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Processing and Utilization of Legumes in the Tropics

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1. Introduction

Legumes belong to the family *Leguminosae*. In the tropics, they are the next important food crop after cereals (37). They are sources of low-cost dietary vegetable proteins and minerals when compared with animal products such as meat, fish and egg (8). Indigenous legumes therefore are an important source of affordable alternative protein to poor resource people in many tropical countries (23) especially in Africa and Asia where they are predominantly consumed. In the developing countries, research attention is being paid to better utilization of legumes in addressing protein malnutrition and food security issues. Legumes can be classified as:

1. Pulses or grain legumes which are various peas and seeds that are low in fat content
2. Oilseeds such as soybean and groundnut
3. Forage leguminous crops such as *Mucuna pruriens*, *Psopocarpur tetragonolobus* (winged bean).
4. Swollen root or tuberous root consumed as vegetable or fresh salad such as *Pachyrrhisus erosus, P. tuberosus* so called as Yam bean. Yam bean in Indonesia is widely planted by farmers for cash crop with better income. The other species such as *Flemingia grahamiana, F. procumbent, Psoralea esculenta and Pueraria lobata* are still under-utilized.

The highlight of this chapter is on the pulses and the leguminous oilseeds. Different types of legumes grown are consumed in different tropical regions in the world. Legume growing areas in Tropical Africa include Nigeria, Senegal, Togo, Cameroun and Cote d'Ivoire and in Tropical Asia include Indonesia and India (9). Some legumes are commonly used as commercial food crops such as cowpea in West Africa while some are lesser known, neglected or underutilized outside their indigenous areas. Table 1 shows some of the legumes grown in the tropics. Underutilization can be due to the hard- to cook phenomenon in legumes and lack of information on potential food uses. Pigeon pea, African yam bean, lima bean and bambara groundnut are neglected or underutilized crops in many parts of tropical Africa.

Common name	Botanical names	Other names	Areas available / consumed
Cowpea	*Vigna unguiculata*		Asia, Tropical Africa, West Indies
Blackeyed pea	*Vigna sinensis*	Catjan cowpea, Hindu cowpea, Kaffir bean	Asia, Africa, West Indies
Soybean	*Glycine max*		America, Asia, Africa
Groundnut	*Arachis hypogaea*	peanut	Tropical Africa, Central and South America
Pigeon pea	*Cajanus cajan*	Red gram, Congo bean	West Africa, East Africa, Pakistan, Middle East, Asia
Lentils	*Lens esculenta, Lens culnaris*	Split pea, red dhal	Central America, India, North Africa West Asia
Mung bean	*Phaseolus aureus*		East Asia, East Africa
African yambean	*Stenostylis stenocarpa*		West and East Africa
Lima bean	*Phaseolus lunatus*	Sieve bean, butter bean	Central America, Africa, Tropical Africa
Faba bean	*Vicia faba*	Broad bean, horse bean, windsor bean	Africa
Kidney bean	*Phaseolus vulgaris*	Navy bean, pinto bean, snap bean, black bean, haricot bean, pea bean	East Africa, Latin America
Chickpea	*Cicer ariethinum*	Lathyrus pea, grass pea, Khesari pea, Chickling pea	India, Pakistan
Lathyrus pea	*Lathyrus sativus*		
Bambarra groundnut	*Vigna subterranea*		Tropical Africa
Jack bean	*Canvalia ensiformis*		
Winged bean	*Psophacarpus tetragonolobus*		Tropical Asia, South East Asia

Reference (23)

Table 1. Common legumes grown in the tropics

2. Nutritional, health and economic Importance of legumes

Legumes are rich in protein and their chemical composition varies depending on variety, species and region (24). Table 2 shows the chemical composition of some tropical legumes. The protein content of legumes is twice or triple that of cereals depending on the type of the legume. The protein of legumes though adequate in essential amino acid lysine is however deficient in sulphur containing amino acids methionine and cystine (19). Legumes, however, form good supplements for cereals which are lacking in essential amino acid lysine. Improved nutritional quality can therefore be achieved by combining legumes with cereals.

