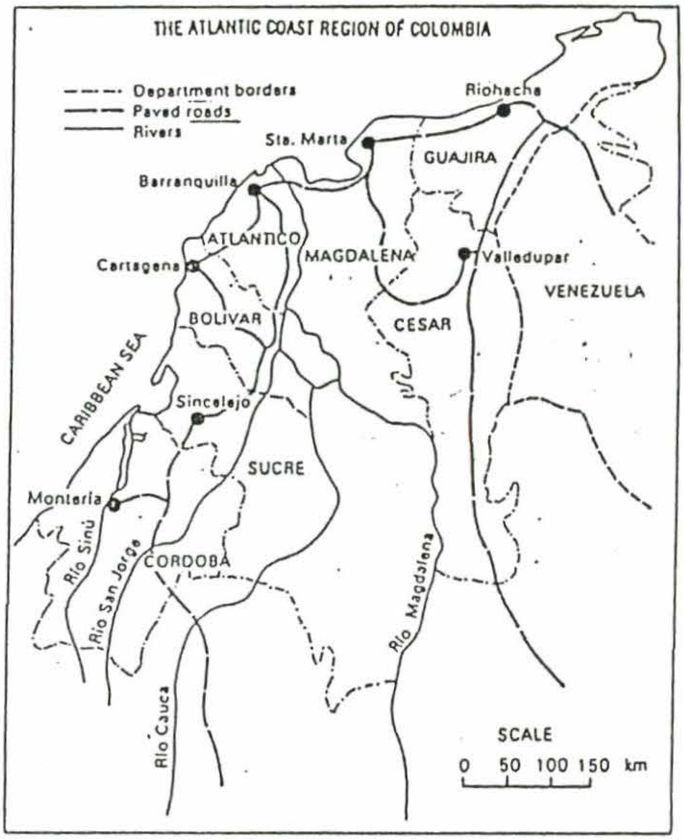


FIGURE 2.

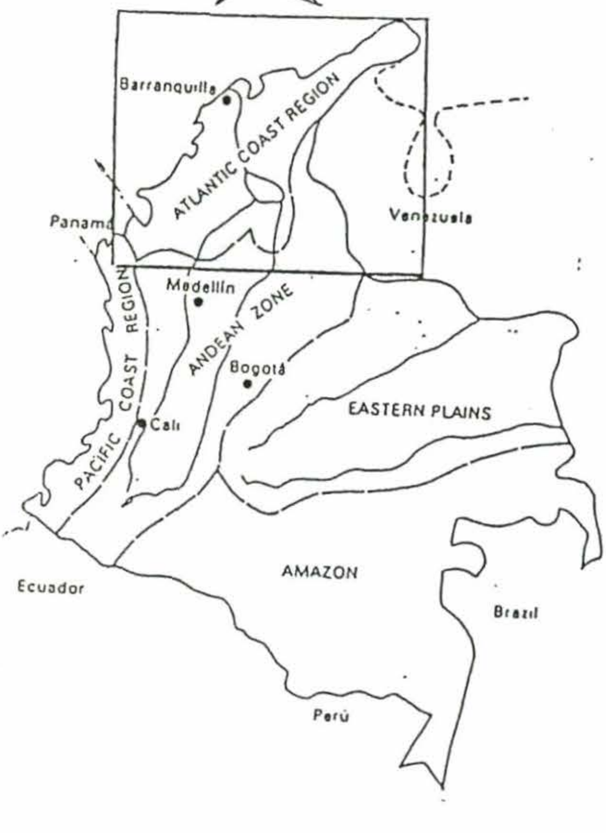


FIGURE 1 and 2: Location of the Pilot Plant of Processing in Atlantic Coast, Colombia.

CASSAVA UTILIZATION PROGRAM - CIAT, COLOMBIA

Pilot plan of cassava is include three activity : Dried cassava for animal feed, fresh cassava and cassava four for human cunsumption.

1. *Dried cassava for animal feed (1981-1989)*

Activity were divided in two phase: pilot phase (1981-1984) and replication commercial phase (1985-1989). Pilot plan location in Chinu-Sincelejo, Sucre, expectant can be given impact of application technology of processing. Cassava production in Sucre are 106,700 ton (plant areas 9.700 hectar) in 1983 largest than other food crops as rice (35,200 ton), shorgum (22,300 ton), maize (14,100 ton), yam (56,00 ton) plantain (15,700 ton) and sugar care (9,000 ton) (Janssen, 1986).

First orientation of the cassava research is used for animal feed becouse to the subsitution of shorgum at concentrate of animal feed. Production of animal feed in Colombia, 1984 are 1,535,600 ton (Table 1) and Import shorgum highest 207,500 ton,1980 (Table 2).

Table 1. Animal feed production in Colombia, 1984

	Production (ooo tons)	% of total production
Animal feed for:		
Layer-lens	790.7	51.5
Broilers	372.6	24.3
Pigs	219.7	14.3
Cattle	130.3	8.5
Other	22.1	1.4
Total	1,535.6	100.0

Source: Janssen (1986).

Table 2. Shorgum production and imports in Colombia,1977-83

	Areas (ooo Ha)	Production (ooo ton)	Import (ooo ton)
1977	189.5	406.2	125.8
1978	224.8	516.7	50.6
1979	221.2	501.3	170.5
1980	206.0	430.5	207.5
1981	231.3	532.0	55.0
1982	291.2	575.5	132.9
1983	280.0	617.3	97.9

Source: Janssen (1986).

Management system, in order CIAT programm to coordinate inter-institutional activity. DRI (Integratet Rural Development), set up tehnical assistence Team responsible for selecting the project areas and the farmer groups (15-30 farmers). The status of farmer groups were possible became an Assocoation of cassava producers (ANAPE) as in San Juan de Betulia (Sucre) was selected for the pilot drying facilities (300 m^2). Some of the famer groups have gone through the bereaucratic hassle of becaming cooperatives. The Team is include some institutions as CIAT coordinator. Institutional on the Atlantic Coast and their principal functions are the coordinator and leadership IRD by (DRI), the credit by (Caja Agraria, FINANCIACOOP, CORFAS), the farmer organization and legal advice by (INCORA), production by (ICA) and processing by (CORFAS).

Dried cassava processing was weighing, washing, chipping, spreading, drying and packaging by Pilot plan-CIAT. Milling was conducted by feed industry (Figure 3).

```
...............................................................
:                                                             :
: FRESH  ---> Weighing ---> Washing ---> Chipping ---> Drying :
: CASSAVA                                                 |    :
:.......................................................  |    :
                                                        :  |    :
                                  ...........   ........  v    :
                                  : Milling : <-- : -- Packaging  :
                                  :.........:     :...............
                                       |                 |
                                 (Feed industry)  (Pilot plan-CIAT)
```

Figure 3. Dried cassava processingfor animal feed
(CIAT, 1991)

```
                Balanced              Integreted poultry
                feed industry         and park producers
                    ^                     ^
                    |                     |
              ......................
Coop. or      :  Drying plants      : <-- Intermediares
Association   :       ^             :          ^
              :       |             :          |
              :   Member farmer     :    Non member farmer
              :.....................:
```

Figure 4. Dried cassava processing and marketing channels
in Atlantic Cost, 1985 (Janssen, 1986)

Spesifecation of the processing equipment are washing machine of the CIAT model, Chipper machine of the Thai model with 3-10 t/h capacity. The natural drying floor areas ranged 300-3000 m² with turning them 6-8 times daily with a wooden rake until 10-14 moisture content which started at 4-6 pm in the afternoon during 36-48 hours. Capacity of natural drying floor is 8-10 kg/m² and the warehouse is 48 m². Plans of 500-1000 m² require 4 workers those of 2000-3500 m² require 9 workers(Figure 5 a).

Result of the dried cassava processing for animal feed was the ratio fresh to dried cassava 2.6 : 1 (30%). Inthe marketing, provit of the dried cassava processing are 19 US $ (Table 3) (Janssen and Ospina, 1983)

Table 3. Provite economic parameters of a cassava drying plant of 500 m²

1. INVESTMENTS (US $)	
Drying floor + warehouse	± 5400
Chipper + motor	± 1800
Other equipment	± 900
Total	± 9000
2. WORKING CAPITAL (US $)	± 5000
3. PROCESSING COST (US $/tons dried cassava)	
Operation cost	15-25
Transport cost	10-25
Interest cost	± 10
Total	35-55
4. MISELLANEOUS PARAMETERS	
Produstion per year	144 tons
Prime material needs	360 tons
Profit/ton	19 US $
Internal rate return (IRR)	30 %

Source : Janssen and Ospina (1983).

