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Soybean: Africa's Potential Cinderella Food Crop

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1. Introduction

Soybean (*Glycine max* [L.] Merrill) is an important oriental crop whose agronomic characteristics were apparently well known in China before 2200 BC. It is a legume that grows in tropical, sub tropical and temperate climates. Originally domesticated in China around 1700-1000 BC, soybean is now cultivated throughout East and South East Asia where people depend on it for food, animal feed and medicine. Soybean reached North America in 1765 via London, and Africa through missionaries in the early 19th century (CGIAR, 2005).

The fact that soybean is fastly becoming the 'toast' of many countries beside China is not in doubt. However, this cannot be rightly said of African countries as a whole. According to FAO data of 2005, 95.2 million ha of land were used for soybean cultivation worldwide and total production was 212.6 million tones. The three major soybean-producing countries were USA (29 million ha), Brazil (23 million ha) and Argentina (14 million ha). Seed production from the cultivated hectares of land were 83, 51 and 38 million tones for USA, Brazil and Argentina respectively. In a strong contrast, the same source revealed that in the whole of Africa, soybean was grown on an average of 1.16 million ha with an average production of 1.26 million tones.

Malnutrition and food insecurity are not being eradicated fast enough; in Africa, they are on the increase. The resources to significantly reduce this tragedy are not that large (Hadad & Martorell, 2002). Already, it is projected that Sub Saharan Africa, with its combination of high population growth and lagging economic performance, the number of malnourished children is expected to increase by six million compared with 1997 (Rosegrant & Meijer, 2002). As it has been earlier opined that resources to tackle the menace of malnutrition is not all that large in Africa, there is a need for critical analysis of what Africa has, and how best it could be utilized, in surmounting the hydra-headed problems of hunger and malnutrition which incidentally constitute the major African challenges.

Considering both Africa's climatic and edaphic factors, tropical soybean varieties can be cultivated in about half of Africa's land. In addition, there is a greater possibility with the introduction of newly developed IITA genetically modified drought tolerant soybean. On the understanding of the well established soybean's medicinal and food values, incorporation of soybean into Africans' diet is a sure way of stemming the tide of malnutrition in Africa. The present review article is focusing on the role of soybean in tackling the menace of malnutrition in the past, present and future Africa.

2. Soybean improvement programme in Africa

In 1908, soybean seeds (which were sourced from Manchuria) were found to be suitable replacement for linseed and cottonseed in the city of Hull, Great Britain. However, subsequent to Sino-Japanese war (which Japan won), Britain, which owned many colonies in Africa, decided to test systematically, the ability of soybeans to produce good yields in British colonies. Sir Alfred Jones and Mr. Grenville Turner were the leader of the British expedition. Incidentally, in the year 2007, the five leading soybean producers in Africa namely Nigeria, South Africa, Uganda, Zimbabwe and Egypt all have strong historical ties to Great Britain (Shurtleff & Aoyagi, 2009). However, it is worthy of note that the introduction of soybeans into Africa was characterized with many pitfalls such as no or poor germination, crop failure after germination and low yields. For instance, in 1908, soybeans planted on 1.35 acres at Moor Plantation, Ibadan, Nigeria failed. While still recounting on Nigeria's soybean experience, Ezendinma (1964), reported that in 1937, ten varieties were obtained from USA and one each from Malaya and British Guiana. Of these, only one US variety, Oootan, the Malayan and Creole from British Guiana survived; the rest either failed to germinate in the first planting. Furthermore, in 1940 more introductions were made from Philippines and Trinidad. It was also reported that eight varieties were introduced from Southern Rhodesia in 1942, and in 1949 a total of eleven varieties were brought into Nigeria from India, Ceylon and the Philippines. The sudden change in ambient temperature in transit was thought to be responsible for the rapid deterioration of the embryos and the subsequent failure of the seeds to germinate (Ezendinma, 1964). However, later advances in scientific knowledge pointed to other directions as *Bradyrhizobium japonicum* populations required for effective nodulation of soybeans are found to be non-endemic to African soils (Hadley & Hymowitz, 1973). Also, in the 1970s, there was a little interest and effort in Africa to grow and improve soybean because of extremely low yields and seed viability, high shattering rate and limited postharvest use.