Most legumes are low sources of fat with the exception of soybean and groundnut. Legumes are also good sources of different minerals such as calcium and phosphorus (24). The bioavailability of these minerals can be improved through processing. Legumes contain anti-nutritional factors such as lectins, saponin, haemagglutin, protease inhibitor, oxalate, goitrogen, phytates, trypsin inhibitor and tannin (8). These compounds reduce protein digestibility and availability. Some anti-nutritional factors in legumes have been reported to have health benefits. Tannin, a polyphenolic compound is reported to possess antioxidative activity (4). Raw legumes have higher content of anti-nutritional factors but can be eliminated or reduced by processing. Legumes are also good sources of carbohydrates, minerals, dietary fibres and water soluble vitamins which are important in human health. Dietary fibre consists of indigestible polymers which are made up of cellulose, hemi-cellulose, pectin and lignin. They provide bulk in natural food and are resistant to hydrolysis by enzymes in the alimentary tract (18). Dietary fibre is important in aiding absorption of water from the digestive track. It also has health benefits such as lowering of blood pressure and serum cholesterol, protection against cardiovascular diseases, diabetes, obesity and colon cancer (36). Legumes also have complex sugars such as raffinose and starchyose which are responsible for flatulence. Legumes are important both in human and animal nutrition especially in tropical Africa where they are more consumed (11). Legumes are processed into various semi- finished and finished products (29). Retailed legume products serve as a means of economic empowerment for individuals which also help to boost the national economy of some countries.

Legumes	Protein	Fat	Carbohydrate	Fibre	Ash
Soybean	37-41	18-21	30-40	4-6	4-5
Cowpea	22-26	1-2	60-65	4-5	3-4
Groundnut	20-33	42-48	22-25	3-4	2-3
Hyacinth bean	24-28	1-2	65-70	7-9	4-5
Common bean	20-27	1-2	60-65	4-5	4-5
Pigeon pea	15-29	1-3	60-66	5-10	3-4
Lima bean	19-25	1-2	70-75	4-6	3-5
Winged bean	30-40	15-20	35-45	6-7	3-5
Bambara groundnut	16-18	6-8	50-57	3-6	3-4

Reference (9)

Table 2. Chemical composition of some legumes (g/100g)

3. Legume processing

One major way of utilizing legumes is through food processing. Food processing involves techniques of converting raw materials into semi-finished and finished products that can be consumed or stored (23). Food can be processed at different levels including home-based food processing and at industrial level. Industrial food processing could be at the cottage level or on a large scale. The advantages of legume processing include:

- transformation of raw produce into edible forms
- improving digestibility of foods

- improving the nutritional quality of foods
- reducing and eliminating anti-nutritional factors
- improving consumer appeal and acceptability of foods
- destruction of food enzymes causing food spoilage thus extending shelf-life
- deactivation of spoilage and pathogenic microorganisms in the food products
- serving as a means of income generation

3.1 Unit operations in legume processing

Common legumes grown in the tropics include cowpea, soybean, pigeon pea, African yambean, bambara groundnut, kidney bean, lima bean etc (7, 14). Right from harvesting of the pods from the field, the seeds of these legumes pass through common post-harvest processes to obtain the dried seeds (9). The dried seeds are further processed into semi-finished or finished products through several processing steps called unit operations. Different unit operations are intended to fulfill different purposes (33).

3.2 Primary unit operations in the processing of legumes

3.2.1 Sundrying

Raw mature grains at harvest are at about 20% moisture content and are subject to spoilage unless dried. They come in long husk or pods which are removed by hands or mechanically. In some areas, grain legumes are steeped in water for hours (2-8 hours) before sun-drying. Seeds are dried on raised platform. In some other cases, grains are treated with oil before drying. The purpose of steeping and oil treatment is to aid dehusking process.

3.2.2 Husking

This process is also called hulling. Husking can be done by dry method or the wet method. Traditionally in African and Asian countries, the dry method involves pounding of the dried grains in mortar with pestles or in hand- operated wooden or stone sheller. Improved power-operated shellers have been designed and abrasive hulling machines have also been developed to improve the hulling process. Wet grinding process for husking involves soaking of the grains before drying. Improvement in husking process has been done through conditioning techniques through moisture adjustment to allow easy husking.

3.2.3 Winnowing

The separated husks are removed from the cotyledons by winnowing. Winnowing can done manually which is time consuming and laborious. Improved abrasive hulling machines which separate husk form cotyledons have been developed.

3.2.4 Seperation

This process is used to remove or separate whole grains from split, broken and powdery ones. It is done manually using sieves or mechanically with machines designed with a sieving device. Sieving manually is laborious and time consuming.

3.2.5 Storage

Proper post-harvest handling of legumes will prevent both qualitative and quantitative losses. It is important that legumes should be dried to safe moisture level of 12-14% to ensure good storage. Table 3 shows the safe moisture content of some tropical legumes. Dried seeds with high moisture content have increased the rate of mold attack and infestation. Dehulled seeds are often dried to a safe moisture level. Milled seeds are packaged and stored under dried conditions that will not allow absorption of moisture thereby leading to spoilage (33).

