FRI/SAFGRAD PROJECT

IMPROVING THE UTILIZATION AND COMMERCIALIZATION OF SOY PROCESSING TECHNOLOGIES: MICRONUTRIENT ENRICHMENT OF SOY PRODUCTS

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Quality Monitoring of Processing Techniques and Soy Products at Darkruby Enterprise

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Quality monitoring of processing and production of Soyproducts at Darkruby Enterprise

ABSTRACT

Darkruby Enterprise, a beneficiary enterprise of a project initiated under the Technology Transfer Grant (TTG) programme of SAFGRAD received collaborative assistance from the Food Research Institute to upgrade its operations for improved product quality and processing efficiency. Samples of soymilk, soyflour and soy powder were analysed from each batch production for nutrient composition, sensory and microbiological quality. Basic equipment needs of the enterprise as prescribed after a needs assessment conducted by the Food Research Institute project team have been purchased and installed. They included a grinding mill, a milk press with sieving accessories, packaging and labelling facilities and a factory building. The nutritional quality of soy products remained fairly constant throughout the period of assessment. The entrepreneur was able to maintain a low level of antinutritional factors indicating that adequate heat treatment for processing was being used. Some microbial contamination with coliforms occurred in one batch production, which was effectively irradicated in subsequent productions. This indicated some ability of the entrepreneur to control points of hazard occurrences in his operations. As part of its final objective the project will establish a HACCP (Hazard Analysis Critical Control Points) system for the processing of soyproducts by Darkruby enterprise.

1. INTRODUCTION

Among vegetable crops, legumes contain the highest amount of protein (Wang and Hesseltine, 1981). Foods made from mixtures of cereals and legumes provide the added improvement in protein quality by the mutual complementation of their limiting amino acids. By incorporating legumes in the traditional diets of people the nutritional status of vulnerable groups as well as those who avoid the more expensive animal foods is enhanced. Soybeans are virtually unrivalled as a world crop due to their high protein content which averages 40% in the whole seed (Weingartner, 1987). The promotion of soybean processing technologies in Ghana aims, among others, at enhancing the role of small scale enterprises in the provision of sufficient quantities of soyproducts for all sectors of the population. Many of these enterprises, however, lack the technical knowledge and expertise as well as adequate quality control facilities resulting in products of poor nutritional, sensory or functional characteristics.

The Technology Transfer and Commercialisation Program of SAFGRAD has as one of its objectives to facilitate the transfer of technologies to small-scale private food processing entrepreneurs. The project aims to upgrade the operations of these enterprises through research and training to advise on appropriate machinery as well as assisting the entrepreneurs to improve the quality of their products. Darkruby Enterprise, a beneficiary under the project, receives collaborative assistance from the Food Research Institute, Accra, to upgrade its operations for improved product quality and processing efficiency. Earlier activities under this collaborative assistance included a critical evaluation of operations of the enterprise to assess their needs with respect to techniques and machinery. Results of the evaluation revealed that the company had inadequate and inappropriate equipment. The quality of products also indicated a lack of standardisation of processing methods.

This report provides information on the second set of activities aimed at assisting the entrepreneur in the installation and operation of basic equipment for the processing of soymilk and soyflour. Training was also provided in the application of appropriate processing techniques for these soy products and quality monitoring of samples from each batch production was undertaken.

2. METHODOLOGY

Training and Equipment installation

Workers of the Darkruby Enterprise were trained in the processing of soymilk and soyflour based on technologies developed at the Food Research Institute. The following equipment recommended for processing of soymilk were purchased and installed:

Mill - This is a grinding mill for the sole purpose of crushing blanched soybeans for soymilk preparation.

Soymilk Press - This is a milk press with sieving accessories for extracting soymilk from crushed blanched beans.

Building - A concrete building with suitable ventilation is in place allowing the operations of the factory to be under one roof for effective process standardisation and production efficiency.

Packaging and labelling - Plastic bottles with tight fitting covers have been purchased for hygienic bottling of soymilk. The Food Research Institute project team also modified labels for soymilk to reflect average nutrient composition, storage conditions and shelf life period. Health claims previously included on the labels by the entrepreneur were excluded since no conclusive evidence exists for the claims.