Consultative Group on International Agricultural Research (CGIAR) soybean research is based in Sub Saharan Africa and has progressed very well in both crop improvement and postharvest processing and utilization. To avoid the need to inoculate soybean with *B. japonicum*, soybean breeders at the International Institute of Tropical Agriculture (IITA) (which was founded by CGIAR), Nigeria, developed new soybean genotypes for Africa, known as *Glycine* cross (TGX), which nodulate with *Bradyrhizobium* spp populations indigenous to African soils (Pulver et. al., 1985). Also, since the 1970s soybean breeders at the CGIAR's IITA in Ibadan, Nigeria have been successfully working on developing improved varieties of soybean that fix more nitrogen from the atmosphere without *Rhizobium* inoculation, are high yielding, store well, and are resistant to pod shattering. Furthermore, soybean improvement activities in IITA include the development of dual-purpose varieties that are tolerant to phosphorus-deficient soils and have enhanced capacity to kill seeds of the parasitic weed *Striga hermonthica* which attack cereals. Such varieties were found to have high grain yield and produce large amounts of biomass, making them useful as a soil-building rotation crop and as fodder for livestock. So far, seventeen IITA-bred tropical soybean varieties have been released by national agricultural research and extension system (NARES) of several West and Central African countries including Nigeria, Benin, Ghana, Democratic Republic of Congo, Togo and Uganda. Unfortunately, support for soybean research among NARES has declined in the recent time.

The great landmark of IITA's breeding effort on soybean is far from being obscured. It was reported that when IITA started soybean improvement research in 1974, the average yield per hectare in Africa was 660 kg/ha and total production was only 0.2 million tones. Thirty years later, using IITA-developed varieties, the average yield in West African countries increased by more than 50% and 67% in the whole of Africa. Currently, twenty-one African countries now produce soybean with Nigeria, South Africa and Uganda being the highest three producers (IITA, 2008)

3. Soybean production and utilization in Africa

Africa is the most tropical of the continents. Most of Africa has high temperatures throughout the year. The most important factor differentiating its climates is the amount, duration and seasonal distribution of rainfall. The different climatic zones found in Africa include tropical wet, tropical summer rainfall, semiarid, arid, highland and Mediterranean (Newman et al., 2007). Due to the different climatic zones found in Africa and other biotic and abiotic constraints, soybean cannot readily grow in all parts of Africa.

The extent to which soybean can be cultivated in different regions of Africa is shown in Figure 1. With the influx of IITA genetically modified drought tolerant soybean variety, there is a possibility of growing soybean in semiarid and arid regions which have earlier being dubbed unsuitable for soybean cultivation. Going by the 2008-2009 records, Nigeria is still the highest Africa's soybean producer (39%), closely followed by South Africa (35%) while Uganda is the third highest African producer (14%). Figure 2 shows the significant soybean producers in Africa. A critical comparison of Figures 1 and 2 would reveal that maximizing Africa's soybean production potential is far from being realized.

According to Newman et al. (2007), since at least the mid-19th century African economies were increasingly reworked to meet the needs of industrial Europe. Soybean, one of the Agricultural raw materials from the turn of the 20th century was not an exception. The British effort of systematically testing soybean in her colonies was targeted at ensuring a sustainable raw materials supplies for the Great Britain. A comparison of Nigeria's contribution to the Commonwealth and World's soybean production between 1938 and 1960 is presented in Table 1. The fact that soybean has not been largely incorporated into African diet up to the first eighty years of the 20th century also contributed to its being majorly an export crop then. However, sequel to the soybean awareness in some African countries in the 1980s, the situation has greatly changed as many soy based African meals were developed. Presently, Africa's soybean production cannot match up with her demand. According to FAO, Africa spent US\$ 1 billion in 2004 to import soybean and soy oil. Of this, US\$752 million was for soybean oil and US\$254 million was for soybean grain/meal.

Year	Nigeria	Commonwealth	World
1938/39	Nil	4	12,562
1954/55	9	144	19,661
1955/56	10	162	20,666
1956/57	16	159	23,780
1957/58	15	190	24,581
1958/59	14	182	27,570
1959/60	4	188	27,501

Table 1. Commonwealth and World's soybean production (000 tonnes) between 1938 and 1960