Legumes	Safe moisture content (%)
Broad bean, cowpea, kidney bean,white bean	15.0
Lentil, pea	14.0
Groundnut (shelled)	7.0
Soybean	13.0

Reference (22)

Table 3. Safe moisture content of some legumes

3.3 Secondary processing of legumes

3.3.1 Sorting and cleaning before use

Legumes are sorted and cleaned to remove dirts, stones, chaff, broken and spoilt seeds and other foreign materials. Sorting is done by hand sorting which is laborious and time consuming or through mechanical or electronic sorting device. Cleaning can be done by dry or wet methods. Dry cleaning is intended for grain legumes meant for storage purpose. Wet cleaning is usually done by washing with water.

3.3.2 Soaking

Different seeds are soaked in water for different periods of time. Soaking in water allows the seeds to absorb water, to decrease and eliminate anti-nutritional factors in legumes. However, soaking for long periods of time has been found to reduce nutritional quality of legumes through leaching of nutrients into the soak water (35).

3.3.3 Blanching

Blanching is a mild heat treatment of seeds. Legumes are usually blanched by soaking in hot water or boiled in water for few minutes. This process destroys food enzymes and some anti-nutritional factors in the legumes. Blanching can also aid the dehulling process.

3.3.4 Boiling / cooking

This process improves the appeal and sensory properties of legume. Boiling is usually at 100^0 C for some minutes. It tenderizes the seeds through water absorption. Traditionally, cooking of beans can be done using firewood. Pressure cooking pots allows legumes to be cooked under pressure and it reduces cooking time. This process eliminates heat labile anti-nutritional factors such as trypsin inhibitors (10).

3.3.5 Roasting

Legumes are roasted on the open frying pan in the presence or absence of salts or ash. Roasting improves the taste and edibility of legumes. It is important also in reducing and eliminating anti-nutritional factors. Roasted legumes are characterized by unique flavours which can increase their sensory appeal.

3.3.6 Fermenting

The process increases the digestibility of plant proteins and also reduces the anti-nutritional factors. Fermentation enhances flavour, colour and texture of legumes. Changes in these attributes are major stimuli in development of legume fermented products. It reduces heat stable anti-nutritional factors such as phytate. Fermented legumes are consumed as condiments e.g fermented locust bean (*iru*).

3.3.7 Germinating

Germination enhances desired qualities such as improved digestibility, reduced anti-nutrients like trypsin inhibitors (3). It improves nutritional quality of the proteins by hydrolyzing them into absorbable polypeptides and essential amino acids. Germinated or malted legumes are eaten in form of sprouts and are better than ungerminated ones. Sprouting improves the availability of vitamins B and C. It also reduces polyphenols content. Chicken pea and broad beans are commonly germinated before eating, cooking or use in salad dressing.

3.3.8 Milling

Dehulled legumes may be wet-milled or dry-milled. Milling is a size reduction process of the seeds into smaller particle forms. Wet-milling of seeds will produce a paste while dry–milling results in flour production. Different types of equipment have been designed for milling for household or industrial purpose. Wet milled legume may be mixed with other ingredients and steamed in leaves to produce pudding (*moinmoin)* or fried in hot oil to obtain bean cake (*akara*). The rehydrated flour maybe used to obtain these products

3.3.9 Sieving

Sieving removes unwanted materials from whole ground legume seeds (dry or wet). Example of wet sieving is in the filtration of ground soybean paste in the production of soymilk. The sieving process removes the unwanted residue called *okara*. For the dry-milled legume flour, sieving helps to achieve different ranges of particle sizes. Wet sieving can be done using cheese-cloth or muslin cloth while dry sieving can be done with different kinds of local or standard sieves. Some milling equipment have sieving devices incorporated into the design.

3.3.10 Frying

Several legumes are wet milled, mixed with other ingredients in preparing different local or oriental dishes. Frying improves the appeal and eating quality of legumes. It also improves digestibility and reduces anti-nutritional factors (1).

3.3.11 Canning

This is a sophisticated technology of packaging cooked beans in cans. The packaged beans are usually in brine, sugar or tomato purees. This technology allows for all year round availability of the product and for food preservation. Legumes processed in this form are however expensive.