Product Quality Evaluation.

Samples from four batch productions of soy products were analysed for their chemical, microbial and sensory properties. Analytical methods used are described below:

Chemical composition

Samples of soymilk, soyflour, and soypowder were analysed for moisture, protein, fat and ash by standard procedures (AOAC, 1990). Carbohydrate was determined by difference, and energy by calculation using the factors 4, 4 and 9 kcal for protein, carbohydrate and fat, respectively. Iron and calcium were measured using the AACC (1983) standard procedures.

Determination of anti-nutritional factors

Trypsin inhibitor activity was determined by the method of Hamerstrand *et al.* (1981) which is a modification of the standard AACC (1983) method for determining trypsin inhibitor activity in soy products. Soy samples were ground and extracted by soaking 1g samples overnight at 4°C in 50 mL 0.01 NaOH (pH was adjusted to 8.4 - 10.0). The suspensions were diluted so that 2 mL of the sample extract inhibited 40 - 60% of the trypsin used as a standard in the analysis. Aliquots (2 ml) of the diluted sample extract were added to each of four test tubes and a fifth was prepared for the trypsin standard by adding 2 ml of distilled water. Trypsin solution (2 ml) was added to the fifth tube and to three of the tubes containing sample extract. The tubes were then incubated in a constant temperature water bath at 37°C for 10 min. Five millilitres of BAPNA solution (prewarmed to 37°C) was rapidly added to each tube and the contents stirred immediately on a vortex mixer. The tubes were replaced in the temperature bath and the reaction terminated exactly 10 min later by adding 1 ml of 30% acetic acid with immediate mixing on a vortex mixer. The fourth tube, which represented the sample blank, was prepared by adding trypsin solution after the reaction was terminated by the addition of 1-ml acetic acid.

The absorbance of each solution was determined at 410 nm after a clear solution was obtained by filtration. Trypsin inhibitor activity (TIA) in terms of mg pure trypsin inhibited per gram sample was calculated as:

$$TIA = \frac{2.632 \times D \times A_1}{S} \text{ mg pure trypsin inhibited } g^{-1} \text{ sample}$$

where

A_1 = change in absorbance due to trypsin inhibition mL^{-1} diluted sample extract

D = dilution factor

S = weight of sample (g)

Microbiological Quality Assessment

The Pour plate technique was used in the determination of aerobic bacteria counts. Ten grams of sample was weighed into sterile stomacher bags. To this 90 ml of Saline Peptone Solution was added and macerated. Serial dilutions of 10^{-1} - 10^{-6} were prepared, pipetted into Plate Count Agar and incubated for 72 h at 30°C (Harrigan and McCance, 1966)

The Mould and Yeast Counts were also determined using the Pour Plate Technique. One millilitre of the 10^{-1} dilution of the sample suspension was pipetted into duplicate sterile petri dishes. This was pour-plated with Malt Extract Agar, mixed and incubated at 25°C for 5 days (Anon, 1987).

For the enumeration of Enterobacteriaceae (Coliforms), one millilitre of 10^{-1} and 10^{-2} dilutions of the sample suspension were pipetted into sterile petri dishes where about 5 ml of Tryptone Soya Agar was added and procedures completed according to Anon (1992a). For direct plating out, streaks were made on MacConkey agar plates using the stock sample solution. The plates were then incubated at 37°C for 48 h. Pathogenic Organisms were determined as *Staphylococcus* sp. and *Salmonella* sp. For the detection of *Staphylococcus* sp., 5g of sample was aseptically weighed and placed in cooked meat medium. A 0.1 ml portion of the undiluted stock solution was transferred to Baird-Parker's medium. The inoculum was distributed with a sterile angle bent glass rod and incubated at 37°C for 24 - 48 h (Anon, 1992b). Salmonella bacteria were identified by the method of Anon (1991). Four separate steps were carried out involving pre-enrichment in buffered peptone water, selective enrichment in Rappaport-Vassiliadis broth, plating out in Xylose-lysine-deoxycholate agar and confirmation by sub-culturing and biochemical tests.