Dried cassava production is far more favorable for the country than shorgum production, as expressed by a DRC-ratio of 0.72 versus 1.26 (DRC= Domestic Resource Cost). Internal rate of teturn (IRR) of round 7%, while dried cassava production has a positive one of about 43%. The Benefit Cost ratio (B/C-ratio) support the provious conclosions : for shorgum the B/C-ratio is 0.89 and for cassava 1.21 (Table 4) (Janssen, 1986).

Table 4. Indicators of economic value of shorgum versus dried cassava International prices, 1984

	Shogum production	Dried cassava production
DRC-ratio	1.26	0.72
IRR	-7.10 %	43.80 %
B/C-ratio	0.89	1.25

Source: Janssen (1986)

2. *Fresh cassava for human consumption (1987-1988)*

Location of the Pilot plan in Barranguilla-Atlantic Cost. Operational activities wasconducted by the Team, with the coordinate of CIAT programm, includes CIAT, DRI, SENA, ICA and CECORA.

Fresh cassava for human consumption, wich appears to lose importance in the urbanization process. It´s assumed that improvement of fresh cassava market can be reahed by improving the storage capability of the fresh roots (Janssen, 1986).

The treated root are stored by CIAT with fungicide Mertect 450 (Thiobendizole) concentrate 4 ml/ liter water and dipping large saks of roots in the barrel containing the Mertect solution for 5 minutes, followed by a 15-30 minutes wait to remove excess moisture. Packaging is a polyethylene bags for up two weeks. Changes in root dry metter and strach content are non significant during storage and only minor in sugar content occur and is not toxic for humans. It´s used commercial to treat banana and potatoes.

Semi commercial tials showed it was possible to reduce cost from US $ 12 to $ 4/ ton, and the roots had to be packed only once. Consumer reaction were positive and the baggad cassava was being sold throug retailers in the pricipal open market and through sphopheepers in several neighbourhoods. Net prfit for the farmer/ groups were Col. $ 24000/ton in 1987 (US $ 1= 242 Col.$, avg for year). Several name were consumer tested and the most favored was a name Associated with freshness "YUCAFRESKA", wich was regestered in the name of the National Association of cassava producers and processors (ANPPY)(Figure 5b).

Marketing system of the fresh cassava in Atlantic Cost Region of Colombia, 1983 as Figur 5. Net profit margin for marketing cassava in bags: 1987 was 288,875 PS $ from salling 51 tons fresh cassava (Table 5).

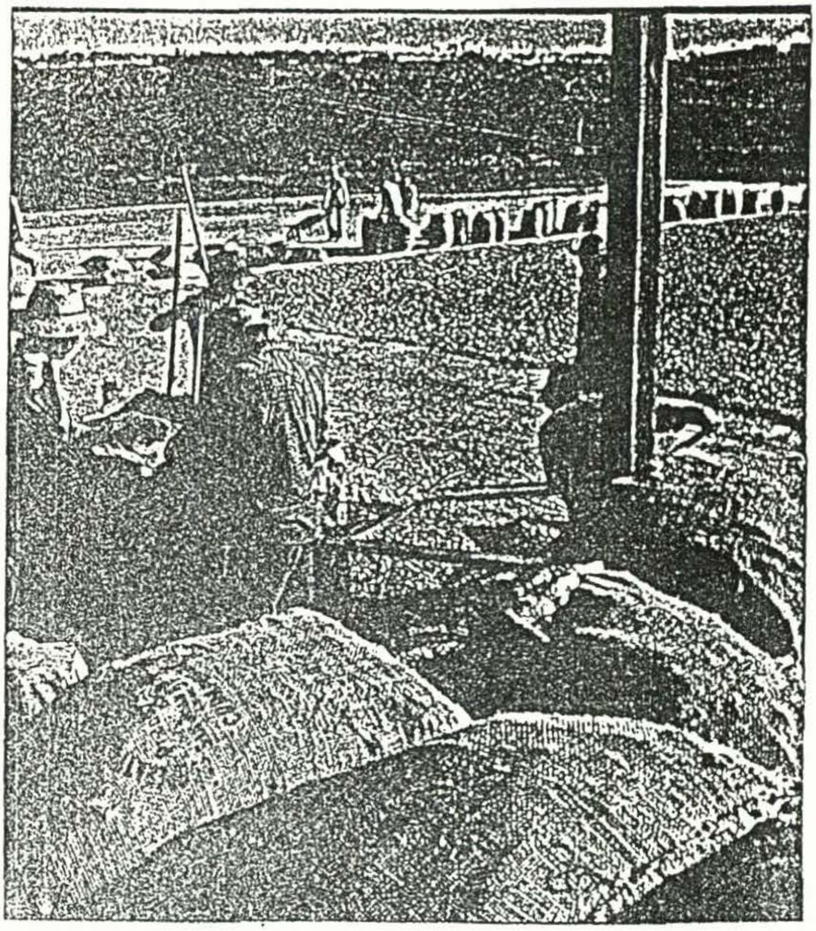


Figure 5A. Drying process for the animal feed in Colombia

Table 5B. Fresh cassava commercial with the trial of the Mertect 450SC fungicide

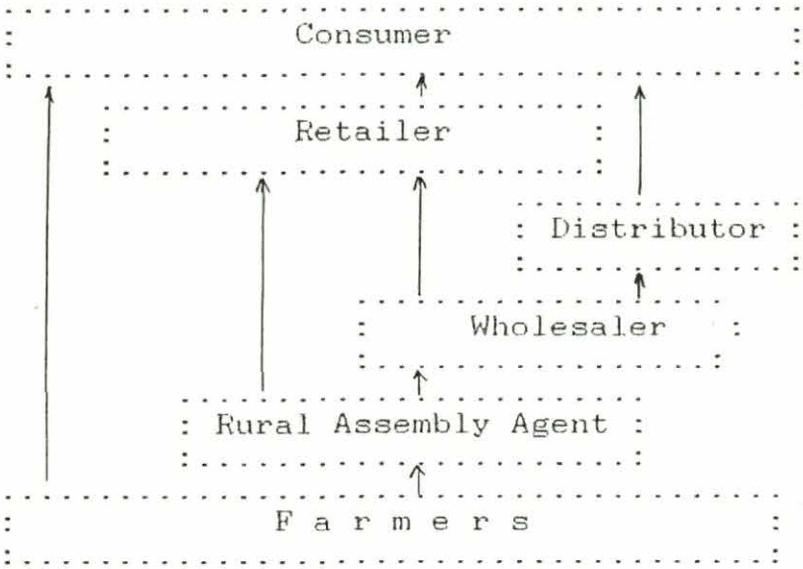


Figure 5. Marketing of fresh cassava in Atlantic Cost Colombia

Table 5. Estimate of profitability of marketing cassava in bags during August and September 1987 (51 tons sold)

	Total (Col.$)	Unit
Income from sale of cassava	2,266,592	44.44
Treatment and marketing cost	1,961,017	38.45
Cash floun	305,575	5.99
Working capital *	15,000	0.29
Depreceation **	1,700	0,03
Net profit margin	288,875	5.66

* Working capital Col.$ 500,000 lent by cooperative for cas sava merketing at annual interest of 18%.