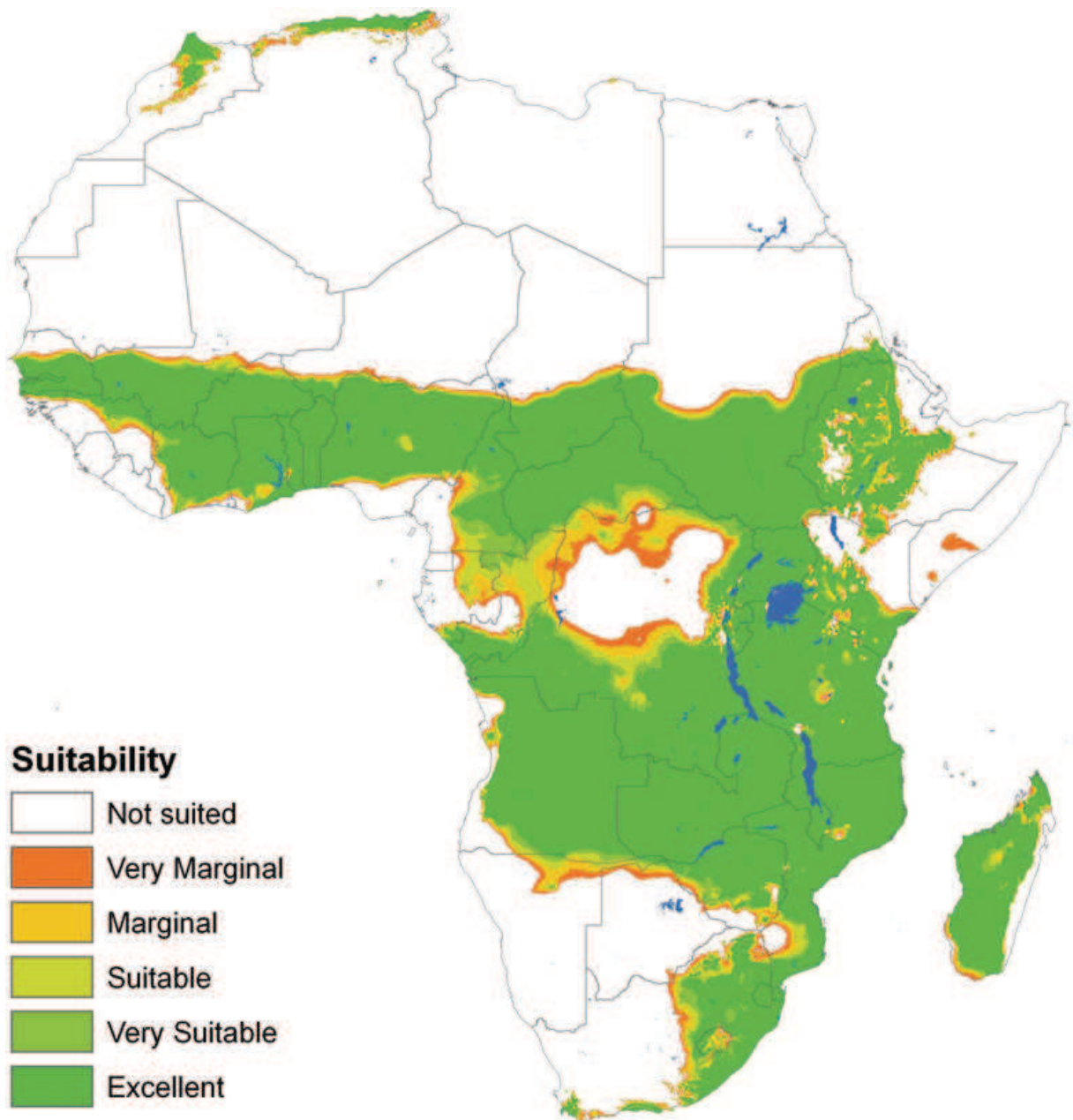


Fig. 1. Soybean suitability map for Africa (IITA, 2008)