For culture identification smears of growth from the plates were made on clean slides with sterile loop. These were Gram stained and viewed under the microscope to identify the morphology and Gram reaction. Selective identification for *Aspergillus flavus/parasiticus* was performed using a specific medium prepared with Aspergillus Flavus Parasiticus Agar (AFPA) Base (Oxoid Limited, Hampshire, England). The pH of the samples was determined with a laboratory pH under PHM 92 (Radiometer analytical A/S-Denmark). Approximately 5g of sample were weighed into plastic pH cups and mixed with 5 ml of carbon dioxide-free distilled water. Measurements were made with the pH meter

previously calibrated using standard buffer solutions of pH 4 and 7 at 25°C.

Sensory evaluation

Sensory quality characteristics were evaluated for soymilk samples by a ten-member trained panel using the method of quantitative descriptive analysis (Larmond 1977). Unstructured scales with anchor words at the ends only were used for the descriptive analysis.

3. RESULTS AND DISCUSSION

Technology transfer

The processing technologies for soymilk and soyflour developed by the Food Research Institute were transferred to Darkruby Enterprise in the form of training for the factory workers. The processes are described in Figures 1 and 2.

Training sessions

Several training sessions were held by a team of soy processing experts from the Food Research Institute on location at Darkruby Enterprise. Areas of training covered soymilk production, good hygiene and manufacturing practices, packaging and labelling, and management. Categories of workers involved included factory hands, the production manager, the distributors and the General Manager. Each category received adequate training in the relevant area.

Production of Soymilk by the Food Research Institute

Raw soybeans of the Salintuya variety were cleaned to remove among others stones, sand, husks and chaff. The cleaned beans were then soaked in potable water (1:5, w/v) for 30 min. The soak water was drained and the soaked beans dropped into boiling water (1:10, w/v) and boiled for 10 min. A slurry was prepared by grinding the hot beans for 3 min in a grinding mill using all of the blanch water. The slurry was stirred well and milk extracted by means of a milk press. The extract obtained was boiled and allowed to simmer for 20 min. Sugar (3 g/1000 ml milk extract) and salt (0.2 g/1000 ml milk extract) were added if desired and the soymilk was filled into pre-sterilised plastic bottles. Labels on the bottles indicated a shelf life of three days under refrigerated conditions (4°C).

Production of Soyflour by the Food Research Institute

Local salintuya variety of soybeans were cleaned to remove, particularly, stones, sand, husks and chaff. The beans were soaked for 20 min, drained and dropped in boiling water. They were boiled for 30 minutes and then dried using a hot air cabinet drier at 65°C – 70°C to a final moisture content of about 8%. The dried beans were dehulled by breaking in a disc attrition mill and

