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PERFORMANCE CHARACTERISTICS OF PILOT PRODUCTION PLANT FOR CEREAL-LEGUME BASED BLEND

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SUMMARY

A pilot plant for the production of cereal-legume based blend has been assembled and evaluated for technical performance and nutritional characteristics at the Pilot Plant Complex of Food Research Institute. Material recovery and capacity of each unit of the plant were determined as well as chemical composition of the product in terms of protein, carbohydrate, fat, ash and moisture at each processing stage. The overall plant capacity was determined as 100 kg per hour and the material recovery as 79%. The product from the plant retained high protein and energy levels thus producing a product with 14.2% protein, 73.4% carbohydrate, 5.9% fat, 2.0% ash and 4.5% moisture.

1.0 INTRODUCTION

The development of high protein-energy foods from inexpensive local raw materials to help combat protein-energy malnutrition in children has been steadily promoted in many developing countries over the past three decades. In Ghana, the National Nutrition Co-ordination Committee in their promotion of `Weanimix' (weaning foods based on local legumes and cereals) have effectively achieved a great deal of awareness among mothers about the need to incorporate legumes in traditional weaning foods to enhance protein quality. Research work at the Food Research Institute within the grain legumes programme have resulted in the development and formulation of nutritious weaning foods using maize, cowpea, groundnut, soybean, winged bean, and pigeon pea in various combinations (Plahar and Hoyle, 1987a,b; Hoyle, 1988; Plahar and Annan, 1994).

A 1.5 tonne per hour Winged Bean Dehulling Plant (WBDP) designed and constructed in India was donated to the Food Research Institute by the United Nations University (UNU) in 1982 and installed for dehulling winged bean to be used as protein supplement in weaning foods. In 1992 a programme to modify and adapt some units of the WBDP to process other legumes such as soybean and groundnut and cereals such as maize was initiated in order to increase the utilization of the WBDP.

In this study a pilot plant assembled from some of the modified units of the WBDP and other machinery available at the Institute was used in a trial production of a cereal-legume based blend.

The objectives of this study were:

- to investigate the feasibility of producing high quality weaning foods from the assembled plant
- to evaluate the assembled plant for technical performance in respect of plant capacity and efficiency
- to investigate the effect of processing methods employed on the quality in terms of nutritional characteristics of the cereal-legume based blend.

2.0 MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 Raw materials

Raw materials used were maize(*Zea mais*), cowpea(*Vigna unguiculata*) and groundnut(*Arachis hypogea*).

All the raw materials were obtained from Ejura Farms Drying Centre at Nkoranza in the Brong Ahafo Region.

2.1.2 Plant Description

The plant consists of the following units: roaster, grader-aspirator, dehuller, attrition mill and a Y-cone blender. Weighing and packaging machines were not considered.

2.1.2.1 Roaster

The multipurpose roaster(Fig. 1, A), manufactured by FATECO in Ghana, was used to roast the maize, cowpea and groundnut. It consists of a 1200 mm-wide, 300 mm-high cylindrical vessel mounted on a wood shaving stove and a motorized stirrer.

The vessel is heated using wood-shavings or in combinations with sawdust, rice husk, dried leaves, etc. as fuel. The stirrer speed is 20 rpm and average process temperature of 131°C can be attained at the vessel base after a preheating period of 20 min. (Blay, 1991).

2.1.2.2 Grader-aspirator

The grader-aspirator (Fig. 1, C), designed by Central Food and Technological Research Institute (CFTRI) and constructed by S.A.K. Industries of India, consists of a hopper, an extractor fan, a rectangular box which has been modified to accommodate a single replaceable screen and two outlet chutes. Three different screens have been designed and fabricated to grade maize, cowpea and groundnut respectively. The grader-aspirator is fed with materials by means of a bucket elevator (Fig. 1, B).