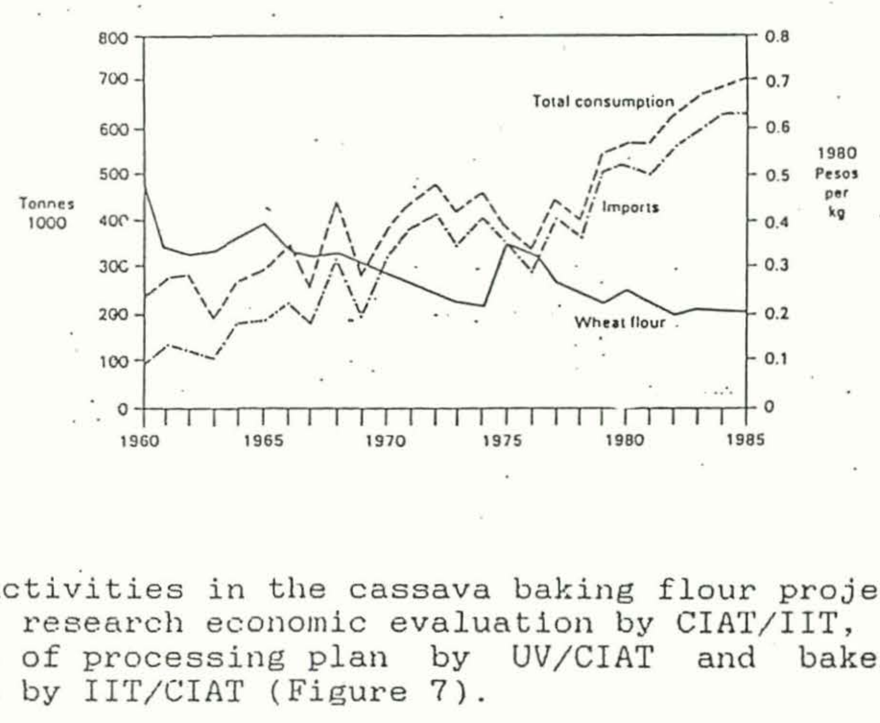
** 10% deprecion of spreyer, stapers etc., spread over the 4 month period during which cassava will be harvested by the cooperative.

3. *Cassava flour for human consumption*

Location of cassava flour pilot plan is in Chinu, Sincelejo, Sucre Dept.-Atlantic Cost. Activity is conducted by Team with the cassava Utilization-CIAT Programm. In order the coordinator CIAT, to involve the instituties was IIT (Instituto de Investigaciones Tecnologicas) Bugota and Univalle (Universidad del Valle), Cali at phase I (1985-1988) and added DRI (Integrated Rural Development-Fund) at phase II (1989 -).

Increasing in consumption of processed foods and bakery product have effect an increasing import of wheat (Figure 6). Cassava flour is potential to substitute wheat flour in bread up to levels of 15% (CIAT, 1988).

Figure 6. Colombia: Trends in imports and total consumtion of wheat and wholesale price of wheat flour. 1960 - 1985



Principal activities in the cassava baking flour project was include the research economic evaluation by CIAT/IIT, design and development of processing plan by UV/CIAT and bakery product development by IIT/CIAT (Figure 7).

Composite wheat -cassava flour system was include the system of cassava production, cassava flour processing, composite flour, bakeries production and consumers (Figure 8).

Processing of the cassava flour were involve preception and weighing, selection and treatment, sorting, washing and peeling, chipping, drying, premilling, packaging and storage. Milling was conducted in the wheat milling on the bakery industry (Figure 9 and 10). The process operations of cassava flour in the Pilot plan (capacity, 1 t/day) showed at Figure 11.

Figure 7. Principal activities in the cassava baking flour project

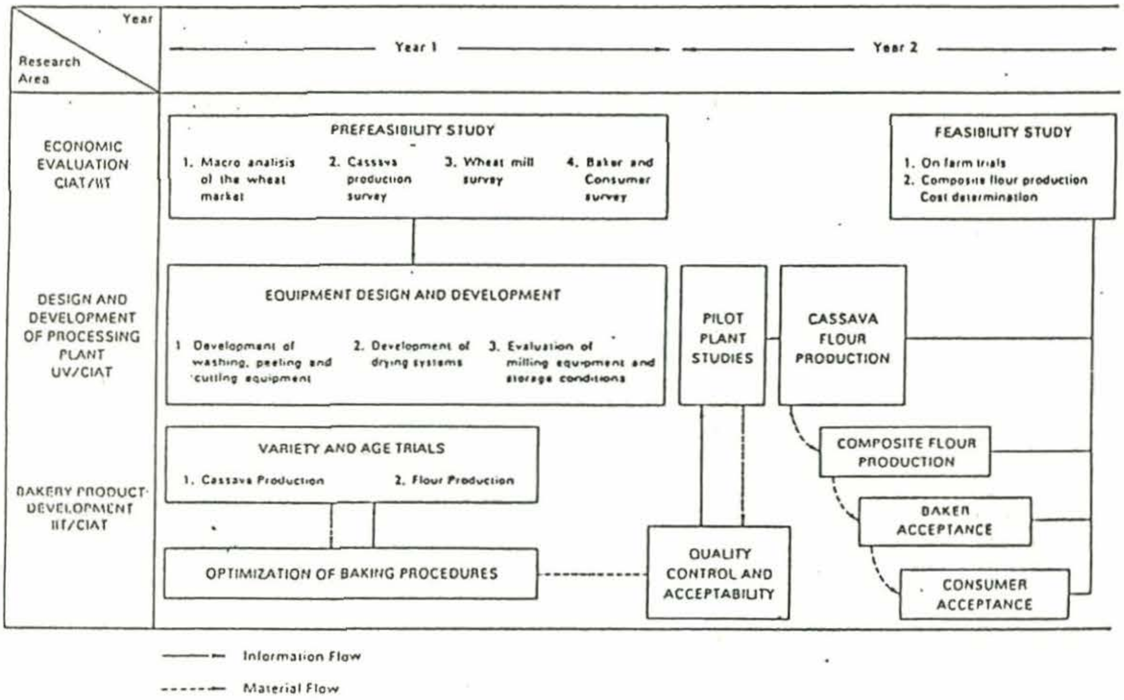
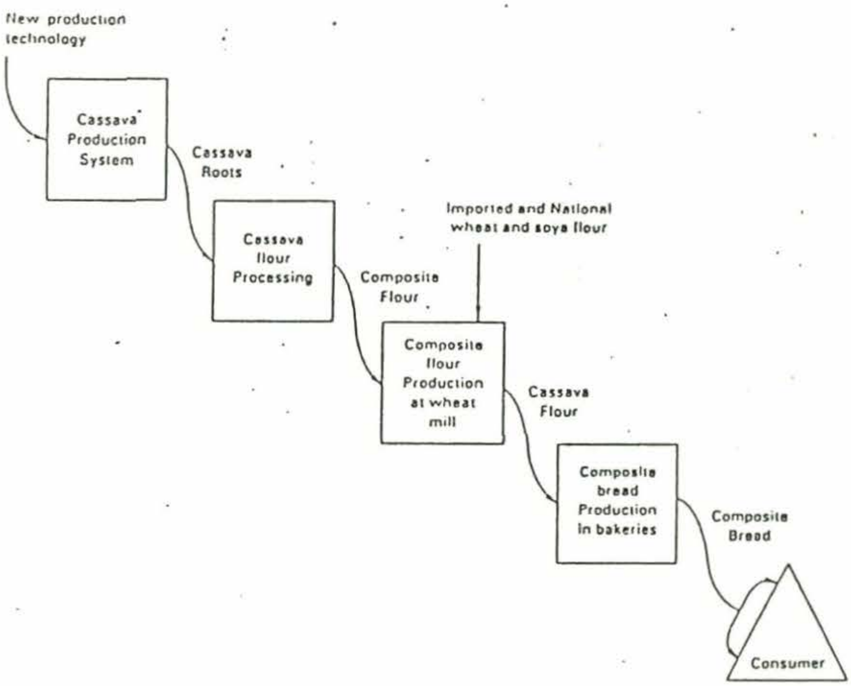


