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Development of a Cheese-like Product from the African Yam Bean (*Sphenostylis sternocarpa*)

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ABSTRACT

*A vegetable cheese-like product (Akede cheese) was developed in the study from the African yam bean (*Sphenostylis sternocarpa*) by curdling of a filtered slurry of dehulled beans soaked in 4% sodium chloride. The coagulants were hydrated calcium sulphate (4×10^{-2} M) or 5% mixed cultures of lactic acid bacteria. The most acceptable products as regards flavour and texture were produced in a 1:4, bean to water ratio, and a short homogenisation time. The crude protein content of the product was 48·1%. Moisture content was 51·9%, and it has 35×10^{-6} meq/g total titratable acidity. The shelf life of the product was 48 h under refrigerated storage. The results could be important in providing an alternative method for utilising the bean seed.*

INTRODUCTION

Legume seeds are consumed by man throughout the world as a primary source of protein. In developing countries, they are usually much cheaper than animal protein such as eggs, meat, milk and dairy products. Legumes, therefore, are of much importance to the low socio-economic group, among whom there is usually a high incidence of protein energy malnutrition (Aylward & Jul, 1975). The most popular seeds are cowpeas (*Vigna unguiculata*), winged bean (*Psophocarpus tetragonolobus*), mung beans (*Vigna radiata*), soyabeans (*Glycine max*), and red kidney bean (*Phaseolus vulgaris*). These have been much studied (Hang & Jackson, 1967; Wang, 1967, 1984; Ilany *et al.*, 1969; Djurtoft, 1982; Beauchat, 1984; Chopra *et al.*,

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1984; Johnson & Wilson, 1984; Reddy *et al.*, 1984; Rao *et al.*, 1988) but others, for example, the African yam bean (*Sphenostylis sternocarpa*) have attracted little attention. Apart from recent work (Njoku *et al.*, 1989) not much information on the legume seed is available in the literature. It is thought that the bean could be processed into a new product, in the same way that soybeans are used in oriental diets (Beuchat, 1984; Wang, 1984). It is expected that the protein-rich product would improve the protein supply and alleviate some of the nutritional problems caused by inadequate protein intake. Thus, the objective of the study was to produce a cheese-like curd (Akede cheese) from the African yam bean (*Sphenostylis sternocarpa*), with acceptable organoleptic properties.

MATERIALS AND METHODS

Materials

The African yam beans (*Sphenostylis sternocarpa*), marble variety, were purchased locally. Benzoyl-D,L-arginine-nitroanilide hydrochloride (BAPNA) was obtained from Sigma, London Ltd, UK; Bovine trypsin from Calbiochem, Boehring Corp., UK. Other chemicals were of analytical grade. Lyophilised cultures of *Lactobacillus plantarum* and *Streptococcus lactis* were obtained from the National Collection of Industrial Bacteria, Colindale, UK.

Production of bean milk

Trial experiments were first performed to determine the best ratio of seed to water, that would produce an acceptable test slurry (milk). Satisfactory results were obtained with the ratio of 1:4. Therefore, about 50 g of the seeds were soaked in 200 ml of 4% sodium chloride solution. After 12 h, the seeds were rinsed twice in tapwater, blanched for 5 min at 100°C, and then dehulled and homogenised in distilled water for 3 min, with a minohun blender (Model MS 223, Taiwan). The resultant slurry was filtered through a double layer of cheese cloth (Fig. 1).

Chemical coagulation of milk protein

The milk was boiled for 15 min and then cooled to 80°C. Calcium sulphate solution (4×10^{-2} M, pH 6·2) was prepared by heating the suspension to 80°C with continuous stirring, and then allowing to stand at room temperature (30°C) for about 3 h. It was heated again to 60°C and was then added to the milk with a gentle continuous stirring for proper dispersion. It was allowed