4. Household utilization of some tropical legumes

4.1 Cowpea

Cooked beans: This can be in the form of cooked whole beans or cooked dehulled beans. Whole beans take longer period of time to cook than dehulled beans. Whole beans are boiled for about 45 to 60 minutes on the cooking stove or gas cooker depending on the hardness of the hull at household level. It is eaten whole or mashed. It used in or may be eaten alone or in combination with other food products like bread, *gari*, boiled yam with vegetable soup or fish meat sauce. Cooked dehulled beans reduce flatulence and is an excellent meal for both children and adults. The whole cooked bean can also be made into bean porridge by adding other ingredients such as palm oil, salt, pepper, onion and spices. Cooked beans prepared for income generating purpose are usually cooked with firewood which imparts a characteristic flavour. This, however, has its occupational hazards to processors. Long term effect of wood smoke in contact with eyes has its health and cost implications (17). Modern cooking methods also involve the use of locally fabricated cooking gas equipment at the commercial level.

Bean soup: In this food preparation, beans are washed, soaked, dehulled , boiled, mashed and sieved. The sieved beans is then cooked with palm oil along with other ingredients such as pepper, spices and seasoning with or without fresh or dried fish to taste to produce *gbegiri*. It is eaten with reconstituted yam flour product *amala.*

Bean cake and pudding: beans are washed, soaked, dehulled and milled into paste. In making the bean cake, the paste is mixed to a fluffy texture by trapping in air. Other ingredient such as onion and pepper are milled with the dehulled beans and the paste is fried with oil. Among the Yorubas of Nigeria , this product is called *akara* while the steamed pudding is called *moinmoin*. The pudding however is mixed with other ingredients that include vegetable oil. Traditionally, the mixture is packaged in leaves and steamed. Steaming of the pudding however today may be done in stainless steel cups. Some local processors use polyethylene bags in steaming the paste. Use of polyethylene bag is however being discouraged due to leaching of the chemicals in the package into the product which may lead to future health complications. Bean cakes and pudding are excellent diets that are usually consumed with fermented maize gruel *ogi, bread, gari, eko, or just on its own.* Bean cake and pudding are usually consumed as a breakfast meal, but they can also be consumed during lunch and supper too. They are considered as light meals.

4.2 Soybean

This has been known as an excellent source of protein, fat and minerals especially calcium. Soybean also has its unique characteristics in that it can be processed into a number or variety of products. Many economically challenged families in Nigeria utilize soybean processing as a means of income generation for household as well as ensure food security.

Soymilk: This is a popular soybean product rich in protein, fat and minerals. It is usually processed by soaking soybean in water, followed by milling, sieving, boiling and adding ingredients such as sugar and desired flavours to taste. A common hindrance or limitation to soymilk consumption is the beany flavour. However, research efforts have been conducted to reduce the beany flavour and obtain a better tasting and acceptable product. Soy-corn milk is another product from a blend of fresh sweet corn and soymilk to improve the nutritional quality of soymilk (31).

Soy cheese: This in the Orient is called *tofu*. In Nigeria, the local name is *soya-wara* or *soy-warankasi*. It is a highly digestible product that is good for people suffering from lactose intolerance. Locally, it is processed by first preparing soymilk and further precipitating the milk with a coagulant. Different cheap locally sourced coagulants have been used in soy cheese processing. This includes the enzyme based *Calotropis procera* leave water extract or acidic based lime juice, lemon juice, fermented maize water liquor (32, 28). Fermented maize water liquor is the most common type. Some local processors also use alum. Calcium salts are not usually used due to the cost implication.

Tempeh: This is a soy product that orginated form Indonesia. It is made from whole soybean seeds which are soaked, dehulled and partly cooked. Spores of *Rhizopus oligoporus*, used a s fermenting culture is mixed with the seeds. The seeds are spread thinly on a tray and allowed to ferment for 24 to 36 hours at 30^0 C. Good *tempeh* is characterized by proper knitting together to have a firm texture. This can be cut, soaked in brine or salty sauce and then fried. *Tempeh* has also been processed from other types of beans or mixture with whole grains. Figure 1 shows the pod of climbing beans, the mature seeds and the processed beans made into *tempeh*.

Fig. 1. Common climbing beans from young pod to matured seeds which can be used as vegetable, old seeds may be processed into *tempeh* mixed or supplemented with soybean.

Soy yoghurt: Yoghurt is a fermented milk product produced from mixed culture of *Lactobacillus bulgaricus and Streptococcus thermophillus* (6). Soy yoghurt is processed from

soybean which is quite cheaper than yoghurt from milk. It is a good source of protein and minerals.