Figure 8. Composite wheat - cassava flour system



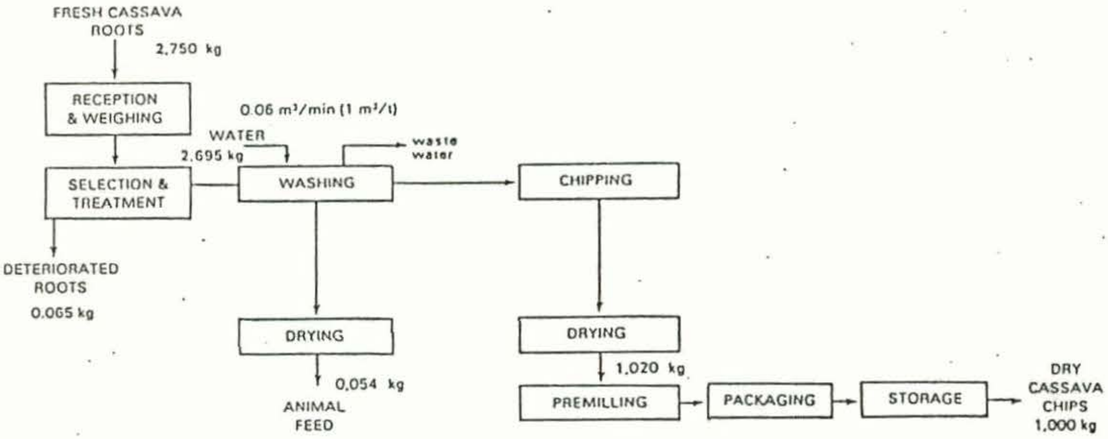


Figure 9. Flow diagram of a dry cassava chip producing plant

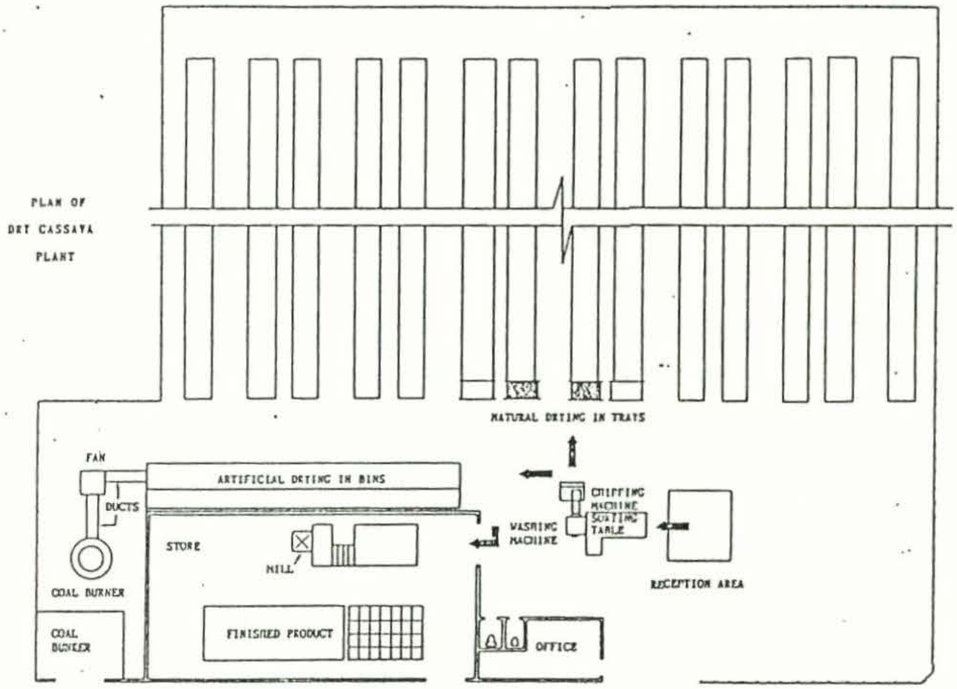


FIGURE 10. DISTRIBUTION OF A PLANT TO PRODUCE PREMILLED DRY CASSAVA CHIPS.

ACCESS ROAD

Products	Steps of processing	Extentions
Fresh cassava <----	Reception	-Weigh (3 t/day) -Inspect for physiological/ microbial deterioration
	Selection and sorting	-An inspection table to eliminate deteriorated roots and woody steams (120 kg) -Very lage roots are cut in half
	Washing	-System process and speed -Water spray -Eliminates soil and 85-90% of the bark,takes 2 min and uses about 1 m^3 water/t of fresh roots
	Chipping	-The modified Malaysian chipper -Machine capacity -System for transportation to the drying area
Dried <------ cassava of large size	Drying	-Natural and artificial drying -Natural drying,the chips are predried one day,spread (16kg/ m^2) over 118 trays (0.75 m x 1.80 m) -At artificial drying,the bin dryer (19 m^2) coupled to a 5-hp centrifugal fan heats air to $60^{\circ}C$ by means of an indirect coal-fired burner -Fuel sources (coal, oil and propane gas) -Plant capacity is doubled (2 t/day) during the dry sea son (20 weeks), giving a total yearly production of 360 tons
Dried <------ cassava of small size	Premilling	-Type of machine (Simple roll) -Chip size (5x5x5 mm)
	Packing and storage	-Kinds and weigh of packaging -Time of stored

Figure 11. Cassava flour processing at Cassava Utilization CIAT Programm

Table 6. Production cost of the one ton per day cassava drying plan 1988 costs

	Quantity	Price per unit Col.$	Cost per ton of dry chips Col.$/ton
FIXED COSTS			
Maintenance			334
Administration			3,584
Depreciation			1,833
SUBTOTAL			5,751
VARIABLE COSTS			
Labor (wage)	4	1153	4,612
Raw material (tons)	2,75	8178	22,490
Package (units)	20	120	2,400
Energy (kwh)	52	7,6	395
Carbon (kg)	225	9	2,025
Water (cubic meters)	4,5	10	45
SUBTOTAL			31,967
FINANCIAL COST			
-on fixed investment (18%)			3,907
-on working capital (16%)			614
SUBTOTAL			4,521
total cost			42,239

Source: CIAT (1991).

Total production cost of dry cassava processing is 11,826,825 Col. $ per ton in 1988 (Table 6).
The produce cassava flour was competative price compared to wheat flour. Allowing a 25 % provit margin for both the cassava grower and processor, cassava flour can be produced at 72 % the cost of wheat flour. Cassava growers will need to maintain their competitivenness through improved production technology as trends in volumes and price of imported wheat indecate that price are tending to decline.

Consumer testing, over 80% of the consumers liked composite flour and 15 % preferred it is to the plain wheat bread. (In a panel of 200 families from 5 neighbourhoods in Bogota-Colombia).

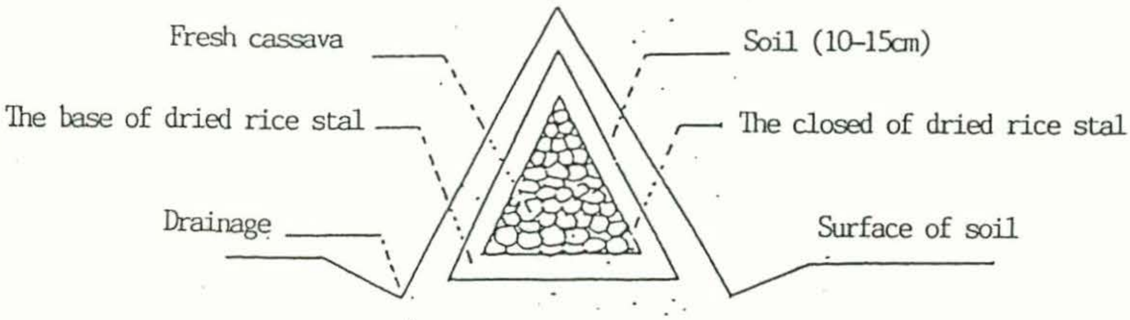
II. CASSAVA UTILIZATION PROGRAMM - SURIF, INDONESIA

1. *Fresh cassava for human consumption (1980-1985).*

Generally, the farmers in Indonesia are the planting and harvesting times almost together to result over and resulted over the fresh cassava production and cheap the price. Fresh cassava can be deteriored 3 - 5 days if not conducted processing. Some the farmers were storage the fresh cassava with the purning system (not harvesting to wait higher the price). Harvesting more the optimum plant age is decrease the quality of fresh cassava (Grace,1977).

Based the research result of the fresh cassava storage in SURIF, so the storage thecnology was proposed with "*the curing method*". Curing is a process the densing of parenchyme by effect high temperature (40°C) and humidity (80%), especially on trace of injury.

The storage media is used the dried rice stal and the rice husk becouse they are produced in the rural and as a waste from the rice milling (Figure 10 and 11).



