Research Report

PRODUCTION AND EVALUATION OF COWPEA TEMPE POWDER

by

A. HAYFORD

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Abstract

Cowpea tempe powder produced had a greyish color, compared with the creamy white color of cowpea flour. There were no marked changes in proximate composition of the various steps during processing. Crude protein remain fairly constant, ash and fibre contents reduced, except for a slight increase in fibre after fermentation, which was a result of the mold fermentation.

Antinutritive factors were greatly reduced during processing, a percentage lose of 91% in trypsin inhibitor 60% in phytic acid, and 84% in tannin (Tannic acid). During processing of tempe powder heavy losses were observed in vitamins, 87% loss in thiamine and 94% loss in niacin before fermentation. However, after fermentation, there were slight increases. Thiamine 2 times and niacin 8 times the amount of unfermented dehulled soaked beans. Biscuits made from cowpea tempe flour was highly acceptable than that from cowpea flour which, although highly rated for appearance and color panelist complained of hardness in texture and a strong beany flavour.

Introduction

World hunger and food scarcity accentuated by unequal distribution systems have stimulated increase in research and development of relevant appropriate technologies for new protein sources.

For millions of people in developing countries in areas of tropics and subtropics, where more than half the worlds population is concentrated, edible legumes including pulses and beans are their main source of dietary protein. Legumes, because of their ability to fix atmospheric nitrogen, are very high in protein.

In countries such as Ghana the use of legumes as a cheap protein food is constantly stressed in nutrition extension programmes. Cowpeas, commonly referred to in Ghana as beans, are the most popular of the leguminous grains used in Ghana and their economic value has long since been recognized as a subsidary crop to be relied on during the "hungry season" (Aykroyd and Doughty, 1964 as cited by Dovlo et al., 1976). Its protein content (20-25%) makes it important nutritional booster to relatively low protein cereal diets consumed in Ghana and Africa on the whole. Traditionally (Ghana) cowpeas grains are processed into a flour by soaking, hand dehulling, dried and ground into a flour. To combact labour in domestic production as well as maximizing extensive use of the beans the cowpeas flour is presently in the introducting stage being mechanically developed by food Research Institute, Ghana. Various recipes have been developed (Dovlo et al., 1976, Randolph et al.,1981) to encourage its consumption in order to enhance the nutritional status of the Ghanaian people.

Despite the high quality protein of legumes, most are unavailable or unutilized by the body because of the way they are processed before consumption. Most beans contain antinutritive factors, and unless cooked, boiled,soaked or fermented, these factors will not be halted. Thus the body is deprived of many important nutrients. In the light of nutrition, attempts have been made to increase the digestability of cowpeas by protein supplementation with other - sulphur - containing amino acids legumes (Akpapunaw and Markakis, 1981) and also processing cowpeas by natural fermentation (Zomora and Fields, 1979) and by fermentation using a specific microorganism Rhizopus oligosporus and other species(Djurtoft and Jensen, 1977, Omotala, 1984) into a product known as tempe. The world tempe is a collective name for a food product which is fermented by Rhizopus species (Koswan and Hesseltine, 1979). It is usually made from legumes and it has been found from worker all over the world to be of higher protein quality and higher digestability over their respective unfermented legumes.

The unique mould fermentation apparently improves the digestability, the protein efficiency ratio and the vitamin content of the soybeans, and contributes a pleasant flavour to this food. In the light of this, the desire to compare the traditional way (Ghana) of processing cowpea for consumption in Ghana and that of cowpea tempe processing, with the utimate hope that, one day Ghanaians will adopt that technology because of its good benefits.

Objective

1. The objective of this project is aimed at compairing the traditional processing of cowpeas in Ghana and that of cowpea tempe processing.
2. It is aimed at improving the Ghanaian diet as well as introducing tempe in the diet of Ghanaians.
3. Cowpea was chosen in this project because of its high consumption and availability as against soybeans which are unavailable.
4. Tempe in the powder form was chosen as the form in which to be introduced, because from personal experience the acceptability of the raw form would be difficult.
5. Cowpea tempe flour (powder) can be easily replaced for cowpea flour in the, various recipes developed. In this form the use will be exetensive as oppose the raw tempe.
6. The ultimate objective is aimed at introducing the technique of tempe preparation in Ghana.

Literature Review

Tempe also known as tempe kedele and tempe is a popular Indonesian food generally made from soybeans fermented by Rhizopus species. It is a highly nutritious food and for that matter many workers all over the world have shown a lot of much interest and as such have suggested as a possible source of protein for developing countries.

Murata et al. (1967) in the study of the nutritive value of tempe, observed no large differences in crude protein content and that of nonfermented soybeans, however free amino acid were increased during fermentation. The amount of different free amino acids in the palatable tempe was from 1 to 85 times as much as that of unfermented soybeans. Riboflavin, vitamin B6, nicotonic acid and pathothenic acid were increased during fermentation although thiamine was little altered. Changes in riboflavin, nicotinic acid and vitamin B12 were also found by Steinkraus et al. (1961). In his study pantothenic was shown to be decreased.

It has also been observed that during 72 hrs fermentation lipolytic activities occured, hydrolyzing over one-third of the nutrient fat (Wagenknecht et al., 1961). Of the fatty acids liberated during fermentation only linolenic acid showed a depletion of 40%, and there was apparently no preferetial utilization of any particular fatty acid. Decrease of linolenic acid including free linolenic acid was also observed by Murata et al. (1967), however, changes in olenic and linoleic acids were not necessarily consistent with those reported by Wagenknecht et al. (1967).