Soy sauce: This is a condiment common in East and South East Asia. It is processed by fermenting soybean seeds with two molds of *Aspergillus oryzae* and *Aspergillus soaje* in the presence of salt and water. The fermentation process yields a product called *Moromi* which is pressed to obtain a liquid called soy sauce. Soy sauce is also called *Miso* which may also be prepared from rice or barley.

Natto: This product is traditional to the Japanese. Soybean seeds are soaked in water for 12 to 20 hours. The seeds are fermented with *Bacillus subtilis* at 40^0 C for 24 hours. The product is cooled and aged in the refrigerator for a week.

4.3 Groundnut

Boiled and roasted groundnut: In some West African countries, groundnuts are cooked with the pods to get the cooked/ boiled groundnuts while shelled or unshelled groundnut are usually roasted. The shelled groundnut can be roasted in the presence or absence of salt. This can be consumed directly. Roasted groundnuts can also be grounded into powder and used in the preparation of sauce or as ingredients in other food dishes.

Peanut butter: This is usually used as sandwich spread. Groundnuts also called peanuts are dry roasted and ground into a smooth paste. Stabilizers in form of partial or complete hydrogenated vegetable oil, sweetener, spices, emulsifier and salt are also added.

4.4 Fava beans

Roasted fava beans: fava beans are cleaned, roasted at about 200^0 C for 20 minutes, cooled and packaged. The roasted beans can be consumed directly as snack or used as raw ingredient in gruel preparation

4.5 Chickpea

This can be processed into split legume called *kikk* in Ethiopia. This is used in producing a traditional sauce. This can be used in eating with local staples like *injera,* a cereal based product.

4.6 African locust bean

Dawadawa: Fermented African locust bean is called dawadawa or Iru . Dawadawa is generally processed from fermented oilseed called African locust bean (2, 27). This product is a traditional Nigerian condiment. The seeds are cooked,dehulled, spread thinly in containers usually calabash lined with leaves and fermented for 24-36 hours. African locust bean seeds are very hard to cook. Traditionally they are cooked overnight over firewood. Dawadawa has characteristic ammoniacal smell with its unique flavour in dishes. Dawadawa is used as natural seasonings in preparing soups, stews and traditional delicacies. Dawadawa has been processed also from other legumes such as soybean, bambara groundnuts and pigeon pea seeds (2, 25).Table 4 shows fermented products from different legumes.

Legume	Condiment	Predominant micro organisms	Optimum fermenting conditions
Soybean	Soy sauce or miso	*Aspergillus oryzae Aspergillus soaje*	-
Soybean	*dadawa*	*Bacillus subtilis, B. licheniformis*	3 days 35^0 C
African locust bean *(Parkia biglobosa)*	*dadawa*	*Bacillus spp, Staphyloccous aureus*	3 days, 35^0 C, pH 7-9
Bambara groundnut	seasoning	*Staphylococcus sp, Streptococcus sp ,Enterococcus sp*	3 days, 37^0 C, pH 7.8
Pigeon pea	seasoning	-	3 days,37 ^{0}C, pH 7-
African oil bean (*Pentraclethra macrophylla*)	*ogiri*	*Bacillus spp, Staphylococcus sp, Micrococcus sp*	3 -5 days, 30-33 ^{0}C, pH 5-8.7

References (2, 25)

Table 4. Fermented legumes and oilseeds used in preparing traditional condiments

5. Industrial products from legumes

5.1 Flours

Legumes are multi-purpose crops. At the household, cottage and large scale level, flours have been processed from different types of legumes. This has added to household convenience. Due to changing trends in consumer demands for more convenient products. Research studies have been geared towards developing innovative products from legumes. Many people working outside of their homes desire foods that can be easily prepared. Cowpea, soybean, pigeon and African yam bean seeds have been processed into flours (5, 16, 25). The common unit operations involved in flour production include washing, soaking, dehulling, drying , milling, sieving and packaging. Flours have been developed into different household recipes such cake, cookies, kokoro (20, 30) with comparable sensory attributes with products from fleshly prepared legumes. Composite flours have also been developed from cereals and tuber crops mixed with legume flours. In Africa, cowpea is the most popular legume (9). Cowpea flour is usually rehydrated and utilized in formulations as desired.