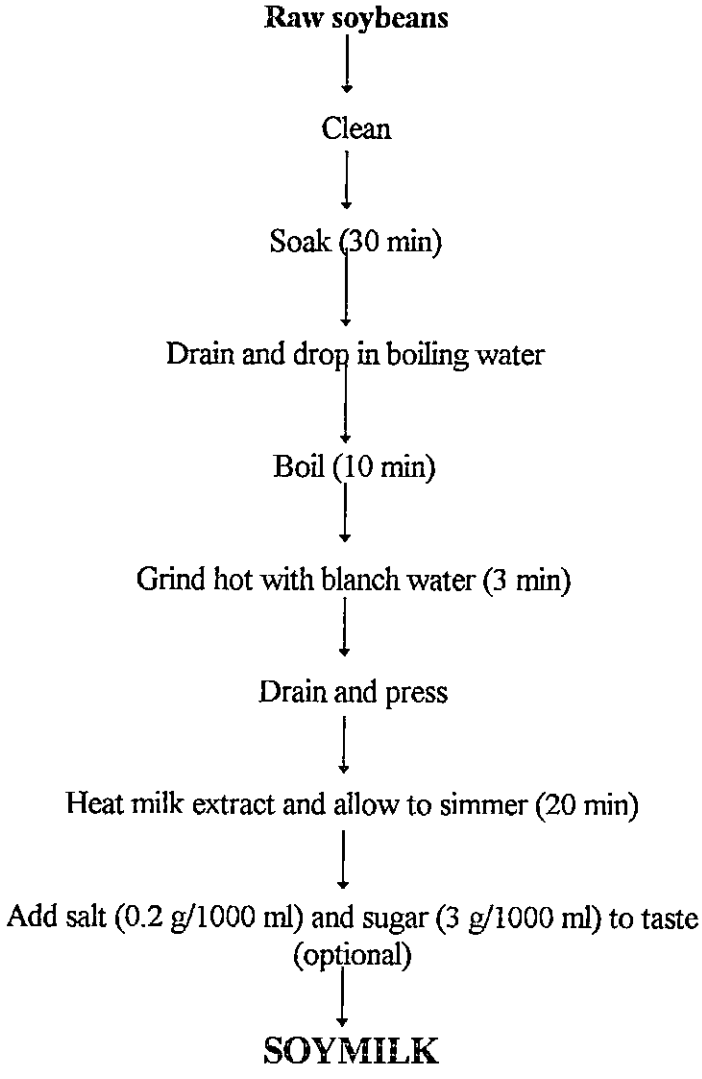


Fig. 1. Flow diagram for the production of soymilk – Technology transferred by the Food Research Institute

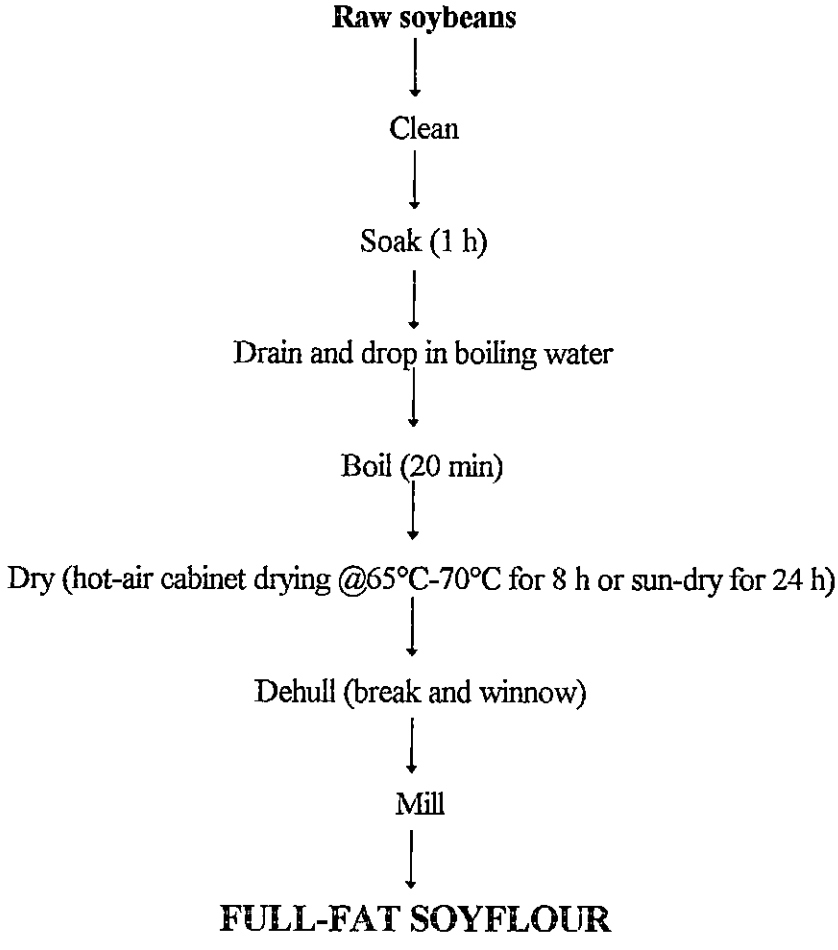


Fig. 2. Flow diagram for the production of soyflour – Technology transferred by the Food Research Institute

winnowed. The dehulled and cleaned beans were then milled into a smooth flour and packaged in polyethylene bags. A shelf life of 10 months was indicated on the labels.