In a study by Gyorgy et al. (1964) it was observed that tempe had antioxidant activities not demonstrated by original soybeans. The active substances were identified as geristein, daidzien, and 6,7,4 trihydroxyisoflavone (factor 2). These substances present in bound, inactive form in soybeans, however the last named compound has not been isolated from natural sources.

Steinkraus, et al. (1961) determined peroxide value on the lipids extracted with others from samples of soybeans, and tempe which has been dried, pulverized and stored for several months at room temperature, he observed that the peroxide numbers from tempe samples ranged from 0 to 1.1 while that of soybeans handled in the same conditions except fermentation ranged from 18.3 to 201.9.

The method of processing soybeans into tempe has also received much attention by various authors. As with any traditional method, there are many minor variations in the production of tempe in Indonesia. The essential steps are :

1) Soybeans are hydrated and cooked, they are rubbed by hand or feet to looses the skin which are then floated off by water.
2) The dehulled beans are recooked, partially dried and inoculated with ragi mold form the previous fermentation. They are then wrapped in either banana leaves or plastics (Polyethylene) and placed in warm places.

Variations in methods have been described and use for tempe by many workers (Steinkraus et al., 1961, Hesseltine and Wang, 1967, Hermana and Soetedja, 1970).

Hermana and Soetedja (1970) observed that tempe produced by their method of processing was of a milder aroma, better texture and longer keeping time.

The principles of tempe fermentation are such that a number of bean types and even cereals or mixtures of cereals grains and beans can be substituted for soybeans.

Djurtoft and Jensen (1977) prepared cowpea tempe using the laboratory method discribed below.

Cowpeas

↓

Soak in water (1:3 w/v)
17-18 hours, 20-25°C

↓

Dehull

↓

Drain

↓

Cool and surface dry

↓

Inoculate with Rhizopus sp.

↓

Pack in petridishes or perforated
plastic bags

↓

Incubate
24 hours at 30-32°C

↓

Cowpea tempe

He prepared tempe by this method using different species of Rhizopus. Tempe from Rhizopus arrihus was found to be sour and had an aromatic aroma and flavour and after 48 hrs a bitter taste, the pH unexpectedly fell to 5.3, accounting for acid flavour. However, tempe prepared from Rhizopus oligosporus and Rhizopus oryzae were more yeastlike in aroma and flavour. The pH found using Rhizopus oryzae to be slightly higher than that of soybean tempe. In his assessment of protein quality in cowpea and cowpea tempe he observed with feeding experiments with rats, true digestibility to be 87.5 to 89.5, Biological value 54 to 57 and NPU 50.0 to 50.5. An increase in soluble nitrogen was observed which suggested the product to be more digestible than cowpea. His results was later confirmed by Omotola, 1984. He in addition, observed an increase in the total lipids during fermentation. Free fatty acids were liberated and increased during fermentationi

Materials and Methods

Materials.

1. Cowpeas
2. ~~Cooking utensils for frying~~
3. Chemicals for the various chemical analysis.

Cowpeas bought from the open market were used for this study. All chemicals used were of analytical reagent grade.

Cowpeas (whole)

↓ - cleaning

Soak in boiling water (1 hr)

wet.

↓

Dehull (machine)

Dehulled seeds

↓

Dried at 50-60^{o}C (24 hrs)

↓

Milled (Humner mill)

↓

COWPEA FLOUR

Soaked dehulled beans
for 2 hrs

Taken
for
Analysis

↓

Steamed 10 min.

↓

Drain and Dried
inoculated with 0.03% laru

↓

Packed in Plastic bags
incubated at 37^{o} (24 hrs)

↓

COWPEA TEMPE

↓

Cut in to small pieces(0.5 x 5 cm)

↓

Blanched for 15 mins in
boiling water

↓

Drain, dehydrated at 50^{o}-60^{o}C

↓

Milled (Hamner mill)

↓

COWPEA TEMPE POWDER

The samples were prepared as shown above, cowpeas were cleaned by hand and the chaff were separated from the beans, and then soaked in boiling water for one hour to allow for easy dehulling using the dehuller. Dehulled beans were then separated from the hulls by floatation and hand picking.

a. For cowpea flour, dehulled seeds were drained and dried in a hot air oven at a temperature of about 50-60°C for 24-30 hrs. This was then milled into a fine powder.

b. For cowpea tempe powder, the dehulled seeds were further soaked for 2 hrs and then steamed for 10 minutes. The seeds were then drained, dried, and inoculated with 0.03% laru, packed in perforated plastic bags and incubated at 37°C for 24 hrs. The resulting tempe was then cut into pieces, blanched, drained and dried in a hot air dryer at 50-60°C for 24-30 hrs and then milled into a fine powder using a hammer mill (Hermana, 1981).

PREPARATION OF BISCUITS:

To evaluate the tempe powder for acceptability, biscuits were prepared using a recipe formulated by Randolh et al. (1981) this was compared to the normal recipe using cowpea flour.

INGREDIENT

	Flour (g)	Wheat flour g	Egg g	Margarine g	Sugar g	Nutmeg g	Salt g
Cowpea flour	60	120	1	60	60	5	1
Cowpea tempe flour	60	120	1	60	60	5	1

Some quantity of ingredients were used for the preparation, the sugar and margarine were creamed together and beaten egg added. All dry ingredients were then stirred in to form a dough which was then rolled, cut into biscuit shapes, and baked in a hot oven at 200°C, for 10-15 minutes.