Figur 10. Fresh cassava storage with the dried rice stal or the dried grass

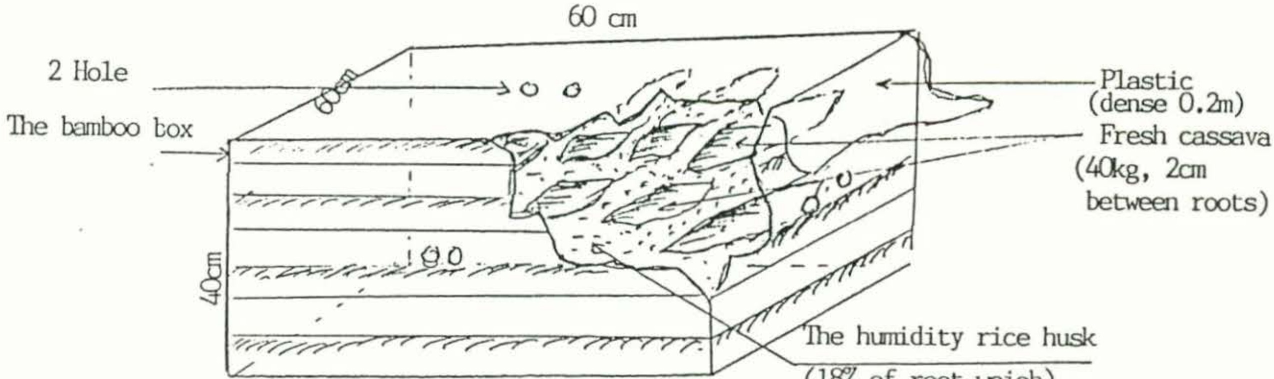


Figure 11. Fresh cassava storage with the humidity rice husk

The lose and demaged of the fresh cassava stored are treated the humidity rice husk lower than not the humidity rice husk (Figure 12). Marketing of the fresh cassava is saled to the local market or the pellet / tapioca manufactory (Figur 13).

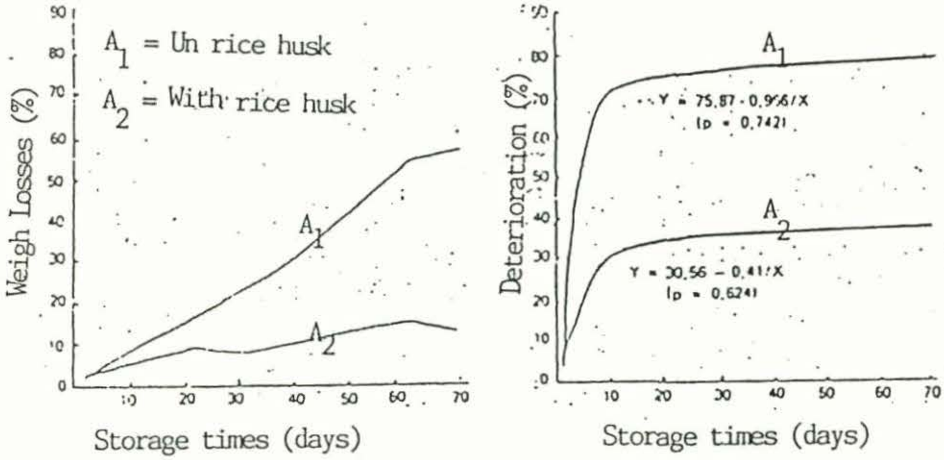


Figure 12. Losses and demage fresh cassava during stored (Suismono and Yetty, 1985)

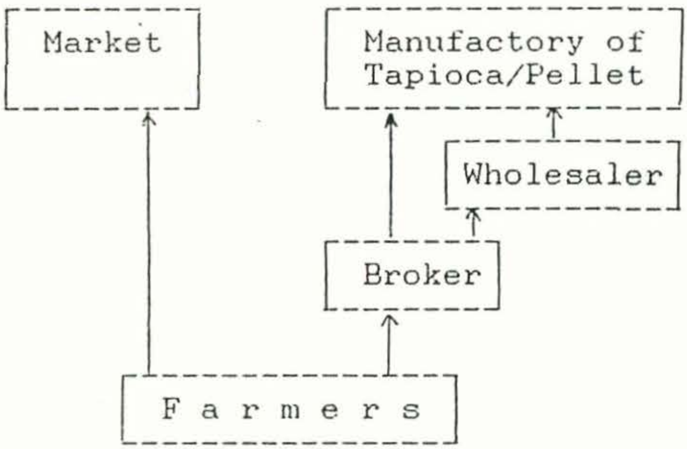


Figure 13. Marketing system of fresh cassava in Lampung (Suismono, Antarlina and Barret, 1984)

2. *Cassava flour for human consumption (1989 - 1991)*

In Indonesia the farmer level had been processed fresh cassava became dry cassava (gaplek) and cassava flour (gaplek flour) with the traditional system for food product the name "Tiwul" and "Gaplek bead" some years ago. This process is not developed becouse with the traditional processing, the gaplek size is very large (only peeled and drying process) and traditional milling with stone or wood materials, consequence the capacity and quality pruduct lower.

Until 1986, using the cassava in Indonesia were 64.4 % from total production (13.3 million tons) for the fresh cassava and dried cassava (gaplek) consumption, 9,2% exported forms gaplek, chip or pellet to EEC-Euope, 6.3% for tapioca industry and 6.5% for the food industry (CBS, 1988). Production of cassava in 1988 was 15.5 million tons and exported gaplek to EEC-Europe 1,065 million tons and quota of export to EEC 825,000 tons so 240,000 tons (Over products) or to reach " Level-off"(Damardjati et al. 1990).

The goverment policies were the cassava flour production and used for food products. SURIF had indiced by Central Research Institute fo Food Crops (CRIFC)-Bogor and Departement of Aruculture of Indonesia to conduct the Pilot Plant of cassava flour Agro-inductry in central of the cassava production.

Central of cassava production in Indonesia are five provinces, to include as East Java (3,428,574 tons), Central Java (3,489,763 tons), West Java (1,921,842 tons), Lampung (1,951,410 tons), NTT (811,379 tons), D.I Ygyakarta (705,322 tons) and South Sumatra (437,578 tons) in 1988 (Madethen, 1988).

Location of Pilot plan of cassava processing program-SURIF, West Java Indonesia were in three provinces include as Karangjoho-Purbalingga Central Java, Jarisrono-Wonogiri Central Java (near D.I Yogyakarta) and Badegan-Ponorogo East Java. Scale up of the cassava flour processing is in SURIF - Sukamandi, West Java.

Activety of the Pilot plan of cassava flour Agro-industry SURIF includes :

1). The scale up research of cassava flour processing (1989-1990) capacity 1-2 tons/day, in SURIF,Sukamandi West Java
2). The applycation Pilot plan of cassava flour agro-industry (1991-1992) in Central Java, D.I Yogyakarta and East Java.

Orienting of pilot plan are the cassava flour agro-industry in the rural and objective is the added value of the farmer income with the cassava flour processing. The field operational is handled by Team involve SURIF (Coordinate) the Postharvest Groups (Institutions from Agriculture, Cooperative and Industry Office) and the Region Header. Some alternatives in the Pilot plan of cassava flour is used into the operational in rural level (Damardjati et al, 1990 and Damardjati et al, 1991) (Figure 14).

Design of the processing equipment is the Mechanic Research Groups-SURIF. Steps of processing for scale up the cassava processing were selection and shorting, pelling and wasing, soaking, chipping, pressing, drying (sun drying of rack system), milling and packing (Figure 15 and 16).