Production of soypowder by Darkruby enterprise

The technology for the production of soy powder is not among technologies transferred by the institute. However, recommendations for improvement have been given to the entrepreneur. These include the need to use a mechanical roaster with controlled conditions of temperature and time

Nutritional Composition of Soyproducts

The results of nutrient composition for four batch productions of soymilk, soyflour and soy powder produced by Darkruby enterprise are shown in Tables 1, 2 and 3, respectively. A reasonable level of consistency in chemical composition of soymilk was maintained for all batch productions. Slight increases in protein content were observed within batch productions. This is attributable to the composition of soybean used, but more importantly, to an improvement in the efficiency of milk extraction from the beans. The `Anidaso' and `Salintuya' varieties of soybeans which are recommended for use in soymilk production have been reported to have similar physical characteristics but differ in nutrient composition (Annan and Plahar, 1994). The protein content of `Anidaso' was found to be 45.8% (dry weight basis) while the `Salintuya' variety had a protein content of 41.2% (dry weight basis). A low level of trypsin inhibitor activity was also maintained for all batch productions. This is indicative of the use of adequate heat treatment as directed in the method transferred by the Food Research Institute project team. This would ensure a high Protein Efficiency Ratio for good nutritional quality.

A low moisture content was maintained for all batch productions of soyflour. This is very commendable since a low moisture content reduces contamination by micro-organisms and prolongs the shelf life of the product. Low levels of trypsin inhibitor activity observed are also indicative of adequate heat treatment and appropriate processing of soybeans into flour.

The nutrient compositions of soypowder samples were relatively variable within batch productions. The variability in product quality is attributable to a lack of standardisation of the roasting process used

Table 1. Nutrient composition of soymilk samples from four batch productions by Darkruby Enterprise[1]

Component	Batch 1	Batch 2	Batch 3	Batch 4
Total solids (%)	8.2	10.2	11.2	11.5
Moisture (%)	91.8	89.8	88.8	88.5
Fat (%)	1.1	1.9	1.0	1.3
Ash (%)	0.3	0.4	0.5	0.4
Protein (%)	1.4	2.0	3.7	3.7
Carbohydrate (%)	5.4	5.9	6.0	6.1
Energy (kcal)	37	43.2	47.6	50.9
Iron (mg/100g)	2.0	1.7	2.1	2.0
Calcium(mg/100g)	12.0	11.7	12.1	12.0
TIA (mg/g sample)*	0.35	0.3	0.35	0.3

*TIA = Trypsin Inhibitor Activity

[1] Values are means of triplicate determinations expressed on as-is-basis

Table 2. Nutrient composition of soyflour samples from four batch productions by Darkruby Enterprise[1]

Component	Batch 1	Batch 2	Batch 3	Batch 4
Moisture (%)	5.8	7.0	5.9	5.6
Fat (%)	19.9	20.6	21.1	19.6
Ash (%)	5.2	5.4	6.2	37.9
Protein (%)	39.5	35.8	33.9	31.8
Carbohydrate (%)	29.6	31.0	32.8	5.1
Energy (kcal)	455	453.4	456.7	455.2
Iron (mg/100g)	11.3	9.9	9.1	10.8
Calcium(mg/100g)	284	269	307	336
TIA (mg/g sample)*	3.0	3.5	3.5	3.0

*TIA = Trypsin Inhibitor Activity

[1] Values are means of triplicate determinations expressed on as-is-basis

Table 3. Nutrient composition of soypowder samples from four batch productions by Darkruby Enterprise[1]

Component	Batch 1	Batch 2	Batch 3	Batch 4
Moisture (%)	4.3	4.5	3.5	2.8
Fat (%)	20.5	19.1	23.1	26.9
Ash (%)	5.3	5.1	5.3	5.1
Protein (%)	39.9	38.8	40.8	43.8
Carbohydrate (%)	30.0	32.5	27.3	21.4
Energy (kcal)	464	457.1	480.3	502.9
Iron (mg/100g)	9.0	8.9	9.1	8.7
Calcium(mg/100g)	268	278	305	271
TIA (mg/g sample)*	4.0	4.5	3.8	3.5