SENSORY EVALUATION :

Biscuits samples from cowpea flour and cowpea tempe powder for sensory evaluation were served to panelists, who evaluated them for appearance, color, aroma, texture, and flavour which were rated on hedonic scale of 9 to 1 (9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely) by a volunteer panel consisting of ten persons of which three are Africans with no experience in tempe taste and seven Indonesians.

Sensory quality scores were analyzed by standard procedures of analysis of variance and multiple comparisons testing of the significance of mean differences ($p > 0.05$) using the method employed by Larmond (1977).

CHEMICAL ANALYSIS:

Chemical analysis was done in the raw whole cowpeas, dehulled cowpeas (cowpeas flour), dehulled soaked and steamed cowpeas and cowpea tempe powder. All the samples were dried and milled for analysis except the whole bean which was only milled.

Proximate analysis was carried out to obtained the proximate composition of the various steps during processing of cowpea tempe powder.

PROTEIN :

Crude protein content was determined by AOAC official method of analysis A - 47.021 (1984). The weighed samples (0.059) were digested in Kjeldahl flask with recommended quantities of mercuric oxide, sodium sulphate and concentrated H_2SO_4. The clear digested mixture was cooled, diluted with water followed by addition of 50% NaOH solution and heated to distill out ammonia. The distilate was titrated agains a known normality of HCl.

Crude protein was calculated as below :

Protein percentage = % nitrogen x 6.25.

FAT :

2g sample was put in a beaker and 50 ml 4NHCl added and boiled for 15 minutes. Then cooled and put in a separating flask with 50 ml ethanol absolute, 50 ml petroleum benzene and 15 ml amyl alcohol and shaken for 30 minutes. The bottom layer was removed and top layer poured into already weighed soxhlet flask, after the solution was allowed to stand for a few minutes. This was repeated. The solvent was then evaporated and flask and content dried at 130°C for 3 hours.

% fat was calculated as below :

$$\% \text{ fat} = \frac{B - A}{\text{sample weight}} \times 100\%$$

A = weight of flask

B = weight of flask + fat

MOSTURE :

About 2g samples were dried in previously cooled tarred moisture dishes in hot air oven at a temperature of 130°C until a constant weight was obtained. Moisture was calculated as loss in weight of samples on drying (AOAC, 1981).

ASH :

About 2g of sample was ashed in a cooled previously tarred porcelain crusible in a muffle furnace set at 700°C for 5 hrs. until contrant weight was obtained. Ash content was calculated as loss of weight of sample after ashing (AOAC 1981) A-14.006.

FIBER :

Crude fiber was determined by AOAC official method A 7.067. About 2g sample after extraction of fat was transfered into a 600 ml beaker + 0.5 gm treated asbestos and 200 ml boiling H_2SO_4 and digested for 15 minutes. The residue after filtration was washed with water and further digested with required quantities of boiling NaOH. This was then poored into a prepared mat in a crusible with a known weight and washed free of alkali by means of ethyl alcohol and suction pump. The crusible with sample was then dried in oven for 5 hrs and ashed at 600°C. Crude fiber was calculated as the loss in weight before ashing and after ashing.

ANTINUTRITIVE FACTORS:

TANNINS:

Tannin content of the various steps during processing of cowpea tempe powder were determined following AOAC official method of analysis..... A-9.098 1975. About 50 mg sample was weighed into 600 ml and 200 ml distilled water added and refluxed for 2 hrs. The filtrate after filteration was diluted to 200 ml. 1 ml of this solution was pipetted in triplicate into 15 ml tubes and required quantities of $NaCO_3$ solution, Folin-Dennis reagent and distilled water was added mixed well and allowed to stand for 10 mins. Distilled water was used ~~w~~as blank and tannic acid as standard. The resulting color after mixture was read at absorbance of 760 nm.

$$\% \text{ Tannin was calculated as: } \frac{\text{Absorbance x slope x dilution factor}}{\text{weight of sample}}$$

PHYTIC ACID:

Approximately 1g sample and 50 ml solution of 1.5% HCl 10% Na_2SO_4 was added and shaken for 2 hrs. 10 ml filtrate after filteration was put in 50 ml erlenmeyer flask and 10 ml deionized water and 0.2% $FeCl_3 6H_2O$ in 1.2% HCl added and boiled for 30 minutes in a waterbath to precipitate phytic acid as Fe 4-phytate. The solution was then centrifuged and pellet washed twice with 2.5 ml Na_2SO_4 in 0.6% HCl. The pellets were then diluted with 5 ml conc. HNO_3 and transfered into a flask where 4 drops of conc H_2SO_4 was added and heated till 4 drops of H_2SO_4 remained. ~~H_2SO_4~~ 4 drops H_2O_2 was added and heated till bubbles ceased. 10 ml 3M HCl was added heated for ten minutes and diluted in a 100 ml volumetric flask. 5 ml filtrate, 0.5 ml hydroxylamine-HCl 2.5 ml buffer acetate and 1 ml alpha-alpha dypyridine was put into a test tube and colored developed after 30 minutes was read on spectrophotometer at absorbance of 515 nm. A working solution of iron was used as standard and HCl (0.02%) as blank. % phytic acid was calculated as in AOAC official method of analysis (1975).

TRYPSIN INHIBITOR:

Trypsin inhibitor (Tl activity) was determined by AACC official method of analysis A 71-10 (1974). The weighed grind sample plus 50 ml 0.01N NaOH was shaken on as electric shaker for 3 hrs. Enzyme assay determination was done following the method employed by Hamerstrand et al. (1980).

AMINO ACID:

Amino acid pattern for cowpea flour and cowpea tempe powder were analyzed with Beckman Amino Acid Analyzer.