Figure 14 Rural cassava post harvest system in cassava flour production

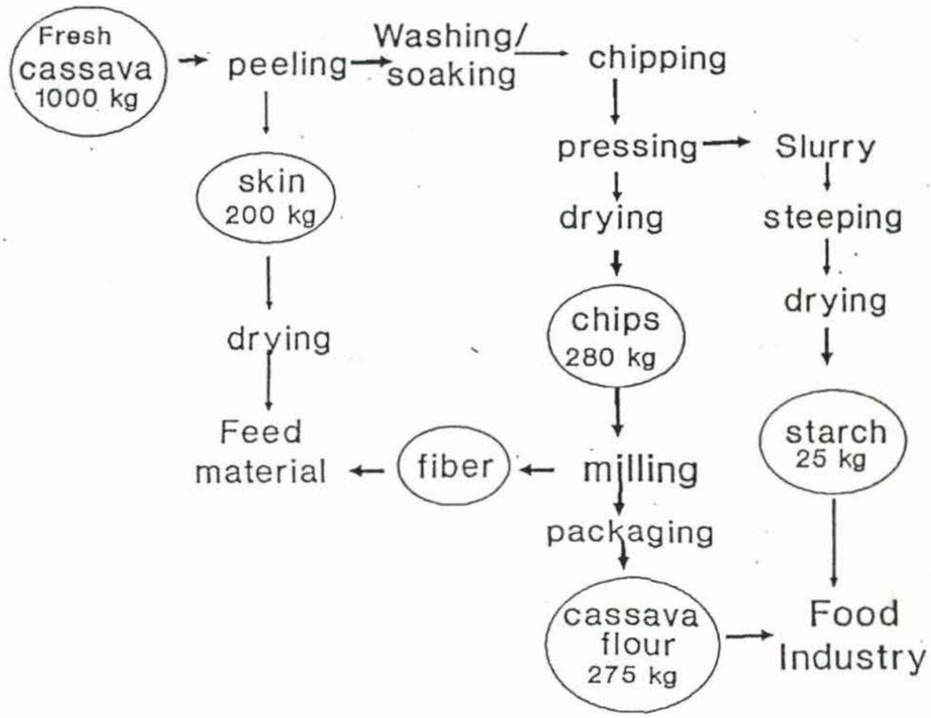
	Farmer			Processor		Milling Unit	
Process	Harvesting	Fresh handling	Peeling	Chipping	Drying	Milling	Marketing
	-Harvesting -transporting	-Reception -Sortation -Fresh storage	-Peeling -Washing -Soaking	-Chipping -Pressing	-Drying -Sortation -Cleaning	-Pre-milling -Milling -Packaging	-Storage -Promotion -Selling
Product form		Fresh cassava	peeled cassava	wet chips	dried chip	Cassava flour	Packed flour
Percent recovary		100%	70 - 80%		25-30%	24 - 29%	
Alter- native process	A<------	(1)------>	<------	------(2)------	------>	<------(3)	------>
	B<------	------	(1)------	------	------>	<------(3)	------>
	C<------	(1)------>	<------	------	(3)------	------	------>
Price/kg		Rp.40 - 50	Rp.55 - 60		Rp.225-250		Rp.400-425

(1) Farmer or farmer group

(2) Collector/Processor/Farmer group

(3) Milling Unit

Figure 16 Processing system of cassava flour production in Indonesia



Products	Steps of processing	Extention
FRESH CASSAVA	Raw material	-The opt.plant age (8-10 months) -Harvesting system -Handling after harvesting or towed -Storage system of fresh cassava
FRESH ROOTS OF PEELED SKIN	Peeling	-Dificulty the peeling dependent on variety -Capacity and times dependent the capability, species and pay system of labours
	Washing/ Soaking	-The wasing and soaking times -Kinds of water -Soaking can avoid the brown and blue colours
WET CASSAVA CHIP	Chipping	-The kind and capacity chipper -Size of cassava chip -Labour and paying system
PRESS CASSAVA CHIP OF WET STARCH and WATER	Pressing	-Capacity and pressing system -Capability of labour
	Drying	-Capacity and dense of sun drying -Sum of returned, times and layer of sun drying -Moisture content and storage of dried cassava
CASSAVA FLOUR	Milling	-The milling system and capacity -Moisture content and size (mesh) of cassava flour
	Packaging	-Kind, sum weigh/bags and storage of cassva flour

Figure 15. Scale up of cassava flour processing in SURIF-West Java, Indonesia (March,1991)

Recovery of the cassava products after processing are showed 22.81 % for dried cassava and 22.30 % for cassava flour (Table 6). With the recovery of cassava flour 22.3% and the raw materials 2.4 ton fresh cassava so the yield cassava flour are

537.6 kg. If the generally price of cassava flour Rp.450,-/kg and cassava flour Rp.50,-/kg (Table 7), so profitability is approximately Rp.42,170,- per 2.4 tons.

Table 6. Recovery of the scale up of cassava processing in SURIF, Indonesia (March, 1991)

Components	Final weigh (kg)				Recovery (%)
	Benzoat 0.2%	Sulfit 0.2%	Water	Total	
Fresh cassava	1147.8	1231.6	47	2426	
Fresh cass. of peeled	823.5	884.2	34	1792	71.79
Wet cass.of press	663.5	643.3	32	1339	55.18
Dried cassava	296.3	238.2	19	553	22.81
Cassava flour	294.0	230.0	17	541	22.30
Peel	324.0	347.4	13	684	28.20
Water from press	160.0	240.9	2	603	16.60
Starch/tapioca	-	-	-	62	2.55

Source :Anonimous, 1991.

Table 7. Labour, times and processing cost during the scale up of cassava processing (2.4 tons fresh cassava capacity)

Activities	Labour per day	Times (hours)	Cost (Rp.)
Peeling	25 (w)	10	20,000,-
Washing and soaking	2 (m)	10	5,000,-
Chipping and pressing	14 (m)	8	27,000,-
Sun drying	10 (m)	8	14,750,-
Milling and packing	5 (m)	8	13,000,-
Total			79,750,-

(w)-women,(m)-man; (US$ 1=Rp.1950,- in 1991)
Source : Anonimous, 1991

Evaluation of the cassava flour pilot plant in 4 province will be roported on December, 1991.

CUNLUCIONS

1. Land use areas for the cassava planting by some farmers in In donesia is small areas than the farmers in Colombia larger areas. Then CIAT used the equipment of machine and product capacity larger than in SURIF.

2. Quality product, the form and size of cassava chip in CIAT/Colombia larger than cassava chip in SURIF, but the colour of cassava flour in SURIF more white. Dried cassava the CIAT product is still contain peel becouse is not the peeling and pressing process.

3. Orientation of the product for food and feed consumption are only in Colombia and in Indonesia the dried cassava and cas sava flour for human consumption and export to EEC-Europe.

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SECTION 4.

STUDY OF ANALYSIS METHOD FOR CASSAVA ROOTS AT CIAT - COLOMBIA

by : Sulamono

STUDY OF ANALYSIS METHODS FOR CASSAVA ROOTS AT CIAT-COLOMBIA *

SUISMONO **

INTRODUCTION

Cassava plant involve leaves, steams, old stalks and roots. They are contain chemical composition as moisture content, the cyanide components (total and free cyanide contents, linamarin content), the carbohydrate components (starch, amylose, total and reduce sugar contents), protein, fat, fiber and ash contents.

Products of cassava root are fresh and dry cassava roots, cassava starch, cassava flours and food products. Parts of fresh and dry cassava roots are peel and parenchyma and the flour products are cassava flours and by-products which contains peel and cord (vasos del xilema y fibras-spanish). The changes of phisyco-chemical have been affect of cooking quality of food products. During in CIAT (Centro Internacional de Agricultura Tropical) Cali-Colombia from June-December 1991 had study of analysis methods for cassava root involve all analysis of chemical composition and cooking quality as above.

I. Analysis of Cyanide components (linamarase activity, total and free cyanide contents).

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* Report in visiting Reseacher-Cassava utilization of CIAT Program June 20 - December 20, 1991. Cali-Colombia.

** Staff of Researcher from Surif (Sukamandi Research Institute for Food Crops/ - West Java Indonesia.

flash and diluted 100 times in 0.1M buffer phosphate pH 6.0 (a solution 2.5 μg/ml).

B. Linamarase assays

a. Preparation of linamarase from cassava.

- Acid cassava peel (150gr) is homogenized in a blender in 250 ml buffer acetate pH 5.5 during 1 minute and then store in freezer 1 minute and homogenizer again 1 minute (duplo).
- Filter with a clots on the low temperature (use icebath).
- The solution is centrifuged at 8.500 rpm for 30 minutes and temperature 4°C and supernatant measured the final volume.
- Precipited the enzyme with ammonium sulfate, used 390 gr/l solution. Mixing and giving ammonium sulphat with slowly and the temperature have to low in a icebath (± 2 hours) and then stored at 4°C overnight.
- Centrifuge a 8.500 rpm, 1 hour at 4°C.
- To dealyse enzyme solution during 3 days and used buffer phosphate 0.1M pH 6.0 (every day, buffer phosphate changed). (The enzym solution should be stored at 10°C and maintains it's activity for 2 to 3 months).

b. Determination of linamarase activity

- Linamarase solution diluted 10.000 times (Fd = 10.000): Take 0.1ml of concentrate enzyme and dilute until 10 ml with buffer phosphate 0.1M pH 6.0. Take of first dilution 1 ml and complets until 10 ml with buffer phosphate 0.1M pH 6.0. Take of second dilution 1 ml and complets until 10 ml with buffer phospahate 0.1 M pH 6.0.