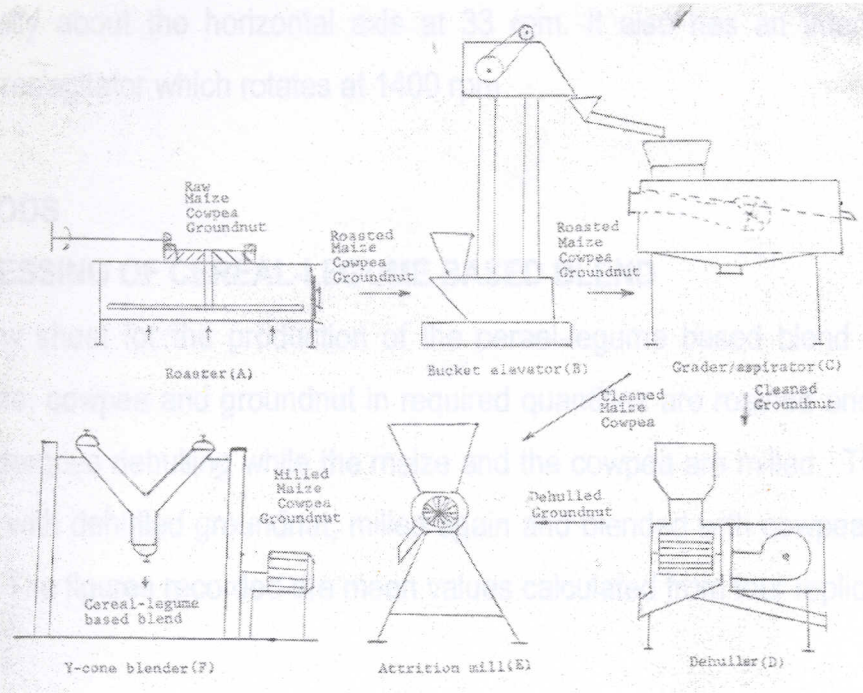

Figure 1: Schematic diagram of the plant

2.1.2.3 Dehuller

The groundnut dehuller (Fig. 1, C), manufactured by Industrial Research Institute (IRI) of the CSIR consists of a hopper, a dehulling chamber and a blower driven by a single phase electric motor via pulley systems. The dehulled groundnuts are collected into a container at the front whilst the husks collect in a sack at the rear.

2.1.2.4 Disc attrition mill

The attrition mill (Fig.1, D) used in this study is Indian made (Rex, Type A713) and it is popularly referred to in Ghana as "corn mill". It is driven by a 7.5 kw, 3 phase and 1400 rpm electric motor.

2.1.2.5 Y-cone blender

The Y-cone blender, Type 255D (Fig. 1, E) is a product of Apex Construction Ltd of London. It has two inlet branches which join at the middle to form a single outlet (to give a Y shape). It

rotates vertically about the horizontal axis at 33 rpm. It also has an internal horizontally positioned stirrer/agitator which rotates at 1400 rpm.

2.2 METHODS

2.2.1 PROCESSING OF CEREAL-LEGUME BASED BLEND

A process flow sheet for the production of the cerael-legume based blend is presented in figure 2. Maize, cowpea and groundnut in required quantities are roasted and cleaned. The groundnut undergoes dehulling while the maize and the cowpea are milled. The milled maize is then mixed with dehulled groundnut, milled again and blended with cowpea to produce the final product. The figures recorded are mean values calculated from four replicates.

2.2.1.1 Roasting

The following quantities: 96.0kg., 96.6kg. and 81.4kg. of maize, cowpea, and groundnuts respectively were roasted separately using the gradual loading of fuel method (Blay, 1991). The roasted products were collected and spread on flat containers and allowed to cool before weighing.

2.2.1.2 Cleaning

The following amounts: 86.0kg., 84.4kg. and 70.6kg. of roasted maize, cowpea and groundnut respectively were cleaned in the grader-aspirator using appropriate screens for each commodity. The underflow was collected and recleaned. The lighter debris extracted by the fan were collected into sacks and weighed together with the final underflow. The overflow which represented the product was also collected and weighed.

2.2.1.3 Dehulling

The cleaned groundnut was dehulled twice. The husks and the dehulled groundnut were collected and weighed separately.