VITAMINS:

The vitamins were determined by chemical method.

THIAMINE:

Thiamine content was determined by AOAC official method of analysis, 1979. The weighed sample (25 g) were boiled for 15 minutes with recommended quantities of 0.05N H_2SO_4 (150 ml) and pH was adjusted with recommended quantity of 3N CH_3COONa, 10 ml Taka diastase was used as the enzyme and incubated at 37°C over night. Samples were diluted till 400 ml and filtered. 250 ml of filtrate was taken and recommended quantities of solution A and B (phenol red indicator, Alcohol-phenol, 0.2N NaOH P-amino acetophenon $NaNO_3$ H_2O, NaOH $NaHCO_3$) were added and kept in a dark room for 2 hrs. After seperation in a seperating funnel the bottom layer was discarded and the top layer was put into centrifuge tubes containing 1 gm $NaSO_4$ this was centrifuge for 5 minutes. Color developed was read on the spectrophotometer at absorbance of 520 nm. The samples were compared with standard solution containing 10, 20 and 30 ug of thiamine, mg/% thiamin was calculated as

$$\frac{100}{\text{wt sample}} \times \text{dilution factor} \times \frac{\text{Abs.sample}}{\text{Abs.stand}} \times \frac{10\ \text{ug}}{1000}$$

NIACIN :

Niacin content was also determined by AOAC official method of analysis A-43.044 (13th ed.) The weighed sample (10g) was mixed with 200 ml of 1N H_2SO_4 and autoclaved for 30 min at 15lb pressure. The sample was then cooled and adjusted to pH of 4.5 with 10N NaOH using a pH meter, this was then diluted in 250 ml volumetric flask and filtered 40 ml of the filtrate was added to 17g $(NH_4)_2SO_4$ and diluted to 50 ml. 1 ml filtrate was pippetted after vigorously shaking and used for color development. Standards of Blank and samples were prepared using recommended quantities of standard solutions, H_2O, NH_4OH, 10% sulfanilic acid, HCl and HBR. Color development was read with spectrophotometer at 440 nm (AOAC, 1979).

Results and Discussion

Cowpea tempe powder processing involved a first soaking in boiling water for 1 hr., 2nd soaking for 2 hr of dehulled beans, steaming inoculating with 0.03% laru incubating at 37 °C for 24 hrs. Tempe formed was blanched for 15 minutes dried and milled into a fine powder. Cowpea flour was obtained after dried dehulled beans were milled into a fine powder. Cowpea tempe powder was darker in color as compared to the creamy-white color of cowpea flour. This could be due to the darker color observed when the beans were steamed.

DEHULLING:

Removal of seed coat of cowpea variety used in this project was found to be difficult.Wet dehulling by hand not only consumed time but water. Beans had to be soaked in boiling water for 1 hrs to allow easy dehulling using a dehulling machine. However it was not easy to separate hull completely due to inefficiency of the dehuller (machine). Complete separation was attained during the second soaking period. As a result of the difficulty in dehulling a lot of beans were lost through dehulling which reflected in the low recovery of 40% (% dry weight) after tempe powder was made.

FERMENTATION:

Inoculated beans needed an initial high temperature of about 37^{o} - 40^{o} to start fermentations. Beans incubated at room temperature all failed to ferment, unless wrapped to increase temperature, all the beans resulted into bacteria fermentation which produced a bad odour. Tempe were always removed after 12 hrs of incubation from the incubator and incubated at room temperature. High temperature observed in the incubator as a result of increase in temperature in the fermenting beans were found to be detrimental to the mold growth. Although high temperature favour the growth of mold, prolonged incubation at high temperature could cause a high temperature in the bean mass which may damage subsequent growth of the mold (Steinkraus, 1981).

PROXIMATE COMPOSITION:

Proximate composition of cowpeas in the various steps during processing of tempe powder and cowpea flour are shown in Table 1. From the data it may be seen at there were no marked differences in crude protein of the raw beans till after fermentation. Crude fibre decreased but slighly increased after fermentation, from dehulled steamed beans to cowpea tempe powder, this results confirms with that of Murata et al. (1967). Ash content decreased from raw whole cowpeas till after fermentation and blanching to cowpea tempe powder. This could be due to leaching of soluble minerals during soaking periods and blanching (Akpapunam, 1985).

ANTINUTRITIVE FACTORS:

The degradation of three antinutritive factors, Trypsin inhibitors, phytic acid and tannins were observed and the results are shown in Table 2. The results obtained in this study suggests a high phytic acid and tannin content for the cowpea variety used.

Tl activity in the whole cowpea was less than in the cotyledons (dehulled cowpeas). Elias et al (1979) in his study with different variety of Phaseolus vulgaris observed also that with one variety the Tl activity was higher in the cotyledon than the whole seed. This increase in Tl activity after dehulling could be due to at least two factors, that this could be characteristically present in the cotyledon fractions of the beans, and secondly that the seed coat contributes a substantial portion of the whole seed weight, so that removal of the seed coat may lead to increase in concentration on a unit weight basis (Deshpande et al., 1982). Tl activity (trypsin inhibitor

Table 1. Proximate composition of the various steps in the processing of cowpea tempe powder (% dry weight)

Samples	Protein	Fat	Fiber	Ash	Carbohydrate (by difference)
Cowpeas whole	26.4	2.3	4.90	3.31	63.09
Cowpeas dehulled (cowpea flour)	27.3	2.4	1.7	2.1	66.50
Cowpea dehulled soaked steamed	27.7	2.3	1.8	1.78	66.42
Cowpea tempe (blanched dried) (cowpea tempe powder)	29.7	4.04	2.60	1.3	62.36