5.2 Vegetable oils

Vegetable oils are usually produced from soybean and groundnut more at the industrial level than at the household level. These oils contribute to gross domestic products and foreign exchange earnings in vegetable oil producing countries (21). Groundnut has about 42-48% oil content and soybean has about 18-21% (21) which are extracted locally by means of mechanical presses. Refining of expressed oil in Nigeria is still rudimentary. Cake from the expressed seeds is used as animal feed and that of groundnut is fried to produce *kulikuli* a snack commonly eaten by children. Cake from melon seeds are used in producing *robo* a fried snack.

5.3 Legume protein isolates

These are concentrates which have versatile functionalities (24). Soy protein isolate is a common isolate. It has high protein content of about 90%. It is made of defatted soy meal by removing most of the fats and the carbohydrates. Soy protein isolate is usually combined with other food ingredients such as minerals, vitamins and flavours in preparation of soy protein shake powder. Protein isolates have also been developed from a variety of legumes such as pinto and navy beans (34).

6. Limiting factors to household utilization of legumes

The hard- to -cook phenomenon due to the hard testa of some of the legume has led to long cooking times and utilization of more fuel during preparation. This led to under-utilization of legumes (12). The presence of anti-nutritional factors such as phytates which affect digestion and cause flatulence have also limited consumption of legumes by people. Research studies have shown that removal of the outer testa will reduce some of these effects. Dehulling process can be laborious and time consuming for hard testa seeds especially for cottage or large processing. Research efforts should however be geared towards improving the utilization of legumes to achieve improved nutritional status.

7. Legume processing and Income generation

In a developing country like Nigeria , legume processing into products like soymilk, soy cheese, cowpea cake and puddings are common income generating activities. The processing is usually carried out by women. This food processing activity plays a vital role in the survival and sustenance of their household and in meeting domestic financial obligations. However, these products are usually prepared under poor sanitary conditions. These processors need to be trained on improved processing methods and food safety practices (17). Processing techniques at the household or cottage level for processing needs to be upgraded. This to enhance productivity in terms of yield and quality to ensure food security, income generation and food safety especially in the developing countries. The following highlighted points below are important areas of focus for improvement.

7.1 Need for improved appropriate processing facilities

Equipment utilized in household and local processing needs to be upgraded to allow for increased productivity, reduced drudgery and efficient time management.

7.1.1 Improved product quality and safety

Most household and cottage processing activities in the tropics are usually carried out without product quality control. There is no standardization of product quality. Many local processors also produce under non-hygienic conditions. The products from different process batches have slight differences in product quality. This is due to lack of measurement of quality parameters during processing. Most operations are done using subjective judgments e.g hand feeling to estimate temperature, ingredients added to the taste of the processor (not according to a standard formula) etc. Local processors need to be sensitized and trained on the benefit of ensuring consistent quality products for increased income generation.

7.1.2 Improved shelf-life of freshly processed legume products

Dried low moisture semi-finished legume products like flours have excellent keeping qualities at ambient condition when stored away from moisture. However, the freshly prepared products such as soymilk, soy-cheese, bean pudding and cakes have short shelf-life of about a day or two at ambient condition. Dried and fried soy-cheese samples have better shelf-life of about a week in comparison with the freshly prepared products. Research studies need to be conducted be conducted on developing low cost techniques for extending the shelf-life of these products. Refrigeration, freezing and sophisticated preservative techniques which have high cost implication are usually not adopted by local processors.

7.2 Need for improving nutritional quality of local staples

Legumes are important foods in addressing protein – energy malnutrition concerns in developing countries. They contain the essential amino acid lysine which is deficient in cereals. On the other hand, cereals contain amino acid methionine which is limiting in legumes. Legumes can be supplemented with cereals to give a balance of amino acid called protein complementation. Flours are important improved products from legumes. They can be utilized in fortification of local staples to form composite flours like maize –soybean flour, cassava-soybean flour, maize-cowpea flour, cassava-cowpea flour, maize- pigeon pea flour, cassava-pigeon pea flours. The flours have been used in developing different types of recipes such as snacks and different nutritionally improved diets. There is still the need to develop novel food recipes from such composite flours to increase nutrient diversification.

7.3 Need for value addition through proper packaging

Dried legume seeds in the tropics are usually sold in the market places using different measuring weights which can indicate inconsistency in size. Proper packaging , labeling and branding are important considerations that local processors can add to boost sales for supermarket and export i.e pre-packaging. It minimizes time wastage, ensures uniform packed weights, eliminates access by rodents in the store, facilitates quick shopping but requires trust on the part of the buyers or consumers.