*TIA = Trypsin Inhibitor Activity

[1] Values are means of triplicate determinations expressed on as-is-basis

in the production of soypowder. There is the need to use a mechanical roaster with controlled conditions of temperature and time. This has not been purchased by the entrepreneur due to financial constraints. Moisture content was appreciably lower than that observed for soyflour due to higher temperatures used in the roasting process. A low moisture content would also ensure a longer shelf life, however, high temperatures reduce nutrient quality as a result of the destruction of essential amino acids. Trypsin inhibitor activities were not as low as observed with soyflour. Dry heating such as roasting is less effective in the reduction of trypsin inhibitor activity than moist heating used in the preparation of soyflour (Weingartner, 1987).

Microbiological quality of soyproducts.

The microbiological quality of soymilk, soyflour and soypowder are shown in Tables 4, 5 and 6, respectively. The results show relatively low total viable counts in all four batch productions of soymilk with levels decreasing with subsequent productions. Some contamination with coliforms occurred, however, in the second batch production within the period of evaluation. This is indicative of poor handling and sanitation techniques introduced during processing or bottling. After notification of the entrepreneur about this development a marked improvement occurred in subsequent batch productions. There were no microflora isolated and total viable counts were less than 10. In all batch productions there were no pathogens or indicator organisms thus establishing a high level of microbiological safety and confirming the suitability of the processing method used.

Total viable counts were found to be also very low in soy flour samples. The mould and yeast count were relatively high in the first batch production as evidenced by the presence of *Aspergillus* among microflora isolated. Subsequent batch productions were characterised by very low levels or absence of mould and yeast. Contamination with coliforms was observed in the first two batch productions but this did not occur in subsequent productions. Inadequate drying of soyflour after moist heat processing of beans is responsible for the levels of contamination observed. No pathogenic or indicator organisms were, however, found in any samples.

Soypowder had low counts of all micro-organisms evaluated. There was no contamination with mould or yeast or coliforms in any batch production. The high temperatures

Table 4. Microbiological quality of soymilk from four batch productions by Darkruby Enterprise

Component	Batch 1	Batch 2	Batch 3	Batch 4
pH	5.8	4.9	6.2	6.0
Total viable count (cfu/g)	5.8×10^1	1.0×10^1	<10	<10
Mould & Yeast (cfu/g)	3.9×10	6.9×10^2	<10	<10
Coliforms (in 0.1ml)	not found	found	not found	not found
E. coli (in 0.1 ml)	not found	found	not found	not found
Salmonella (in 25 ml)	not found	not found	not found	not found
S. aureus	not found	<10	not found	not found
V. parahaemolyticus	not found	not found	not found	not found
Flora isolated	*Bacillus* sp.	Yeast, Gm+ve rods	No Growth	No Growth

Table 5. Microbiological quality of soyflour from four batch productions by Darkruby Enterprise

Component	Batch 1	Batch 2	Batch 3	Batch 4
pH	6.3	6.5	6.6	6.5
Total viable count (cfu/g)	6.7×10^2	3.7×10^2	3.7×10^1	4.0×10^1
Mould & Yeast (cfu/g)	6.9×10^3	<10	<10	<10
Coliforms (in 0.1ml)	found	found	not found	not found
E. coli (in 0.1 ml)	not found	found	not found	not found
Salmonella (in 25 ml)	not found	not found	not found	not found
S. aureus	not found	<10	not found	not found
V. parahaemolyticus	not found	not found	not found	not found
Flora isolated	*Asp. Sp.*, *Micrococci*, *Bacillus sp.* Gm +ve rods, cocci	*Bacillus sp.*	*Bacillus sp*	*Bacillus sp*

Table 6. Microbiological quality of soypowder from four batch productions by Darkruby Enterprise

Component	Batch 1	Batch 2	Batch 3	Batch 4
pH	6.5	6.6	6.5	6.6
Total viable count (cfu/g)	5.4×10^1	2.0×10^2	3.7×10^1	4.0×10^1
Mould & Yeast (cfu/g)	not found	not found	<10	<10
Coliforms (in 0.1ml)	not found	not found	not found	not found
E. coli (in 0.1 ml)	not found	not found	not found	not found
Salmonella (in 25 ml)	not found	not found	not found	not found
S. aureus	not found	not found	not found	not found
V. parahaemolyticus	not found	not found	not found	not found
Flora isolated	*Micrococci,*	Gm +ve cocci & rods	Gm +ve cocci	Gm +ve cocci & rods

used for roasting in the preparation of soypowder significantly reduced the level of viable micro-organisms. Pathogenic and indicator organisms were also absent in all samples.