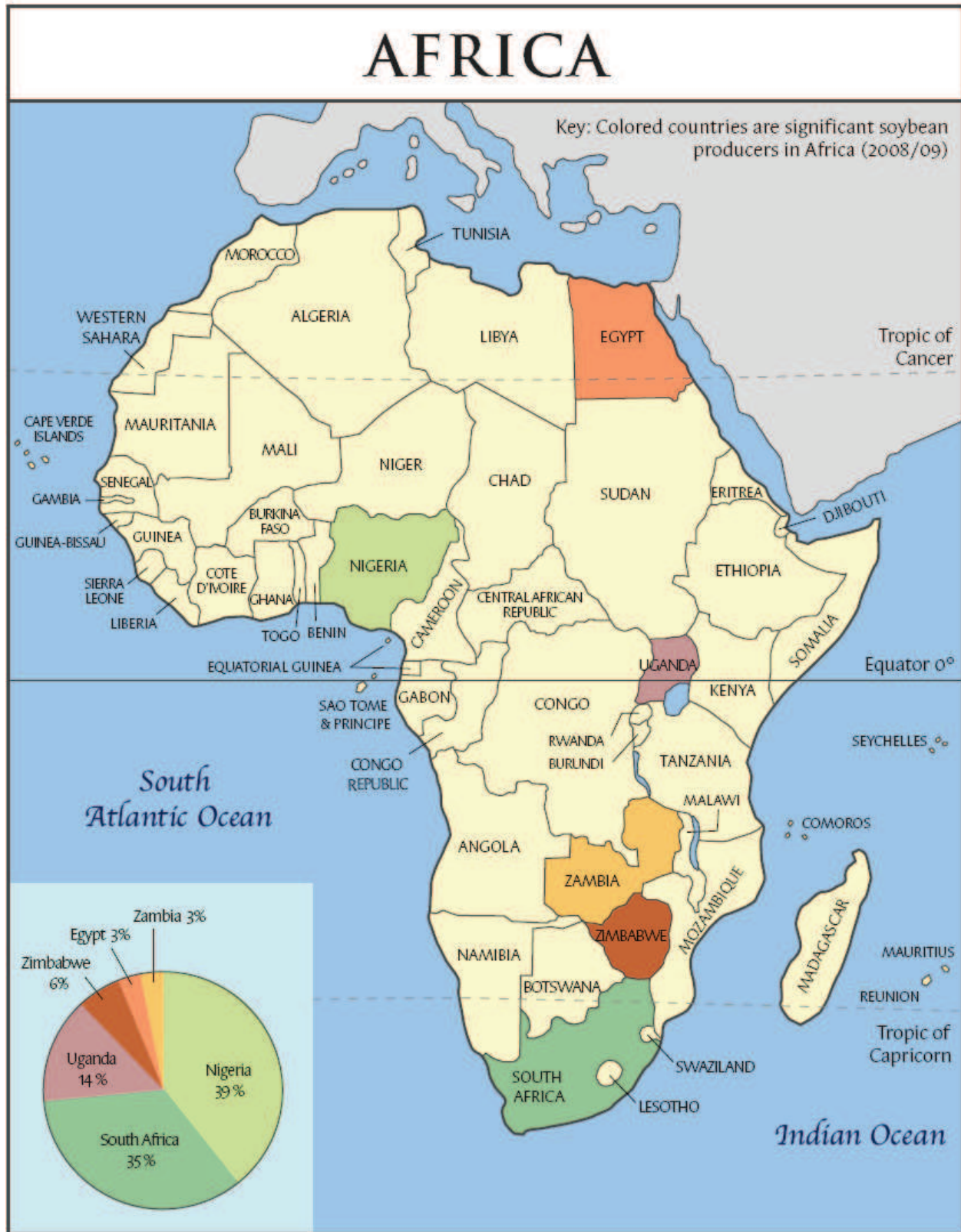


Fig. 2. Significant soybean producers in Africa (Shurtleff & Aoyagi, 2009)

4. Soy foods in Africa

Although the value of soybean as high protein source has been recognized, its use as human food was not immediately developed in Africa. Difficulties of soaking, preparation, cooking and a certain lack of palatability apparently precluded its use by many African people in the past era (Onichie, 1965). However, it should be stressed that as far back as 1938 commercial soy food products began to find their way into Africa, even where soybean was not cultivated. For instance, ProNutro, the earliest known commercial soy food product in Africa, was introduced into South Africa by Hind Brothers and Co Ltd (Odendal, 1965). Soy foods appeared in Ethiopia in 1945 (Shurtleff & Aoyagi, 2009), while Cape Verde, Eritrea and Liberia had their first contact with soy foods in 1960. Furthermore, in 1965, a black American and Seventh-day Adventist medical missionary, Dr D.W. Harrison started black Africa's first soy foods Company- Africa Basic Foods in Uganda. In a bid to incorporate soybean into Africa diet and improve nutrition, in 1965, a west African gruel derived from maize was fortified with soybean to produce Soy-Ogi by Akinrele in Nigeria. Much more later, the United State Development Agency (USDA) Food for Peace Programme employed soy food in her program in Mauritania and Djibouti in 1973 and 1978 respectively to solve problems of Malnutrition and Protein deficiency.