- Add 0.1 ml dilute enzyme in 0.5 ml linamarin 5mM solution with quickly, closed and share.
- Incubation the enzyme solution 30 minutes at 30°C.
- Add 0.6ML NaOH 0.2M, 2.8 ml buffer phosphate 0.1 ml pH 6 and 0.2 ml chloramine-T and share.
- Put the tubes in ice bath during 3 minutes.
- Add 0.8 ml phyridine and share, wait 1 hour and read at 620nm.

$$UE/ML = \frac{\text{Abs. sample } (\mu gr\ HCN) \times F.d.}{0.1ml \times 810\mu g\ HCN/UE} = X$$

UE = Units enzyme (sample solution contains 3 UE/ml)

Fd = Factor of dilution, Abs = absorbance

1 unit of enzyme (UE) = $\frac{X}{3}$ ml = (1 + y)ml

(1 ml concentrate linamarase + y ml buffer phosphate 0.1 M pH 6.0).

C. Assays of total and free cyanide

a. Preparation of samples

- Sample of flour (10gr) or peel (10 gr) or parenchyma (60gr) add 150ml orthophosphoric acid contain 2.5% (v/v) ethanol.
- Homogenized with the blender during 1 minute at home temperature wait 1 minute and then repeat again during 1 minute.
- To filter with fibre glass, whatman paper GF/A (ϕ 15cm/used buchner funnel with vacum pump at 8.5 atm. and assay of the filtrate volume.

b. Determination of free cyanide

- Aliquot (sample extract) 0.1 ml are pipetted in test tuber.

- Add 0,4ml buffer phosphate 0.1 M pH 4.0 and 0.6 ml NaOH 0.2M, closed and share.
- Put the cover and wait 5 minutes
- Add 2.9 ml buffer phosphate 0.1M pH6 and 0.2 ml chloramine-T and share
- Put the tubes in a icebatch during 3 minutes (30°C).
- Add 0.8 ml pyridine and share.
- Wait 1 hour and read at 620 nm (made the blank and standard solution).

c. Determination of total cyanide

- Aliquot (sample extract) 0.1ml are pipetted in test tubes.
- Add 0.4ml buffer phosphate 0.1M pH 7.0, closed and share.
- Put the cover and add 0.1ml enzyme solution closed.
- Made incubation at 30°C during 15 minutes and
- Stop the reaction with 0.6ml NaOH 0.2 M
- Add 2,8 ml buffer phosphate 0.1M pH 6.0 and 0.2 ml chloramine-T and share
- Put the tubes in icebatch during 3 minutes (30°C)
- Add 0.8 ml pyridine and share
- Wait 1 hour and read at 620 nm (made the blank and standard solution).

$$CN\ (ppm) = \frac{\text{Abs. sample}\ [\mu gr/STD]}{\text{Abs. Std}} \times \frac{\text{F.d}}{\text{Vol.aliquot}} \times \frac{\text{Vol. extract}}{\text{weight sample}}$$

II Analysis of carbohydrate components

(Amylose, total and reduce sugar and starch contents in cassava roots).

A. Assay of amylose content:

a. Preparation

- Fresh cassava roots processed on the day of harvest.
- The slein and skin are rind, the tubes are washed free of dust and external particles and acid into small pieces.
- The tissue is homogenized in the blender with add the distillate water.
- The suspension is filtered through cheese cloth and mix with the hand.
- Repeated addition of water and mix with the hand.
- The starch granules may be allowed to settle by keeping them undisturbed in the cold, decanting the supernatant and resuspending the cake starch in a fresh quantity of water which is them allowed to settle again.
- The cake starch is washed with distillate water and over-dried at a low temperature of 40 to 50°C.

b. Reagents

1. Ethanol 84%
2. NaOH 0.1M
3. Acetic acid 0.1M
4. Iodine solution 2%

B Determination of amylose

- Weight 0.1gr of sample in volumetric flash (100 ml) and add 1.0 ml ethanol and 9.0ml NaOH 0.1 M and share.
- To leave the sample 24 hour
- To complete at 100 ml with distillate water.
- Take 5ml of the above solution in other volumetric flash (100ml) and add 50ml the distillate water and share.
- Add 1.0 ml of acetic acid 0.1 M and 2.0ml of Iodine solution 2%.
- To complete at 100ml with distillate water and to share in the dark place at room temperature during 20 minutes
- Read on spectrophotometer 620 nm (made the blank and standard solution).

B. Assay of total and reduce contents

a. Reagent:

1. Ethanol 85 %
2. HCL 0.1 N
3. Indicator phenoptalain 1% and $NaCO_3$ solution
4. Alkali copper solution:

   Rochelle salt (kalium Natrium tatrat tetrahidrat) 12 gr and anhydro $NaCO_3$ (24 gr) are dissolved in about 250ml of water. A solution for 4 gr of cupric sulphate pentahydrate in water is added with stirring, followed by 16 gr of sodium hydrogen carbonate. A solution of 180 gr of anhydro $NaSO_4$ in 500 ml of water is boilded to expel air. The solution are then combined and diluted to 1 litre. After allowing to stand for two days, the clear supernatant is used.

5. Molibdate arceto solution:

To 25gr of ammonium molybdate in 450 ml of water add 21 ml of concentrate sulfaric acid, followed by 3 g of disodium hydrogen arsenate heptahydrate dissolved in 2 ml of water. Incubate the mixed solution for 24 hours at 37°C and store in glass stoppered brown bottle.

6. Glucose solution for standard:

120 mgr glucose in 100ml of distillate water.

b. Preparation:

- Weight 2 gr sample of cassava flour.
- Extracted with 150 ml ethanol 85 % at the extractor equipment during 3.5 hour.
- Evaporation of ethanol until 80ml and added 80 ml the distillate water, repeat the evaporation process of ethanol.
- Put the filtrate and to complete 200 ml with distillate water and share (aliquot sample).

C. Determination of total sugar content.

1. Pipet 0.5 ml aliquot sample, standard solution and blank in test tubes 50 ml.
2. Added 2 ml the destillate water and share

2. Added 2 ml the destillate water and share

3. Added 1ml HCL 0.1N and heated at waterbath and closed on high temperature ($\pm$100C) during 7 minutes and put the tubers in ice batch 1-2 minutes (30°C)

4. To give indicator 1 drop phenoptalain 1% and two drops $NaCO_3$ solution and share.

5. Added 2 ml copper solution, share and heated at waterbath and closed on high temperature ($\pm$100°C) during 13 minutes and put the tuber in icebatch 1-2 minutes (30°C).

6. Added 1 ml molibdate arseto solution and share.

7. Complete of volume 50 ml with destillated water and read on spectophometer < 520.

d. Determination of reduce sugar contents

- The procedure is simillary the steps ad c.1,2,5.6 and 7 (not step 3 and 4).

$$\% \text{ Sugar} = \frac{\text{Red. const. sample}}{\text{Red. Const. STD}} \; \frac{\mu gr}{\text{STD}} \times F.d \times 10^{-6} \times 100$$

fd = factor dillution

C. Assay of starch content

Reagents:

1. Buffer phosphato 2M pH = 4.8:

164 gr CH_3COONa added 800 ml the distillate water.

Assay pH 4,8 with pH-meter and stop reaction with CH_3COOH (Acetic acid glacial).

2. Buffer triphosphat pH = 7.0

36.3gr Trisma added 51.468 gr NaH_2PO_4 and 900 ml the distillate water. Assay pH 7.0 with pH-meter and stop reaction with H_3PO_4. The complete volume is 1000ml with distillate water on volumetric flash 1000ml and stored on refrigerator 4°C.

3. Enzym solution of amyloglucosidase 0.15%:

0.0188gr amyloglucosidase in 12.5ml H_2O and closed with aluminum foil or dark glass.

4. Solution of indicator enzym:

0.07 gr GOD (glucose oxidase), 0.0021gr POD (Peroxidose) and 0.035 gr 2,2 Azino-Bis (3-ethyl-benz-theosoline-6-sulfonic acid mixed on beaker-glass 100ml and added 70 ml buffer phosphat-Na pH 7.0 closed with aluminum foil and share.

5. Standard solution of glucose:

0,12 mg glucose standard in 100ml the destillate water.

a. Preparation of samples

- Weight 0.25 gr sample from sugar analysis and glucose standard at erlenmeyer 50 ml.