7.4 Need to explore the processing of underutilized legumes

Food security has been described as the availability, affordability and accessibility to nutritious, wholesome and safe food at all times (13). However, in Africa, many people are living below the poverty line of a dollar a day. Neglected legumes that are not commonly consumed due to the hard-to-cook phenomenon and lack of adequate knowledge on ways of utilization are usually regarded as underutilized legumes. Such include pigeon pea, African yam bean, bambara groundnut, lima bean etc. There is the need to improve the dehulling process of legumes with hard testa. To combat food crisis and poverty in the world, intensive research studies on the underutilized crops as a means to mitigate against global food insecurity need to be conducted. Many underutilized legumes grow well in tropical and sub-tropical countries in Africa, but the impeding need is the capacity to carry out intensive coordinated research studies in these countries in order to improve their utilization as food for improved nutritional status.

8. References

[1] Abd El-Moniem G.M., Honke J. and `Bednarsaka A. (2000). Effect of frying various legumes under optimum conditions on amino acids, in vitro protein digestibility, phytate and oligosaccharides. *Journal of Science of Food and Agriculture*, 80:57-62.

[2] Achi O. K. (2005). Traditional fermented protein condiments in Nigeria. *African Journal of Biotechnology,* 4: 1612-1621.

[3] Ahmed F.A., Albel Rahim E.A., Osama M.A., Volker A.E and Corinna L. (1995). The changes in protein patterns during one week germination of some legumes seeds and roots. *Food Chemistry,* 52: 433-43.

[4] Amarowicz R. and Pegg R.B (2008). Legumes as a source of natural antioxidants. *European Journal of Lipid Science and Technology*, 110:865-878.

[5] Ashaye O.A, Fasoyiro S.B and Kehinde R.O (2000). Effect of processing on quality of *Ogi* fortified with full fat cowpea flour. *Moor Journal of Agricultural Research,* 1: 115-122.

[6] Ashaye O.A., Taiwo L.B., Fasoyiro S.B. and Akinnagbe C.A (2001). Compositional and shelf-life properties of soy-yoghurt using two starter cultures. *Nutrition and Food Science,* 31: 247-250.

[7] Apata D.F. and Ologhobo A.D (1994). Biochemical evaluation of some Nigerian legumes seeds. *Food Chemistr*y, 49:333-338.

[8] Apata D.F. and Ologhobo A.D. (1997). Trypsin inhibitor and the other anti-nutritional factors in tropical legume seeds. *Tropical Science*, 37:52-59.

[9] Borget M. (1992). Food Legumes. Technical Centre for Agricultural and Rural Cooperation, Wageningen, The Netherlands.

[10] Bishoi S. and Khetarpaul N. (1993). Effect of domestic processing and cooking methods on in-vitro starch digestibility of different pea cultivars (*Pisum sativum*). *Food Chemistry,* 47:177-182.

[11] Burkill, H. M. (1995). The Useful Plants of West Tropical Africa. Second Edition, Volume 3, Families J-L. Royal Botanical Garden, Kew, United Kingdom.

[12] El-Taby Shehata A.M. (1992). Hard-to-cook phenomenon in legumes. *Food Reviews International*, 8:191-221.

[13] FAO (1997). Guide for the conduct of the constraints analysis component. Special Programme for the Food Security, Handbook Series, SPFS/Doc/18. Rome, Italy.

[14] Fasoyiro S.B., Ajibade S.R. , Omole A.J. , Adeniyan O.N. and Farinde E.O. (2006). Proximate, mineral and anti-nutritional factors of some underutilized grain legumes in South- Western Nigeria. *Nutrition and Food Science,* 38:18-23.

[15] Fasoyiro S. B., Obatolu V.A, Ashaye O.A., Adeojo F.A. and Ogunleti D.O. (2009). Chemical and Sensory qualities of pigeon pea (*Cajanus cajan*) developed into a local spice dawadawa. *Nigerian Food Journal*, 27: 150-159.

[16] Fasoyiro, S.B, S.R Akande, K.A Arowora, O.O Sodeko, P.O Sulaiman, C.O Olapade and C.E Odiri (2010). Physico-chemical and sensory properties of pigeon pea (*Cajanus cajan*) Flours. *African Journal of Food Science,* 4:120-126.

[17] Fasoyiro, S.B., Obatolu, V.A., Ashaye O.A., and Lawal B.O. (2010). Knowledge Assessment, Improved Storage Techniques and Training of Local Processors and Vendors of Soy Products on Food Safety Practices in South West Nigeria. *Journal of Food and Agricultural Information,* 11: 340-350.