Table 2. The degradation of three antinutritive factors: trypsin inhibitor, phytic acid and tannins during processing of cowpea tempe powder (% dry weight)

	Trypsin inhibitor (Tl mg/%)	% Loss	Phytic acid (g/%)	% Loss	Tannins mg/%	% Loss
Cowpea whole	836.92		0.58		315.56	-
Cowpea soaked dehulled (cowpea flour)	902.57	-	0.64	-	96.79	69
Cowpea soaked, dehulled soaked, steamed	102.06	88	0.31	51	49.26	84
Cowpea tempe blanched dried (Cowpea tempe powder)	78.38	91	0.25	60	56.38	82

inhibites the activities of proteolytic enzymes in both animals and humans, active antitryptic activities have often resulted in growth retardation in rats, trypsin inhibitors such as lima-beans have been found to inhibit proteolytic activity of both human trypsin and chymotrypsin thus resulting in inhibition of protein digestion in the body (Liener,1969). However in this study further processing resulted in a decrease in Tl activity, after soaking and steaming for 10 minutes about 58% loss was recorded and further loss of 23% after fermentation and blanching in boiling water for fifteen minutes. There is no record on the actual fate of Tl activity during tempe fermentation, but it is thought that about 91% Tl activity is lost during the 30 minutes boiling of soybeans (Liener & Kakade, 1969). Tl activity was reduced by 91% after processing of cowpea tempe powder, the loss could be due mainly to cooking, steaming and blanching during processing (Ologhobo and Fetuga, 1984). Phytic acid content observed in this study was quite high 0.58 g%. Phytic acid content of cowpea varieties have been reported to range from between 0.28 g% - 0.792 g% (Longe, 1983, Ologhobo and Fetuga, 1984) values above 0.330 g% were considered to be nutritionally harmful. Phytic acid has been known to interfere with mineral absorption and utilization in the body thus causing deficiencies in minerals such as calcium, iron, magnesium, zinc and other trace elements in human and animals (Sutardi & Buckle, 1985;Obeleas, 1973). It forms complexes with proteins thus inhibiting peptic digestion (Ologhobo and Fetuga, 1984). In this study phytic acid was higher in the cotyledons after the first soaking period than in the whole raw compea 0.64 g% an increase of about 10%. Sutardi and

Buckle (1985) in their study observed similar results, an increase during first soaking of dry beans from 1.07% - 1.09%. This may be due to formation of complexes between phytic acid and the seed coat fractions so that during extraction they may be retained in the residue fraction after centrifugation leading to a lower estimation in the whole bean (Deshpande et al., 1982). However in all of the treatment during tempe production resulted in a decrease of phytic acid content by about 1/3 (Sutardi and Buckle, 1985, Sudarmadji and Markakis,1977), they didnot find any positive result with phytic acid during soaking. Chang, (1977) observed that presoaked beans in water at 60°C for 10 hrs resulted in 90% loss of phytic acid and for soybean 33% decrease only when soaked in distilled water at room temperature, which many indicate that phytase in soybeans has different properties. 51% decrease was observed is this study after second soaking for two hours and steaming of cotyledons, and a further decrease of 19% also after fermentation and blanching to tempe powder. Overall 60% reduction in phytic acid was observed during processing of cowpea tempe powder. The reduction of phytic acid can be accounted for by the activity of phytase elaborated by the mold responsible for fermentation and by some loss due to phytic acid solubility in water (Lolas and Markakis, 1975).

Cowpea also has a high tannin content ranging from 175 mg% - 780 mg% which could be nutritionally harmful (Reddy and Person,1985, Ologhobo and Fetuga, 1984, Lamrena et al., 1984). Tannins are polyphenolic compounds which form complexes with protein and thus causes an inhibitory action in digestive enzymes (Kumar and Singh, 1984).

Work with animals have shown that high concentration of tannic acid in the bloodsteam could causes toxic effects in liver, and as well as carcinogenic, although no such evidence with humans the caution is certainly suggested (Singleton and Kratzer, 1973). The reduction of tannin content during processing of cowpea tempe powder was high in this study. 65% of tannin (tannic acid) was lost after the first one hour soaking period of the whole beans and dehulled. Further loss of about 50% was observed after the 2nd soaking and steaming. So that a total of 84% tannic acid was lost before fermentation process. Tannic acid was lost though leachingof a small fraction of hydrolyzable phenolic compounds, located in seed coats of dry beans (Elias et al., 1979) in soaking medium, some amounts had been found in soaking and cooking water indicating that large amount could be eliminated by soaking and cooking. Most of tannin in legumes resides in the seed coats,after dehulling about 69-97% is lost (Narasinga Rao and Prabharathi,1982).There was a slight increase of about 7% in the soaked steamed dehulled seeds and in the cowpea tempe powder. Tannic acid have been known to from complexes with protein which readers them undetected by routine methods (Reddy and Pierson, 1985, Kumar and Sing, 1984). 7% increase of tannin observed may have been bound to proteins and released after to fermentation. Overall the tannin content reduced about 82% during processing of tempe powder. Tannin content can be reduced by processing like dehulling. soaking coating and germination (Reddy and Pierson. 1985). However there are no records in the effect of fermentation by *Rhizopus oligosporus* an tannin content of legumes.