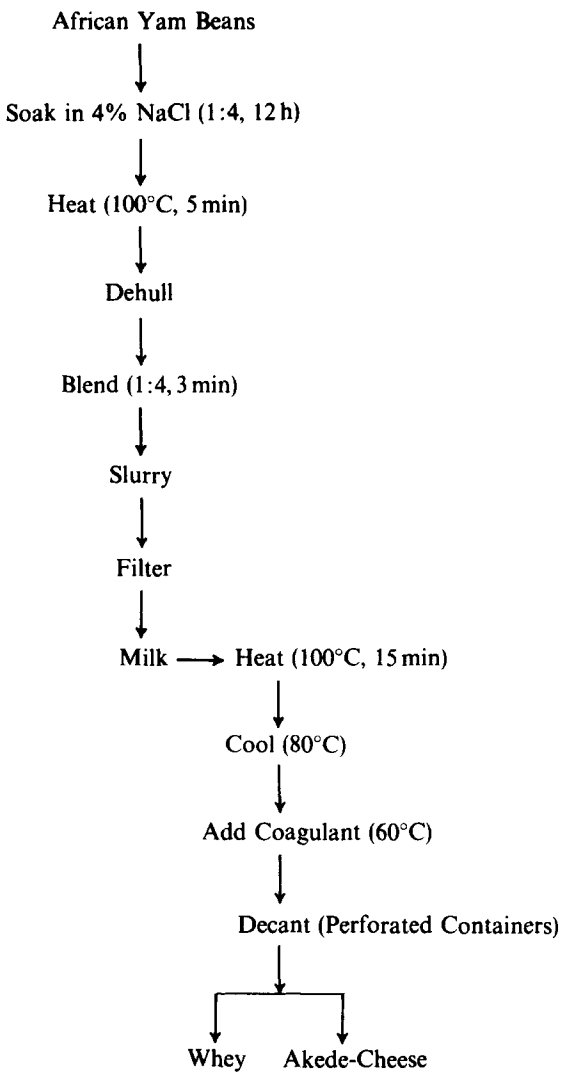

Fig. 1. Flow chart for the production of Akede cheese.

to coagulate in sterile perforated plastic containers lined with a sterile fine cloth. The whey was collected in a beaker.

Bacterial fermentation

Starter cultures were prepared by first seeding 50 ml of autoclaved bean milk with 1 ml of a 3-day old mixed culture of *Lactobacillus plantarum*, and *Streptococcus lactis* on MRS agar (Oxoid). After 24 h at 37°C, the entire milk was used to seed 200 ml of the bean milk. The milk was kept at 4°C to allow the curd to ripen and mature.

Quality assessment of product

Samples of the curd were assessed for flavour, texture and acceptability by an 8 member panel aged between 22 and 31 years. Flavour and acceptability were evaluated on a 9 point Hedonic scale where, 9 denoted extremely liked product, and 1 indicated disliked extremely and poor quality. Texture was measured as previously described for the bean seeds (Njoku *et al.*, 1989) using the crushing weight method. The results were scored on a 5 point scale in which 5 represented firm texture, and 1 represented very soft and watery texture.

General analytical methods

Samples of the bean slurries and of the curd were analysed as follows; moisture was determined by drying in a vacuum oven at 70°C to constant weight, nitrogen by Kjeldahl digestion (Osborne & Voogt, 1978) followed by colorimetric determination of released ammonia. Crude protein was expressed as 6·25 × N (nitrogen). pH was determined with Phillips digital meter. Titratable acidity was estimated by the method of Grover *et al.* (1983). Trypsin inhibition was assayed by determining the reduction of the rate of hydrolysis of BAPNA by bovine trypsin using the method described by Smith *et al.* (1980).

RESULTS AND DISCUSSION

Crude protein content of bean milk

The crude protein content and quantity of the bean milk was influenced by the time of blanching, maceration period, and the ratio of the seeds to water.

TABLE 1
Effect of Bean to Water Ratio on the Protein Content of Bean Milk

Bean: Water	*Volume of milk (ml)*	*Crude protein % (N × 6·25)*
1:8	320 (5)	28·9
1:7	270 (10)	36·3
1:6	220 (5)	49·4
1:5	180 (10)	61·3
1:4	130 (5)	70·0

Values are means of triplicate determinations. Those in parentheses represent standard deviation.

TABLE 2
Effect of Coagulant on Crude Protein Content of Bean Milk

Coagulant	*Weight of cheese (g)*	*Moisture (%)*	*Crude protein % (N × 6·25)*
$CaSO_4.2H_2O$	70	51·9	48·1
$CaCl_2$	75	56·3	43·7
$MgSO_4$	83	59·9	40·1
$MgCl_2$	80	60·0	40·0
Bacteria	70	50·0	50·0

The coagulants were used at a final concentration of 4×10^{-2}M.

A 5 min blanching time was found to remove the beany flavour from the milk and also produced acceptable milk colour. Milk produced from unblanched bean seeds was grey. Adequate maceration was attained after 3 min of blending, producing milk of a dense body, compared with milks from inadequately macerated beans. The results of the bean to water ratio on the crude protein content of the milk are summarized in Table 1.