[18] Fennema O.R. (1996). Food Chemistry. Third edition. Taylor and Francis, Newyork. Pg 218-220.

[19] Friedman M. (1996). Nutritional value of proteins from different food sources: a review. *Journal of Agricultural and Food Chemistry*, 44: 6-21.

[20] Granito M., Valero Y. and Zambran R. (2010). Baked product development based on fermented legumes and cereals for school children . *Archivos Latinoamericanos de Nutritcion*, 60:85-92.

[21] Hawkes C. (2006). Uneven dietary development: linking the policies of globalization with the nutrition transition, obesity, and diet-related chronic diseases. *Globalization and Health* 2:4.

[22] Hayma D. (2003). The storage of tropical agricultural products. Fourth edition. STOAS Digigraf. Wageningen, The Netherlands.

[23] Ihekoronye A.I. and Ngoddy P.O. (1985). Integrated Food Science and Technology for Tropics. Macmillan Publishers Ltd. London. 284p.

[24] Liu, K. (1997). Soybeans, Chemistry, Technology and Utilization. Chapman and Hall, USA. Pg 532.

[25] Obatolu V.A., Fasoyiro S.B. and Ogunsumi L.O (2007). Functional properties of yam beans . *Journal of Food Processing and Preservation*, 31:240-249.

[26] Obatolu V.A. (2008) Effect of different coagulant on yields and quality of tofu from soymilk. *European Food Research Technol*ogy, 226: 467-472.

[27] Odunfa S.A (1983). Carbohydrate changes in fermenting locust bean during preparation. *Plant Foods Human Nutrition*, 32: 1-10.

[28] Okoruwa A.E. (1999). Nutritional value and uses of food legumes in Africa. Paper presented at the legume breeding workshop International Institute of Tropical Agriculture, Ibadan, Nigeria, 27 September-8 October, 1999.

[29] Ojimelukwe, P.C. (2009). Sourcing and Processing of Legumes. In: Nigerian Agro Raw Materials Development, Volume 1: Some Industrial Crops and Salient Issues (P. A. Onwualu, S. C. Obasi and U. J. Ukpabi editors). Raw Materials Research and Development Council, Abuja.

[30] Omueti O. and Morton I.D. (1996). Development by extrusion of soyabari snack sticks: a nutritionally improved soya-maize product based on the Nigerian snack (Kokoro). *International Journal of Food Sciences and Nutrition*, 47, 5-13.

[31] Omueti O., Oguntona E.B., Jaiyeola O. and Ashaye O.A. (2000). Nutritional evaluation of home-level prepared soy-corn milk- a protein beverage. *Nutrition and Food Science*, 30:128-132.

[32] Omueti O. and Jaiyeola O. (2006). Effects of chemical and plant coagulants on yield and some quality attributes of tofu. *Nutrition and Food Science*, 36: 169-176.

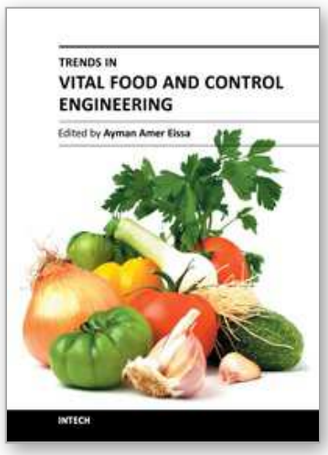
[33] Potter N. N. and Hotchkiss J.H. (1998). Food Science. 5th edition. Springer USA. 608p.

[34] Seyam A.A., Banank O.J. and Breen M.D. (1983). Protein isolates from navy and pinto beans: their uses in mararoni products. *Journal of Agricultural Food and Chemistry*, 31:499-502.

[35] Taiwo K.A. (1998). The potential of cowpea as human food in Nigeria. *Food Review International*, 14:351-370.

[36] Ubom D.E. (2007). Nutrition, health and our environment. Sendina limited, Nigeria. Pg 140.

[37] Uzoechina O.B. (2009). Nutrient and anti-nutrients potentials of brown pigeon pea (*Cajanus cajan* var bicolor) seed flours. *Nigerian Food Journal*, 27: 10-16.



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This book is an example of a successful addition to the literature of bioengineering and processing control within the scientific world. The book is divided into twelve chapters covering: selected topics in food engineering, advances in food process engineering, food irradiation, food safety and quality, machine vision, control systems and economics processing. All chapters have been written by renowned professionals working in food engineering and related disciplines.

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