VITAMINS:

The fate of this nutrients (vitamins) were observed during processing of cowpea tempe powder. According to the results shown on Table 3. There were heavy losses of the two vitamins after the first soaking period 87% and 97% for thiamine and niacin. Thiamin one of the more labile vitamin tend to suffer considerable ~~was~~ loss during food processing as a result of leaching, greater still when soaked on large volumes of water for long periods (Bender, 1971). Niacin which is the most stable is also lost my leaching during processing with water (Bender, 1971, Lund, 1975). This could account for the high losses observed during soaking in boiling water for 1 hr. However there were slight increases in both vitamins after fermentation. 47% increase in thiamin and > 100% increase in niacin were observed between unfermented dehulled soaked steam beans and the resulting tempe powder, this results conforms that of Murata et al., 1985. Although there is a loss of thiamin during tempe fermentation, Murata et al. observed an increase after 24 hrs fermentations. When fresh tempe in this study was analized it was observed that in % dry weight basis, Thiamin was 1.15 mg% while niacin 13.04mg%, there were heavy losses of 80% thiamin 91% niacin after blanching and drying of tempe. About 56% thiamin and 90% niacin losses are observed after blanching (Lund, 1984) of legumes. Although the loss during blanching is quite high there is still a slight increase in both vitamins in the tempe powder over the unfermented beans, values though less than the raw whole beans, were still higher than that of cowpea flour (dehulled beans). Amino acid composition of cowpea tempe and cowpea flour can be

Table 3. Vitamin contents (thiamine, niacin) during processing of cowpea tempe powder (% dry weight)

	Thiamine (mg/%)	% Loss	% Gain	Niacin (mg/1%)	% Loss	% Gain
Cowpea whole	0.97	-	-	2.51	-	-
Cowpeas soaked dehulled	0.18	81	-	0.184	92	-
Cowpeas soaked dehulled soaked & steamed	0.12	87	-	0.131	94	-
Cowpea tempe blanched dried (cowpea tempe powder)	0.23	76	91	1.06	57	>100

Table 4. Essential amino acid composition of cowpea flour and cowpea tempe powder (mg/gN)

Essential amino acid		Cowpea*	Cowpea flour	Cowpea tempe powder	FAO*
Isoleucine		417	328	380	250
Leucine		531	566	635	440
Lysine		414	547.2	584.4	340
Methionine + cystine		120	113	131.1	220
Phenylalanine + Tryosine		487	695	784.4	380
Threonine		250.9	273	277.8	250
Tryptophan		88.9	-	-	65
Valine		428	323	346	310
Limiting amino acid (chemical score)	Meth. + Cyst.	55	51	60	

* Data from FAO, 1973.

seen in Table 4. These values were compared with FAO provisional composition, all the values were higher than FAO values except for Methionine and cystine, an increase of about 9% was observed in the cowpea tempe flour although the value still lower. All the other amino acids showed increases although very small. A decrease in isoleucine was observed in cowpea flour as well as cowpea tempe powder though increase was observed between the two flour.

These results agreed with that of Djurtoft and Jensen (1977) and Omotala (1981) in their studies on cowpea tempe. The increase in the amino acid composition suggests an increase in the nutritive quality of cowpea and also the possibility of fortification of cowpea tempe powder with other legumes or cereals with high methionine and cystine content to raise its content to the required value (FAO, 1977).

Sensory Evaluation

In an attempt to evaluate cowpea tempe powder for acceptability in snack foods etc cowpea biscuits were prepared using cowpea tempe powder and cowpea flour the two were compared for appearance, color texture aroma and flavour, results of the test are shown in Table 5. Cowpea tempe powder were better prefered or accepted than the cowpea flour biscuits at $p > 0.05$ according to the reference test using simple paired comparisons test (according to chart 2 for two sample test in Larmound, 1977). Although this was highly accepted panelist did not like the appearance and color of the products. Although color and appearance were rated high for cowpea flour biscuits panelist complained of hardness in texture and a strong beany flavour. It would be premature to conclude that cowpea tempe flour used in preparation of snack foods and others would be accepted by Ghanaians as this is the ultimate aim of this evaluation, but the possibility of the substitution of cowpea tempe flour in the various recipes developed (Dovlo, et al, 1976; Randoph et al,1981) is confirmed, but then more work will have to be done to improve the appearance and color of these products.

Table 5. Taste panel scores assigned by Africans and seven Indonesians

Product	Appearance	Colour	Texture	Aroma	Flour
Cowpea flour biscuits	7.3*	7.7*	6.5*	6.9**	6.3**
Cowpea tempe powder (biscuits)	6.5*	6.0*	7.4*	7.6*	7.5*

* based on a 9 point scale with 9 = like extremely 5 = neither like or dislike, 1 = dislike extremely.

** when mean score within a given panel differ significance at (p = 0.05) level. Higher value indicate greater preference.

Conclusion

1. The processing of cowpea into cowpea tempe powder as against the Ghanaian traditional processing into cowpea flour is beneficial in terms of nutritional aspects.
2. Antinutritive factors which reduces the nutritional quality of foods is greatly reduced during this process, to levels which is nutritionally harmless.
3. Color of the tempe powder was slightly darker then that of the traditional cowpea flour (creamy white) this resulted in low score for appearance and color of cowpea tempe biscuits during sensory evaluation of the powder with that of cowpea flour.
4. Vitamins although heavily lost during processing was slightly higher in tempe powder as against cowpea flour.
5. Slight increases were observed in the amino acid composition of cowpea tempe over cowpea flour.