The recent expansion of soybean farming in Nigeria is attributable to both the development of improved varieties and soy-based food products. It is in this regards, that CGIAR's IITA also focused on soybean post harvest research. At IITA, post harvest researchers, have developed appropriate technologies that reduce labor and time requirements for processing, and improve the product quality and quantity. Various soybean-processing machines, such as a flour mill (dry mill or grinder, an extruder/expeller), a screw press and thresher, have been adapted for use in Sub-Saharan Africa and have been widely adopted by both small and medium scale processors (CGIAR, 2005). Altogether, about one hundred and fifty food products with good nutritive value and consumer acceptability have been developed by IITA food technologists. Many of these new products have been tried out in villages across the region, modified by local people to suit local culinary tastes, and ultimately adopted with increasing popularity.

In addition to IITA research efforts on incorporation of soybean into African diet, various independent researchers have reported on the possible use of soybean in addressing the major Africa's challenges- Hunger and Malnutrition. Soybean seeds have been exploited for the production of food products such as Soybean daddawa (Popoola & Akueshi, 1986), Soybean fortified gari and tapioca (Sanni & Sobamiwa 1994; Kolapo & Sanni 2005; Kolapo & Sanni 2009), cereal-based traditional weaning food (Osundahunsi & Awor 2003), Soy-Coconut milk based yoghurt (Olubamiwa & Kolapo 2008a), Soy-Cow milk based yoghurt ((Olubamiwa & Kolapo, 2008b) and Soy-corn milk (Kolapo & Oladimeji, 2008).

The utilization of soybean food product in Africa is rapidly gaining momentum. In Nigeria, for example, the private sector is becoming a major player in the market for soybean and soy products. Nigeria now has more than 65 soybean processing plants ranging in size from small village-level mills to plants established by food processing giants such as Nestle Plc and Cadbury Plc. These big processors use soybean to boost the protein contents of baked goods, breakfast cereals, weaning foods and dairy products. In a related development, an alliance between Sun Opta Inc and Specialized Protein Products (SPP) of South Africa is targeted at manufacturing and selling liquid and powdered soy ingredients and soy milk beverages in Africa and other International markets. Sales of liquid and powdered products from this alliance are expected to grow over time to over \$15 million.

5. Soybean in nutrition and health

Soybean is often described as the miracle golden bean, the pearl of the Orient, the Cinderella crop of the century, the meat that grows on vines, the protein hope of the future and the salvation crop among others. These attributions are mainly due to the relatively high protein content (about 40%) contained in soybean seeds. It also contains approximately 20% fat. The fatty acids in soybean are majorly unsaturated types e.g. oleic and linoleic acid. Unlike the saturated fat in animal protein, it is suitable in reducing heart ailment which may be caused or aggravated by excessive intake of cholesterol from animal fat. Soybean also provide adequate amount of carbohydrate, digestible fibres, minerals, vitamins etc. In addition to its high food value, it is one of the least expensive sources of protein when compared to eggs, milk, beef and cowpea (IAR&T, 1988).

Soybean is a major source of vegetable protein and oil for human and animal consumption and also for industrial use. Soybean oil is widely used throughout the world for human consumption as margarine, salad, cooking oils and shortenings (Lapades, 1977). Nutritionally, soy proteins are superior among vegetable proteins since they contain good supplies of essential amino acids, though they are slightly deficient in some sulphur containing amino acids such as cysteine and methionine. In a report by IAR&T (1987), it was shown that soybean ranks the highest among leguminous crops in terms of protein utilization and efficient ratio compared with other plant sources. For instance, soybean has a higher total digestible nutrient percentage of 91.99% compared to cowpea with 79.52%. Thus soybean consumption is more relatively helpful in solving nutrition protein-intake problem among the poor people. Though it lack starches, soybean contain such other carbohydrates as cellulose, pectin and phytic acid. Not only does cellulose promote good elimination together with other indigestible fibre, it helps in maintaining good physical condition and preventing rectal cancer. (Tokuji & Asako, 1984).

Studies by Lassitar (1981) revealed that soybean oil is highly digestible, high in polyunsaturated fatty acids, about 85.0% with no cholesterol. The studies also showed that mature soybean seed contains vitamins such as thiamine, niacin, riboflavin, cholin, vitamins E and K. These vitamins are necessary for normal body growth and development. Whole soybean contains 1.6% potassium, 0.3% calcium, 0.3% magnesium and minute quantity of iron, zinc and copper. The mineral present in soy products can contribute to the overall requirement especially for children and pregnant women. (NAERLS/FDA, 1994)

Lecithin is also present in soybean. Davis (1979) reported that adequate diet including soya lecithin will free the cholesterol deposits in the blood vessels, suspend the particles in the blood, carry them away and metabolise them. In this way, the blood vessels are free and blood pressure returns to normal. It is on this premise that Sanni (2000) recommends that people who cannot afford lecithin should include soybeans in their diet.