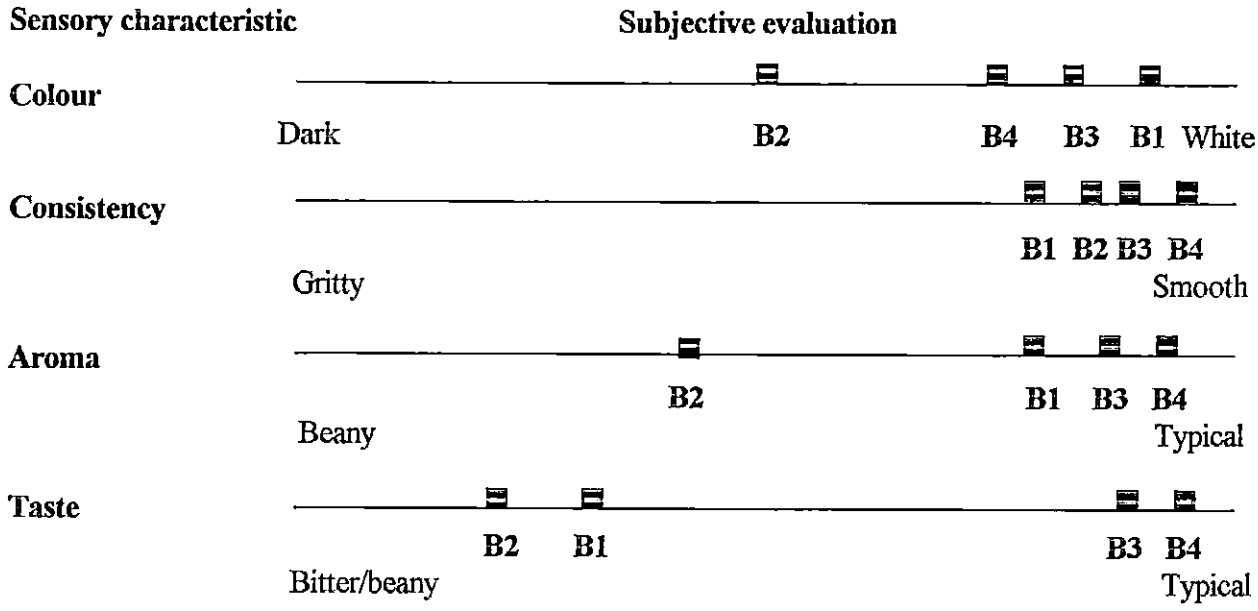
Sensory evaluation of Soymilk

Sensory evaluation was conducted for only soymilk samples. Averaged results from ten panellists for four batch productions are shown in fig 3. The quality of soymilk was a great improvement over that produced during the initial stages of the project. Previous soymilk quality showed variability in colour and the presence of a beany aftertaste (Annan and Plahar, 2000). Soymilk produced during the present period of evaluation showed that with the exception of the second production batch all other productions were characterised as having a typical cream colour of soymilk. Consistency was smooth and coated glass well indicating that it was not watery. The aroma of soymilk samples was typical of soymilk and was not beany. A great improvement was observed in the taste of soymilk, which was judged by panellists to have no beany aftertaste, and was pleasant and typical of a good quality soymilk. The relatively poor quality of soymilk produced in the second batch was the result of over-processing. The milk was darker and there was an overcooked flavour. There was also indication of a slight beany/bitter aftertaste. The entrepreneur was advised to drop soaked beans into boiling water, leave to boil for 10 min. and heat filtered milk extract for only 20 min to reduce over-processing with subsequent loss of nutrients. The hot-break technique where beans were crushed with the hot blanch water was recommended by the project team to eliminate the beany/bitter aftertaste that occurs when lipoxygenase enzymes are not inactivated by adequate heat treatment.