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References

1. AACC. 1974. "Approved Methods", 5thed. American Association of cereal chemists, St. Paul. MN.

2. AOAC, 1975. Official method of analysis. 13thEd. Association of Official Agricultural Chemists. Washington, DC.

3. AOACi 1984. Official method of analysis. 14thEd. Association of Official Agricultural Chemists, Washington, DC.

4. Akpapunam, M.A. 1985. Effects of blanching, soaking and cooking on HCN yields, Nitrogen, Ash and Minerals of Lima beans (Phaseolus lintus) J. of Food Science Vol.50, 1191-1192.

5. Akpapunam, M.A. and Markakis, P. 1981. Protein Supplementatiok of cowpea with sesame and watermelon seeds. Journal of Food Science, Vol.46, 960-961.

6. Bender, A.E. 1971. The fate of vitamins in food processing operations. In "vitamin" Pg.64 Churchill Livingstone. Edin. London.

7. Djurgoft and Jensen, S.S. 1977. Tempe like foods produced from broad beans (vicia faba) cowpea (Vigna sinensis), barley (Hordeum vulgar) wheat (Tricum destivum) or from mixtures. Symposium on Indigenous fermented foods, Bangkok, Thailand.

8. Dovlo, E.E., Williams C.E. and Zoaka, L. 1976. Cowpeas: Home preparation and use in West Africa I.D.R.C. 055c.

9. Elias, L.G., Fernandez, D.G. and Bressani, R. 1979. Possible effects of seed coats polypherols on the nutritional quality of beans protein. J. of Food Science Vol.44 No.2, 524-527. FAO, 1972, Food Composition Taste for Use in East Asia.

10. Ghang, R. 1977. Phytate: removal from whole dry beans by Enzymatic hydrolysis and diffusion. J. of Food Science, Vol.42 (4), 1098-1101.

11. Gyorgy, P.K., Murata K. and Ikehata, H. 1964. Antioxidant isolated from fermented soybeans (tempe). Nature 203, 570.

12. Hamerstrand,G.E., Black L.T. and Glover, S.D. 1980. Trypsin inhibitors in soy products: Modification of the standard analytical procedure Cereal Chem. 58 (1), 42-45.

13. Hermana and Soetedja. 1970. Advances in the preparation of tempe. A New method of preparing tempe. Gizi Indonesia 2 : 167.

14. Hermana, Sibarani, S. and Herlinda, S. 1972. Percobaan perbaikan campuran "Tempe fish Rice". Penelitian Gizi dan Makanan Jilid 2, 57-61.

15. Hesseltine, C.W. and Wang, HiL. 1967. Traditional fermented foods. Biotech., Bioeng. 9 : 275-288.

16. Ko Swan Djien and Hesseltine, C.W. 1979. Tempe and related foods In "Economic Microbiology" Vol.4i Academic Press, London.

17. Kumar, R. and Singh, M., 1984. Tannins: Their adverse Role in Ruminant Nutrition. J. Agric. Food Chem. 32, 447-453.

18. Larmond, E. 1977. Laboratory methods for sensory evaluation of food, Publication No.1637, Ottawa, Canada Department of Agriculture.

19. Laurena, A.C., Van Den, T. and Mendoza, E.M.T. 1984. Effects of undersed Tannins on the in vitro Protein Digestibility of Cowpea J. Agric. Food Chem. 32, 1045-1048.

20. Liener, I.E. and Kakade, L.M. 1969. Protease Inhibitors in "Toxic Constituents of plant foodstuffs". Pg.8, Academic Press, New York.

21. Longe, O.G. 1983. Varietal differences in chemical characteristics related to cooking qualitty of cowpeai J. Food Processing and Preservation 7, 143-150.

22. Lohas, G.M. and Markakis, P. 1975. Phytic acid and the other phosphorus compounds of beans (Phaseolus vulgaris). J. Agric. Food Chem. 23, 13.

23. Lund D.B., 1977. Effect of Blanching Posterization and Sterilization on Nutrients. In "Nutritional Evaluation of Food processing". Avi Publishing Company, Inc. 2nd Ed.

24. Murata, K., Ikehata, H. and Miyamota, T. 1967. Studies in the Nutritional value of tempe, J. Food Science 32, 550-586.

25. Narasinga Rao, B.S. and Prabhavathi, T. 1982. Tannin contents of Food commonly consumed in India. J. Sci. Food and Agric. (23) Pg. 89-96.

26. Obeleas, D. 1973. Phytates In "Toxicants Occuring Naturally in Foods". Pg.363 National Academy of Sciences Washintgon, DC.

27. Ologhobo, A.D. and Fetuga, B.L. 1984. The Effect of Processing on the Trypsin Inhibitor, Hemagg;utinin, Tannin Acid and Phytic Acid Contents of Seeds of Tek Cowpea varieties. J. Food processing and preservation (8), 31-42.

28. Omotola, D., 1984. Cowpea Tempe and its nutritional value. International course in Food Science and nutrition Wageningen.

29. Reddy, M.R., and Pierson, M.D., 1985. Dry bean Tannins: A review of Nutritional Implications. J. AOCS Vol.62 (3), 541-549.

30. Randolph, M., Dake, F., Owusu, E. and Mamuts. R. 1981. Formulation for utilization of cowpea flour. Food Research Institute ~~Alleka~~ Accra Ghana.

31. Singleton, V.L., and Kratzer, F.H. 1973. Plant Phenolics In "Toxic unstituents of Plant Foodstuffs". Pgi309. Academy of Sciences Washington, DC.

32. Steinkraus, K.H., Hand, D.B., Van Buren, J.P. and Hackler, L.R. 1961. Pilot plant studies in tempeh. Proc. Conf. Soybean Products for Protein in Human Food. Peoria Pg.83.