There is no doubt, a strong nexus between nutrition and health. The treatise by Scrimshaw et al. (1968): *Interaction of Nutrition and Infection*, set out a paradigm which has endured for almost a half century. Similarly, Solomon (2007) stated that demographics, food supply and epidemiological transitions determine the specific relevance of the malnutrition-infection interaction in individual circumstances. The strong link between a good nutrition and a good health must have been responsible for the invaluable role which soybean has been playing in maintaining a better health in its consumers for many centuries. Data from different regions of the world have shown that consumption of food containing soybean and soybean products has been associated with improved heart disease risk factor, reduced osteoporosis, alleviation of menopausal symptoms, reduced cancer risk, diabetes and serum

cholesterol. Soybean consumption also help in reducing obesity; this is consequent upon soybean isoflavones especially which cause production of fewer and smaller fat cells (Naaz et al., 2003). Report has shown that soybean could help minimize coronary heart disease through controlling cholesterol, blood pressure, vascular function and direct effects on the cells of the artery wall (AHA, 2000). Men which were at risk of developing coronary heart disease consuming soybean diets have been found to have significant reductions in both diastolic and systolic blood pressure (Sagara et al., 2004).

Studies have established the beneficial effect of soybean to diabetic patients particularly Non-Insulin Dependent Diabetes Mellitus (NIDDM). The protein and fibre in soybeans can prevent high blood sugar level and help in keeping blood sugar levels under control. In addition, the proportion of potassium to sodium (3/1- 11/1) makes soybean an ideal food for diabetes mellitus patients (Lijuan et al., 2000). Furthermore, Texeira et al. (2000) submitted that soy protein help diabetic patients prevent kidney diseases and improve the cholesterol profile. There are evidences that soy foods may help reduce bone loss that typically occurs after menopause. Soya isoflavone can help women with low bone mineral content prevent hip fractures in post menopausal years (Chen et al. 2003; Anderson 2003; Koh et al. 2009). In areas of the world where soybeans are eaten regularly, rates of colon cancer, as well as some other cancers including breast cancer tend to be low. Soybean contains relatively high amounts of glucosylceramide, which may be the reason for the cancer-preventive effect of eating soy foods (Symolon et al., 2004). In more recent studies, it was established that soy food consumption was significantly associated with decreased cancer recurrence and death (Shu et al., 2009; Guha et al., 2009).

6. Africa's nutrition situation

Many of the developing world's poorest producers and most undernourished households depend on Root and Tubers (R&T) as a contributing, if not principal, source of food and nutrition (Alexandratos, 1995). In part, these farm households value R&T because R&T produce large quantities of dietary energy and have stable yields under conditions in which other crops may fail (Alexandratos, 1995). Among these culprit developing countries; African countries are of major concern. More than 30 edible and edible species of R&T are grown today. Foremost among them in terms of aggregate output and estimated value of production are cassava, potato, sweet-potato and yam. Other prominent R&T include cocoyam, ginger, taro, yam bean as well as Andean R&T such as arracacha, mashua, oca and ulluco (Scott et al., 1992).

The diets of people in many developing countries (of which substantial part are in Africa) comprise mainly starchy materials. Unfortunately, animal sources of proteins, which are used to compliment the starchy diets are expensive and out of reach for low-income families (Obatolu et al., 2007). In Nigeria, statistics on cassava production and consumption indicated cassava as major national food and cash crop. According to Ouraga-Djousou & Bokanga (1998), annual consumption of cassava in Nigeria doubled to 250 kg per capita between 1983 and 1994. Cassava production increased from 14.4 milliom mt to 31.1 million mt during 1982-97 (FAO 1999). The increase in consumption and output of cassava can be attributed to several factors. Given Nigeria's low per capita income and rapid population growth, cassava has served as both a basic staple and food security crop; the ban on cereal imports between 1987 and 1990 provided an added stimulus to its production (Adeniji et al., 1997). The crop's multiple uses have also facilitated greater consumption. Roots are

consumed in fresh, boiled form; as toasted granules widely known as *gari*; as chips/flour (or *lafun*); and as unsteamed wet paste (or *fufu*) (Nweke, 1994).