Composition of the cheese (curd)

The effect of the chemical coagulants on the milk protein are shown in Table 2. The total weight of protein in the bean milk produced by calcium sulphate was 48·1%. But only 40% was obtained with magnesium chloride. The products of magnesium chloride and magnesium sulphate had high moistures, hence their watery appearance. Those of calcium salts were firmer and less dense. They contained about 48% crude protein (Table 3) and 52·0% moisture. The pH of the curd was 6·0 and was similar for all the coagulants. The texture of the curd was 3·5 (Table 3). The product from bacterial fermentation was much firmer than products from chemical coagulation. Its colour was acceptable (creamy) but the aroma was not as

TABLE 3
Effect of Bean to Water Ratio on the Crude Protein Content, pH and Texture of Akede Cheese.

Bean: Water	*Moisture (%)*	*Crude protein (%) (N × 6·25)*	*pH*	*Texture*
1:8	84	28	6·0	1
1:7	71·5	38·5	6·0	2
1:6	70·0	30·0	6·0	2·5
1:5	63·0	37·0	6·0	3·0
1:4	52·0	48·0	6·0	3·5

good and acceptable as the curd from calcium sulphate. The protein content was 50%. The total titratable acidity increased from 20×10^{-6} meq/g to 52×10^{-6} meq/g during the fermentation. pH decreased by one log unit from pH 6·0 to pH 5·0 in 48 h. Soaking the beans first in 4% NaCl before processing appeared to have caused 46·2% reduction in the tryspin inhibitor (TIA) activity. In the raw beans the mean value was 4·21 mg/g; in the milk, the value was 2·28 mg/g $\pm$ 0·13.

Organoleptic assessment of the cheese

The product from calcium sulphate was highly rated and very well accepted (Table 4). Those from bacterial fermentation were only moderately accepted. There is a need to popularise the African yam bean (*Sphenostylis sternocarpa*), particularly among the low income population. Presently, its consumption is low because of its long cooking time. It was thought that, in addition to direct consumption of the whole beans, further processing into other products could provide a basis for a broader usage. Thus, a cheese-like product was prepared from the bean by a simple technique which involved the production of the bean milk (water extract), coagulation of the milk protein and formation of the curd. Treating the beans in 4% sodium chloride was found to reduce the trypsin inhibitor activity by 47%. Kailasapathy *et al.* (1985) reported a reduction of 40–45% in winged bean.

The composition of the cheese was highly dependent on the ratio of beans to water and the amount of extracted protein. Similar factors have been found to influence the composition of silken tofu made from soybeans (Wang, 1984; Beddow & Wong, 1987). In the study, a 1:4 bean to water ratio produced the most acceptable product, with regard to protein content, body, texture and flavour. For tofu, Wang (1984) reported a ratio of 1:8 to 1:10. But for winged bean curd, a ratio of 1:3 was found to be most suitable (Srikantha *et al.* 1983). It appears, therefore, that different bean types would

TABLE 4
Sensory quality of the cheese

Attribute	*Mean sensory score*	
	A	*B*
Texture	3·5 $\pm$ 0·74	5·0 $\pm$ 0·64
Aroma	7·0 $\pm$ 0·83	5·1 $\pm$ 0·64
Acceptability	7·6 $\pm$ 0·71	5·9 $\pm$ 0·60

A, cheese produced by chemical coagulant.
B, cheese produced by fermentation.

require different ratios for this kind of work. The heat treatments were used to primarily improve the formation of the curd, and to reduce or eliminate the beany flavour and some of the antinutritional factors, and thus improve its nutritional quality. Blanching was found to facilitate dehulling, and to reduce foaming during homogenisation. The result agrees with those of Kailasapathy *et al.* (1985), who reported much foaming with unblanched beans. It is believed that by inactivating certain enzymes, for example phenolase, by the heat treatment, a readily acceptable colour of the curd was obtained. The composition of the milk also influenced the overall acceptability of the product. Blanched beans produced milk with a denser body than that from the unblanched ones. This was probably due to the higher milk extract that was produced. The optimum concentration of coagulant was similar to the range of concentrations (2×10^{-2} to 4×10^{-2}M) used for tofu (Wang, 1984). The texture of the fermented curd was much different from that produced by chemical coagulants. So also were the flavour and colour. It is difficult to explain these observations, but it is believed that the hard texture is related to the large quantity of whey released during the maturation period.

The study was directed towards increased utilisation of the African yam bean, and the results demonstrate the possibility of producing a protein-rich curd from it. Further work is required to determine its nutritional and toxicological effects, if any. The shelf stability of the product at present is quite low. Methods to improve it would be highly desirable. It is hoped that the cheese will supplement the local Nigerian product 'warankasi' (Ogundiwin & Oke, 1985; Aworh *et al.*, 1987) prepared from cow's milk, and popular among the Fulanis.

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