33. Steinkraus, K.H., Van Buren, S.P. and Hand, D.B. 1961. Studies in tempeh an Indonesian fermented soybeans food. Meeting the Protein needs of infants and children. Pus.849 Nat. Acad. Sci. Nat. Res. Council pp.275-279.

34. Sutardi and Buckle, K.A. 1985. Reduction of Phytic acid levels in soybeans during tempeh Production, storage and frying. J.Food Science Vol.50, 260-263.

35. Whitaker, J.R. and Feency, R.E. 1973. Enzyme inhibitors in foods In "Toxicants Occuring Naturally in Foods". Pg.276. National Academy of Sciences, Washington, D.C.

36. Zamora, A.J. and Fields, M.L. 1976. Nutritive quality of fermented cowpea (Vigna sienensis) and chick pea (Cicer ariatinum). J. of Food Science Vol.44 (1), 234-236.

APPENDIX

ORGANOLEPTIC EVALUATION RESULTS

APPEARANCE :

Judges	Samples 435	641	Total
1	6	8	14
2	5	5	10
3	8	8	16
4	6	7	13
5	9	9	18
6	4	8	12
7	7	7	14
8	5	6	11
9	8	7	15
10	7	8	15
Total	65	73	135
Mean	6.5	7.3	

ANALYSIS OF VARIANCE TABLE

Source of variation	dF	SS	MS	FCAL	FTable 5%	1%
Samples	1	3.2	3.2	3.2	5.12	10.56
Judges	9	25.8	2.8	2.8	3.23	5.46
Error	9	8.8	0.97			
Total	19	37.8				

No significant difference ik color among the samples.

COLOR

Judges	Samples 435	641	Total
1	7	8	15
2	4	7	11
3	7	8	15
4	6	7	13
5	8	9	17
6	4	7	11
7	6	7	13
8	6	8	14
9	7	8	15
10	6	8	14
Total	60	77	137
Mean	6.0	7.7	

ANALYSIS OF VARIANCE

Source of variation	dF	SS	MS	FCAL	FTABLE 5%	1%
Samples	1	14.45	14.45	32.1	5.12	10.56
Judges	9	16.05	1.78	8.9	3.23	5.46
Error	9	4i05	0.45			
Total	19	34.55				

There is a significant difference at 5% level.

TURKEY TEST RESULT

Samples code	641	435
Sample mean	7.7a	6.0b

Any two means not followed by the same letter are significantly different at the 5% level. Sample 641 las best color.

TEXTURE

Judges	Samples 435	641	Total
1	5	7	12
2	7	4	11
3	8	8	16
4	7	7	14
5	9	9	18
6	7	6	13
7	7	6	13
8	8	4	12
9	8	6	14
10	8	8	16
Total	74	65	139
Mean	7.4	6.5	

ANALYSIS OF VARIANCE

Source of variation	dF	SS	MS	FCAL	FTable 5%	1%
Sample	1	4.1	4.1	2.9	5.12	10.56
Judges	9	21.45	2.3	1.6	3.23	5.46
Error	9	13.4	1.4			
Total	19	38.95				

There is no significant difference in the texture of the two samples.

AROMA

Judges	Samples 435	641	Total
1	7	7	14
2	7	5	12
3	8	8	16
4	7	7	14
5	9	9	18
6	7	6	13
7	7	7	14
8	8	6	14
9	8	6	14
10	8	8	16
Total	76	69	145
Mean	7.6	6.9	

ANALYSIS OF VARIANCE

Source of variation	dF	SS	MS	FCAL	FTABLE 5%	1%
Samples	1	2.45	2.45	5.4	5.12	
Judges	9	13.25	1.4	3.1	5.23	
Error	9	4.05	0.05			
Total	19	19.75				

There is a significant difference at 5%.

TURKEY TEST

Sample code	435	641
Mean	7.6a	6.9b

Any two means not followed by the same letter are significantly different at 5% level. Sample 435 has the best aroma.

FLAVOR

Judges	Sample 435	Sample 641	Total
1	6	8	14
2	6	5	11
3	8	7	15
4	7	6	13
5	9	8	17
6	8	6	14
7	7	6	13
8	8	4	12
9	8	6	14
10	8	7	15
Total	75	63	138
Mean	7.5	6.3	

ANALYSIS OF VARIANCE

Source of variation	dF	SS	MS	FCAL	FTABLE 5%	1%
Samples	1	7.2	7.2	6.6	5.12	
Judges	9	12.8	1.4	1.2	3.23	
Error	9	9.8	1.08			
Total	19	29.8				

There is a significant difference at 5% level.

TURKEY TEST RESULTS

Sample code	435	641
Sample meak	7.5a	6.3b

Any two means not followed by the same letter are significantly different at 5% level. The sample 435 has the best flavour.

Amino acid composition of Cowpea Flour, Cowpea Tempe Powder

g/100g

Amino acid	Cowpea Flour	Cowpea Tempe Powder
Lysine	2.32	2.63
Histidine	1.02	1.20
Ammonia	1.41	.57
Arginine	2.38	2.63
Aspartic Acid	2.55	2.90
Threnonine	1.16	1.25
Serine	1.68	1.86
Glutamic Acid	5.76	5.87
Proline	1.52	1.67
Glysine	1.23	1.37
Alanine	1.58	1.83
Cystine	.11	.13
Valine	1.37	1.56
Methionine	.37	.46
Isoleusine	1.39	1.71
Leusine	2.40	2.86
Tryosine	1.01	1.29
Phekylalanine	1.94	2.24