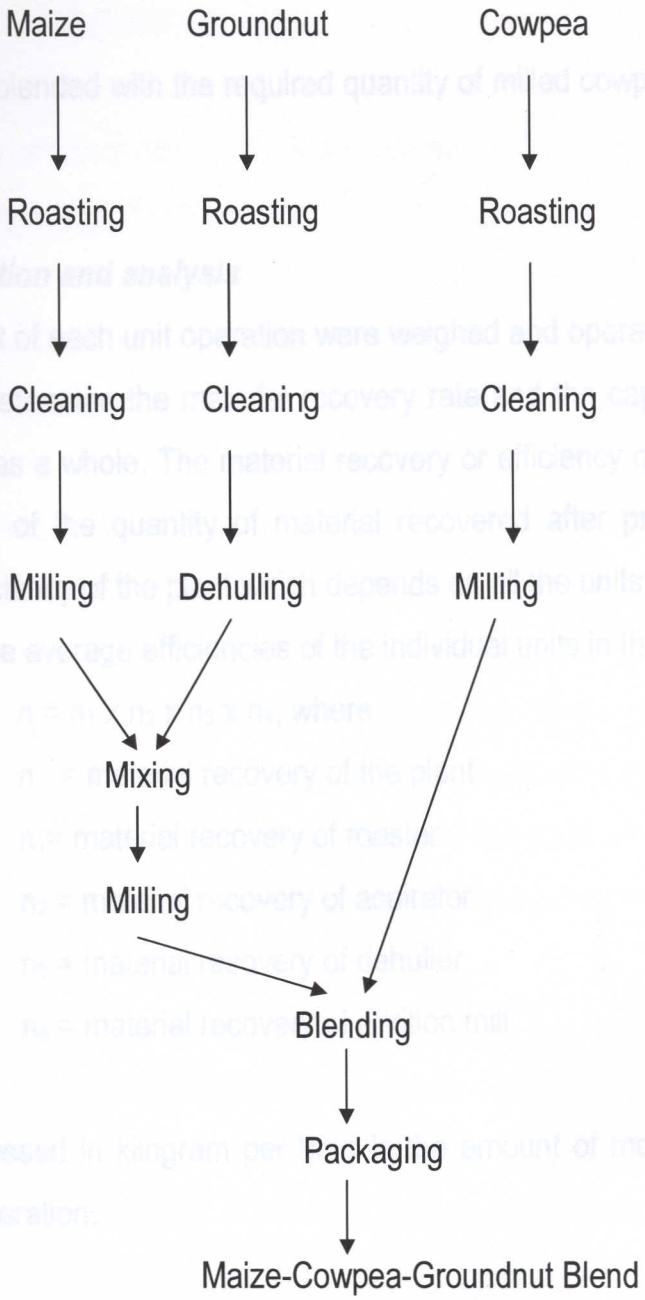

Figure 2: Process flow sheet for the production of maize-cowpea-groundnut blend

2.2.1.4 Milling/mixing

The cleaned maize and cowpea were milled separately and weighed. Dehulled groundnut of known quantity was mixed with the maize and milled.

2.2.1.5 Blending

The maize mix was blended with the required quantity of milled cowpea in the Y-cone blender for 15 minutes.

2.2.1.6 Data collection and analysis

The input and output of each unit operation were weighed and operational time recorded. This data was used to determine the material recovery rate and the capacity of each unit of the plant and the plant as a whole. The material recovery or efficiency of a unit of the plant is the percentage of ratio of the quantity of material recovered after processing to the quantity processed. The efficiency of the plant which depends on all the units of the plant is determined by multiplying out the average efficiencies of the individual units in the following formula:

$n = n_1 \times n_2 \times n_3 \times n_4$, where

n = material recovery of the plant

n_1= material recovery of roaster

n_2 = material recovery of aspirator

n_3 = material recovery of dehuller

n_4 = material recovery of attrition mill

The capacity expressed in kilogram per hour is the amount of material processed per hour during each unit operation.

2.2.1.7 Chemical analysis

Samples of the raw ingredients, intermediate and final products were collected and analysed for moisture, protein, fat and ash by standard procedures (AOAC, 1980). Carbohydrate was determined by difference and expressed as percentages of the samples.