Improvement of soymilk label.

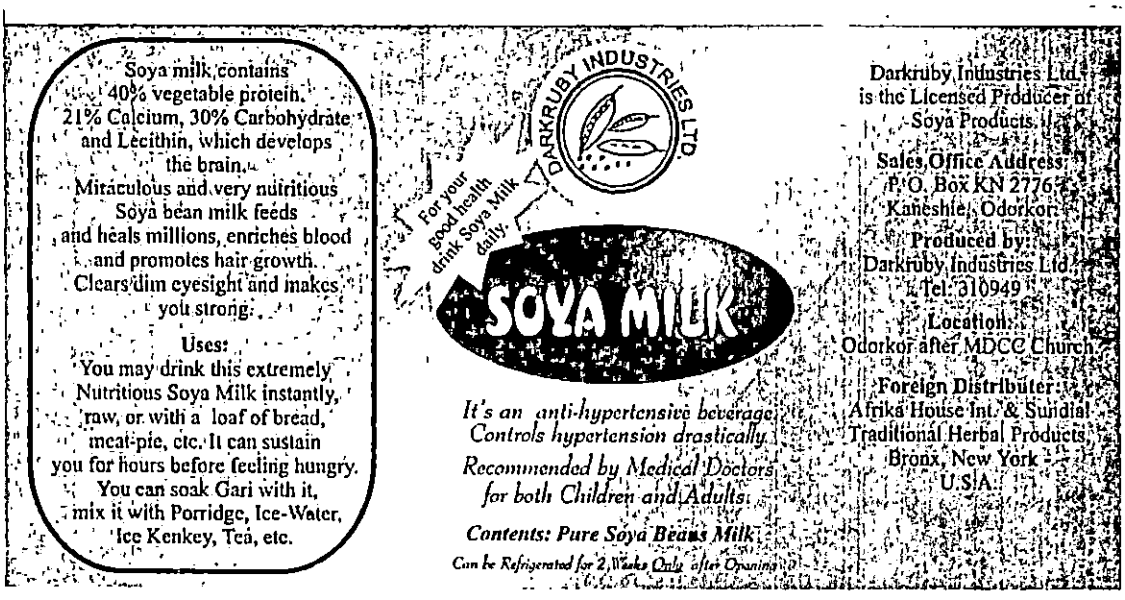
The soymilk label recommended for use by Darkruby Enterprise as well as the label previously used is shown in fig. 4. The previous label included health claims that could not supported by conclusive evidence. Nutrition information provided was also not correct and shelf-life claims were exaggerated. The project team therefore, provided accurate nutrition information based on actual product analysis in the laboratories and all unsubstantiated health claims were advisedly excluded from the label. The shelf life was recommended as three days under refrigerated conditions and not two weeks as previously prescribed.

Fig. 3. Sensory evaluation of soymilk from four batch productions by Darkruby enterprise



B1 = Batch production #1
B2 = Batch production #2
B3 = Batch production #3
B4 = Batch production #4

Fig 4. Copies of previous (A) and improved (B) soymilk labels by Darkruby enterprise.



A

B

4. CONCLUSIONS

Results of quality monitoring of soy products and processes by Darkruby Enterprise show a marked improvement in quality and safety. The technologies transferred to the enterprise have, therefore, proved to be more suitable. The entrepreneur has shown a high sense of adherence to good manufacturing practices as evidenced by the maintenance of consistent quality and the ability to control points of hazard occurrences. All soyproducts analysed over the period of evaluation were of good nutrient quality and the absence of pathogenic or indicator organisms confirm that the products are safe for human consumption. The roasting process for the production of soypowder however, requires improved equipment and more standardised procedures.

FOLLOW-UP ACTIVITIES

Training of factory workers to adhere to a quality assurance system which involves developing a Hazard Analysis Critical Control Points (HACCP) programme will be undertaken. This will ensure soy-products of consistent and high quality.

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