Because the demand for cassava as a food commodity has remained strong, commercial sales of both processed products and fresh roots as raw material for food processing have become a highly profitable undertaking, due in part to technical improvements in processing and the introduction of high yielding varieties (Nweke et al., 1988). According to estimated expenditure elasticities for processed cassava (*gari*), urban households treat it as normal good (Nweke et al., 1994). In another estimates, based on the six-country Collaborative Study of Cassava in Africa (COSCA), expenditure elasticities for rural households hover around 1.0 for fresh and processed cassava (Ezemenari et al., 1998), which is similar to the elasticities for high-value foods. From these studies it was concluded that continued urbanization and improvements in income are likely to translate into continued strong demand for cassava in Nigeria and other Africa countries covered by the study. However, this trend signals a great danger for a populace which depends majorly on cassava on the understanding that cassava roots are an excellent source of carbohydrates but are deficient in protein, vitamins and some minerals. It is therefore not surprising that both Protein Calorie Malnutrition (PCM) and Macro and Micro Nutrients Malnutrition (MMNM) are common characteristics of many African populations. Consequently, it is equally not surprising that the 2009 Global Acute Malnutrition (GAM) prevalence values in many African countries were either poor, serious or critical; with a very few being acceptable (Figure 3).

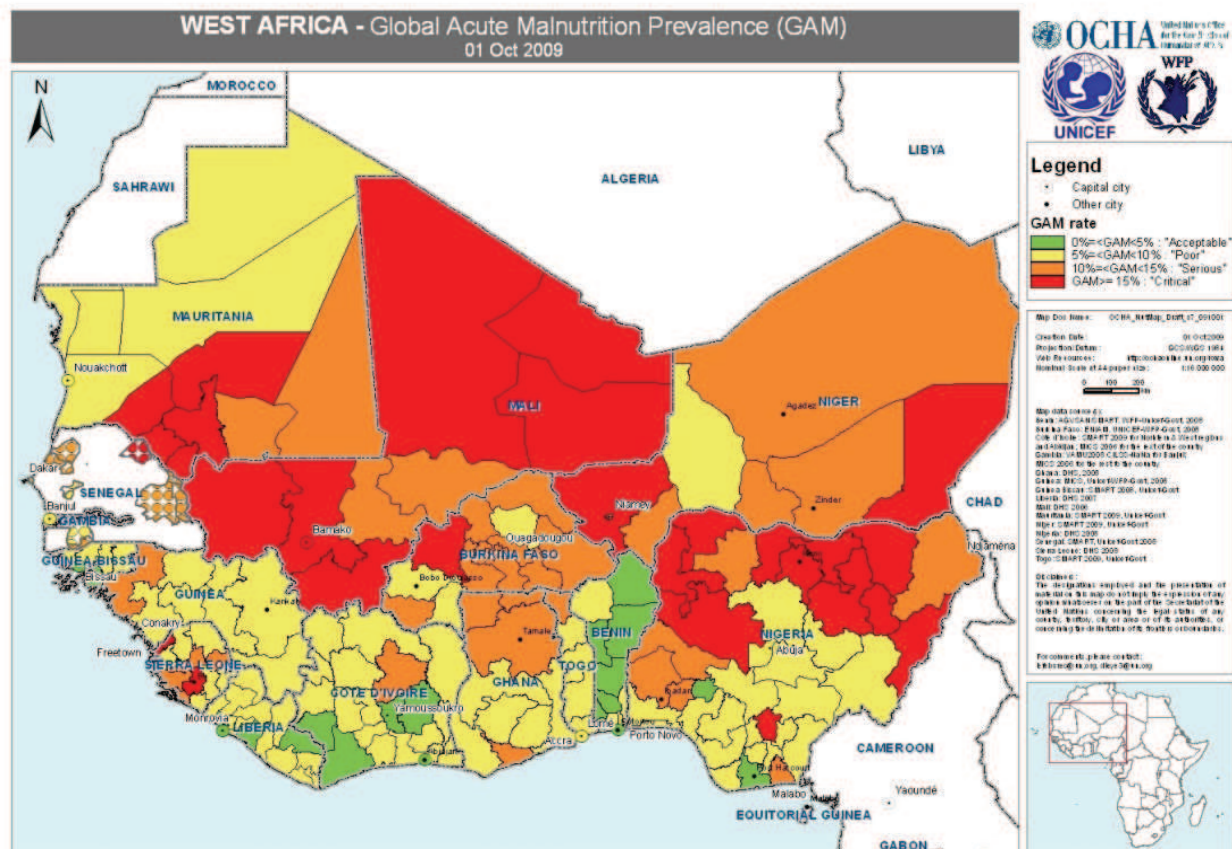


Fig. 3. Global Acute Malnutrition Prevalence (OCHA, 2009)