- Added 50 ml the distillate water and 0.1ml enzyme solution of α amylose and share.
- To heat at waterbatch 90°C during 1 hour.
- To filter with the whatman paper (GF/A, no.1) and wash with the distillate water and the volume completed 100ml at volumetric flash 100ml.
- Sampling is the sample extract (aliquot) 0.2 ml at the tubers and add 9.8 ml the distillate water, share and store at the refrigerator (4°C) overnight.

b. Determination of starch

- 1ml the sample extract (aliquot) standard solution of glucose at each concentrate and blank added 2 ml the distillate water and 2 ml the solution of indicator enzymes, share and to store in the dark place at room temperature during 30 minutes.
- To read absorbance at spectrofotometer 560nm.

$$\% \text{ Starch} = \frac{\text{Abs.sample}}{\text{Abs.Standar}} [\mu gr/STD] \times \frac{F.d}{\text{Weight sample}} \times 10^{-6} \times 0.9 \times 100$$

III. Determination of ash

- Weight crisol (a)
- Weight the sample of flour 0.5 gr (b)
- Put the crisol with the sample in the muffle during 2 hours at 600°C.
- The crisol with the sample to place in the desicator 15 minutes.

- Weight crisol and the sample dry (c)

$$\% \text{ Ash content} = \frac{c-a}{b} \times 100$$

IV. Determination of fat

- Weight the beaker glass (a)
- Weight the sample 1 gr in the thimbles to place in the equipment of extraction (b)
- The beaker glass and added the eter ether (40ml) connect the water at low temperature during 8 hours.
- Weight beaker glass day after extraction (c)

$$\% \text{ fat content} = \frac{c-a}{e} \times 100$$

V. Determination of crude fiber

- The sample from fat extraction to place in special beaker (Berzeline).
- Add 200 ml H_2SO_4 0,25N made the hydrolisis 30 minutes.
- Add 9 ml NaOH 7N, made the hydrolisis 30 minutes
- Weight the crisol (a)
- Fiber glass crisol used vacum pump and wash with the hot water and then wash ethanol latelly.
- To plag crisol in oven at 105°C during overnight
- To place in desicator and weight (a)

- Put the crisol in a muffle at 100°C during 3 hours and to in desicato and weight (b).

$$\% \text{ crude fiber content} = \frac{\text{Weight crisol + ash - weigh crisol}}{\text{weight + sample}} \times 100$$

$$\% \text{ crude fibre} = \frac{a - b}{0.5} \times 100$$

VI. Assay of protein content

A. Reagent

- Katalimtor reagent is the mixing of $CuSO_4$ and Na_2SO_4 y (1:3)
- H_2SO_4
- Indicator phenoptalain
- NaOH
- Boric acid (H_3BO_3)
- HCL 0.02N

B. Preparation

- Weight 0.1 g at the flour sample and added 1.5 g of the mixing of $CuSO_4$ and Na_2SO_4 and added 3.5 ml H_2SO_4.
- Then distruction process with the Tecator of digestion system 400°C minutes and wait 15 minutes room temperature
- Added indicator phenoptalain 1 ml and the distillate with 30ml (sample solution).

- The analysis times of the fresh cassava roots should be processed preferably on the day of harvest.

DETERMINATION OF SPECIFIC GRAVITY

- Fresh cassava roots are cleaned free of dirty (soil and root stalks and weight approximatelly 3 gr (a)
- Weight cassava roots in the water which to connect with the balance. (b)

$$\text{Specific gravity} = \frac{a}{a-b}$$

- To see the table for the determination of moisture content and starch content of fresh cassava roots.

C. Determination of protein: (Using is the equipment of Kjeltect).

- NaOH solution is conected with kjeltect
- The start of equipment at the symbol "on"
- To set the symbol alkali (number "1") and the time number 3.
- The tubes of sample (sample solution) and the erlenmeyer contain 10ml H_3BO_3 prepared at the Kjeltect equipment.
- Using the water circulation to the condensation process
- To close the tuber and symbol "Start" of distillation process during 3 minutes and stop with automatic and erlemeyer to the filtration.
- Assay the volume of HCL 0.02N in titrasi.

SAMPLING METHOD AND PARAMETER ASSAY IN THE FIELD

- For a plot of each replication is contain 256 plants with size 1m x 1m between the plant.
- Two lines from the border is the sampling area (Figure 1)
- At the sampling area are harvest fifteen the plants with randows sampling.
- Assay of the field parameters is weight of leaves, steams and old stalks, and the sum and weight root of commercials, non commercials and demaged.
- The commercials roots in the paper or gunny bags are bring to the laboratory used for the components analysis of cassava roots.

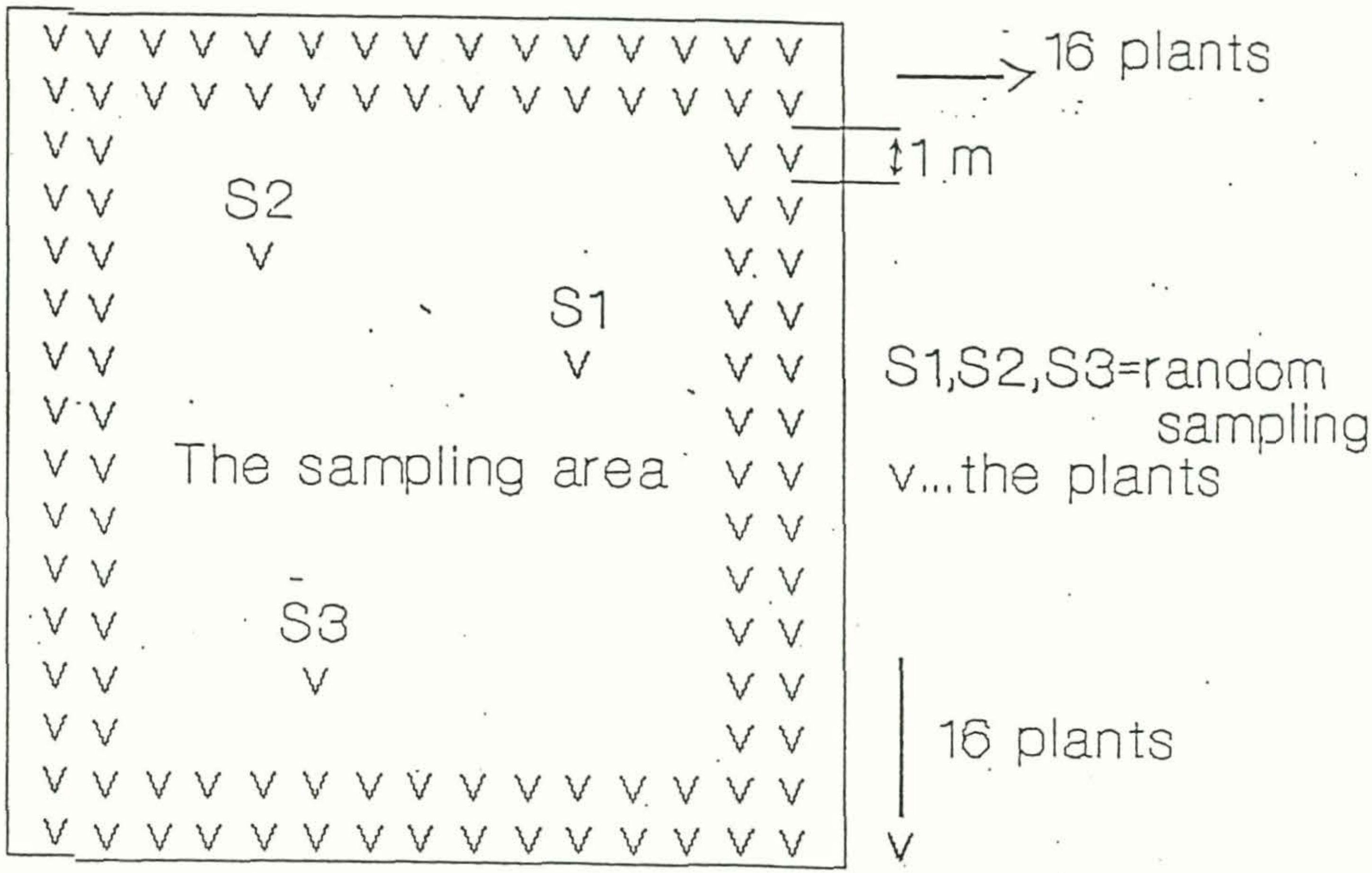

Figure 1. The tecnnic of sampling at the harvesting of cassava roots