3.0 RESULTS AND DISCUSSION

3.1 Performance characteristics of cereal-legume based blend production plant

The results of the physical performance characteristics of the various units of the plant for the three commodities are presented in Table 1. The values are means of four replicates of unit operations. The results show that the capacities of the various units of the plant increased along the processing line from between 90 - 110 kg per hour for the roaster to 318 kg per hour for the blender. This allowed for free flow of materials from the initial stage to the final stage without any backlogging or piling up of materials at any stage of the processing. The capacity of the plant which is determined by the lowest capacity unit (the roaster) was found to be 100 kg per hour. The 318 kg per hour operating capacity of the blender shows that it is being underutilized and operating at about 30% capacity. The plant's capacity can therefore be increased to 300 kg/hr by increasing the number of roasters, aspirators and dehullers to three each and attrition mills to two. The blender recorded the highest material recovery rate of 99.3% while the aspirator recorded the lowest rate during the cleaning of maize at 87.2%. The efficiency of the plant was found to be 79%.

3.2 Effect of processing on chemical composition of cereal-legume based blend

Results of proximate composition of intermediate and final products of a maize-cowpea-groundnut blend using an adapted pilot production plant are presented in Table 2. Results indicate that roasting procedures used were adequate producing acceptable moisture levels of 4.1%, 4.6% and 2.3% respectively for maize, cowpea and groundnut and 4.5% for the finished product. These low moisture levels assure a shelf stable product that limits bacterial and mould infestation of the final product. Milling did not significantly affect the composition of the raw materials and the final maize-cowpea-groundnut blend had an acceptable high protein content. The levels of fat and ash in the final blend were however, low and this suggests that supplementation with oil and some mineral may be necessary.

3.3 Feasibility of producing high quality weaning foods from plant

The unit operations used and the processing methods employed in the production of the cereal-legume based blend were adequate producing a high protein-energy cereal-legume based blend that could be used effectively in the alleviation of protein-energy malnourishment.

Table 1. Physical performance characteristics of plant

Equipment & Unit Operation	Commodity	Input (kg)	Output (kg)	Time (min)	Material Recovery (%)	Capacity (kg/hr)
Roaster (Roasting)	Maize	96.0	87.0	658	90.6	99.3
	Cowpea	96.6	85.2	66	88.2	90.9
	Groundnut	81.4	71.	45	88.0	108.5
Aspirator (Cleaning)	Maize	86.0	75/9.4*	45	87.2	115
	Cowpea	84.0	81.7/2.0*	55	97	92
	Groundnut	70.6	67.2/3.0*	38	95	111
Dehuller (Dehulling)	Groundnut	66.0	63.5	32	96	124
Attrition mill (Milling)	Maize	74.0	73.3	33	99	135
	Cowpea	80.7	79.7	40	99	121
	Maize/Ground-nut	75.0	74.1	28	99	160
Blender (Blending)	Maize/Ground-nut & cowpea	69.0	68.5	13	99.3	318

* x/y = overflow/underflow or product/byproduct

Table 2. Proximate composition of intermediate and final products of maize- cowpea-groundnut blend.

Product	Moisture	Protein	Fat	Carbohydrate	Ash
Maize					
Raw	10.1	.8	4.0	74.7	1.4
Roasted	4.1	9.9	5.3	79.2	1.5
Milled	4.2	10.0	5.8	78.4	1.6
Cowpea					
Raw	10.1	24.7	3.8	60.1	1.3
Roasted	4.6	23.8	3.9	65.3	2.4
Milled	4.3	22.3	1.8	67.7	3.9
Groundnut					
Raw	4.9	23.5	48.1	25.8	2.3
Roasted	2.3	21.8	50.5	22.1	3.3
Milled maize & groundnut	4.6	11.4	6.9	75.6	1.5
Final Blend	4.5	14.2	5.9	73.4	2.0

4.0 CONCLUSIONS AND RECOMMENDATIONS

The technical performance of the pilot production plant for a cereal-legume blend has been evaluated. The plant has a capacity of 100 kg per hour. This can be increased threefold by increasing the number of roasters, aspirators and dehullers to three and the mill to two. The plant's material recovery was established at 79%.

The plant retained the high protein and energy levels thus producing a product with 14.2% protein. 73.4% carbohydrate, 5.97% fat, 2.0% ash and 4.5% moisture. The plant is simple, workable and efficient and can be adopted by food processors especially, those involved in the production of weaning foods to help combat protein-energy malnutrition

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