While addressing the state of nutrition in Africa, another important factor which deserves serious attention is the changing diet and the accompanied disease of lifestyle. Previously in African countries, most populations were very poor and they ate frugally. Their intakes of energy and fat were relatively low, but those of fiber-containing foods were high, as is usual with high consumption of plant foods (Lube, 1971). These are still the dietary features of those living traditional lifestyles and, to a large extent, current rural Africans (Vorster et al., 1994). In the past, prevalences of chronic diseases due to lifestyle were low (Trowell, 1960). However, within the past generation, diets have changed with increases in energy and fat intake but decreases in fiber intake (Bourne et al., 1993). Such diets, with ongoing changes have been associated with the variably rising prevalences of the nutrition-related diseases (Walker 1996; Walker & Segal 1997). In South Africa and some other countries in Sub-Saharan Africa, among Africans, changes in diet and other environmental factors particularly among urban dwellers have evoked large rises in the occurrences of some chronic disorders and disease of lifestyle but hardly any rises in others. Thus, major increases have occurred in obesity in women, hypertension and diabetes in both sexes and cerebrovascular disease (Walker 1996; Walker & Segal 1997). Judging from the experiences of the various populations described, it seems likely that, within the next generation, a marked rise in the occurrence of Coronary Heart Disease in urban African population would be inevitable (Walker et al., 2002).

7. Soybean and the future Africa

There is no doubt that Malnutrition is one of the major Africa's health challenges. As stated earlier, this hydra-headed problem manifests in form of Protein Calorie Malnutrition (PCM) and Macro and Micro Nutrient Malnutrition (MMNM). The resources to tackle this menace is not all that large in Africa; and with the worsening economic performance in many African countries, the end of malnutrition in Africa, is not in sight if some critical and decisive steps are not urgently taken.

In 2000, the world pledged through the Millenium Development Goals (MDGs 1 and 2) to halve hunger and ensure Universal Primary Education by the year 2015. It has since been recognised that school feeding programmes could be a key to achieving these goals, because they bring many synergies that support each other. In response, some national governments in Africa launched School Feeding and Health Programmes. In a particular school feeding attempts by World Food Programme (WFP) in areas of high food insecurity (which included many African countries), fortified biscuits and take home rations have been used (Gelli et al., 2009). However, a study by Kolapo & Sanni (2009) suggested that using a West African foods such as gari and tapioca which are fortified with whole soybean flour rather than 'piecemeal' fortifications will help meet Recommended Daily Allowance (RDA) of many macro and micro nutrients

Reports from Nigeria, Zimbabwe and Kenya have shown that families growing and utilising soybean are more healthier than those families that do not use soybean as part of their diets. Owing to the greatly invaluable nutritive and health benefits furnished by soybased foods, there is a need for a renewed, concerted and sustainable incorporation of soybean into African diet. The IITA soybean success story recorded particularly in Nigeria, Zimbabwe, Uganda and South Africa must be replicated in other African countries.

As stated earlier, previous reports have shown that the changing diets of African is excercibating disease of life style such as diabetes, obesity and the likes. Incidentally,

adoption of soybean has been shown to reduce the incidence of such disease. As the old adage goes, a wealthy nation is a product of a healthy nation. In this regards, various African national governments should consider soybean as being pivotal to building a healthy population. The attributes of soybean as a cinderella food crop can be utilised by African leaders in solving the challenges of food insecurity in the continent as soybean production technology matches the resource of small-scale farmers with the principal inputs being good seed of an adapted variety and useful information. The report of Rukuni (2002) shows how investment, technology and national institutions must interact to bring about food security in Sub-Saharan Africa, the region of the world where all indicators of hunger are worsening. There is no other time other than now which African leaders are to rise to this challenge; and in doing so, soybean should be considered as the cinderella food crop.

8. References

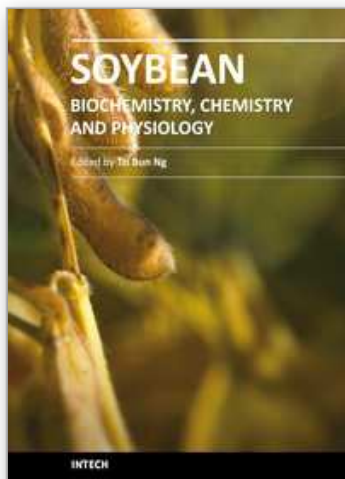
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