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The Potentials of Roots and Tubers as Weaning Foods

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Abstract: Any growing plant that stores edible material in subterranea root, corn or tuber is generally referred to as roots and tubers. Roots and tubers form a major staple food group in most developing countries of Africa, Asia and Latin America. Roots and tubers generally are poor sources of some major nutrients but on of the cheapest sources of dietary energy in the form of carbohydrates in developing countries. Thus, they are potential crops for the formulation of adequate weaning foods. This paper discusses therefore the possibilities of developing weaning foods of high nutritive value from roots and tubers.

Key words: Roots and tubers, weaning foods. Food fortification, food, sprinkles

INTRODUCTION

Roots and tubers refers to any growing plant that stores edible material in subterranean root, corm or tuber. They form a major staple food group in most developing countries of Africa, Asia and Latin America. The most popular of this food group are Cassava, Yam, Cocoyam, Irish and Sweet potatoes. In Africa the total per capital consumption of root crops (181 kg/capital) with cassava 115kg/capital and yam (39 kg/capital) being the most important while in North central America 64 kg/capital of roots crops are consumed with potatoes forming 92% of the share (Sanni *et al*., 2003).

The profile of African's production and consumption of major root and tuber crops as against the world production is presented in Table 1.

Roots and tubers generally are processed into various forms before consumption. Processing makes them digestible and palatable, extends the shelf-life and reduces post-harvest losses (Ekwu and Ugwu, 2000).

Roots and tubers generally are one of the cheapest sources of dietary energy, in the form of carbohydrates in developing countries. There has been a tremendous increase in consumption of these roots and tubers over years as food for adults and young children. Some of these crop particularly yam and potatoes are used sparingly as complementary food in feeding infants in rural areas. The potentials of these crops as weaning foods have not being fully harnessed. This paper therefore reviews the nutritional qualities of these roots and tuber crops and the possibilities of their use as weaning foods.

Weaning: Babies are being exclusively fed with breast milk in the early part of life. Breast milk is an ideal food for the healthy growth and development of all normal infant. Breast milk is safe, uncontaminated and digestible. Colostrum, the milk that comes at the forth or fifth day of life contains a high concentration of antibodies that protects babies from infection before the child's immune system matures. Breast milk is unique and cannot be mimicked in artificial formula.

Table 1: Production and Consumption of major roots and tuber crops

Production (1000 tons)	Total African	Total world	Consumption Africa	Consumption World
Cassava	85,945	158,620	115	27
Yam	28,939	30,378	39	5
Sweet potato	7,018	129,164	9	22
Taro	4,484	6,614	6	1
Potatoes	8,935	295,632	12	50

Sanni *et al*. (2003)

However, the increased needs of calories, proteins, minerals and other nutrients by the growing child makes the introduction of some other food necessary.

Weaning therefore is that process of change in the diet of infants where the child is being introduced to solids. It is a process starting with the introduction of complimentary foods and ending with the complete cessation of breast-feeding. Weaning is usually gradual lasting for months until the child is fully integrated into the family menu. Many mothers especially in developing countries breastfeed for 12 months while some others breastfeed for up to 24 months (Kazim and Kazim, 1979). WHO in collaboration with Unicef have come to a compromise that complementation should begin after the sixth (6th) month of any child (Brown, 1998). Therefore, complementation is done major for infants above six months of age. At this age there is no fear of renal solute load or of any gastro intestinal development.

The quality of weaning foods: Stunting and growth failure occurs from 6-24 month of the infant age thus the quality of food used in complementary feeding is important. Complementary foods/Weaning foods whether manufactured or locally prepared must satisfy the nutritional requirement of infants. They are usually soft, purried or semi-solid in texture. Adequate complementary foods must meet the demand of being frequent, have good density and utilizable in the body of the consumer. Adequate nutrition entails the frequency of the food that is been given.

It involves the completeness of the nutrients. There must not be any deficient nutrient.

The nutrient taken in depends on the activity of the individual and the ability to utilize what he has consumed.

Henrietta (1976) described nutrient density as another way to examine the amount of nutrients per 100 kcal in any given food. The term is related to the concentration of important nutrients such as vitamins, minerals, protein etc in relationship to their kcal value. Low nutrient density refers to food that are high in kcal value but carry insufficient amount of other nutrients. The nutrient value of any food may be expressed in terms of its content of nutrient and energy, each related to Recommended Dietary Intake (RDI).

The nutrient density in foods is calculated as:

$$\frac{\text{(Nutrient in 10g)/energy in 100g)}}{\text{(RDI of nutrient)/(RDI of energy)}}$$

In many developing countries the low energy density of weaning food appear to be the major contribution to growth faltering and ultimate malnutrition..

For nutrient utilization, the entire nutrient from the food must be absorbed by the child. This depends on the body of the child and the kinds of foods that are given to such infants.

In summary adequate weaning foods must have the following nutritional requirements (Obiolephehai, 2003).

(i) High energy content
(ii) Low viscosity (i.e. of an acceptable thickness/consistency)
(iii) Balanced protein (containing all essential amino acids)
(iv) Vitamins (particularly A, D and B group)
(v) Minerals (Iron, folic acid, calcium)
(vi) No anti-nutritional components
(vii) Pleasant taste/palatable.

Weaning food must also have the following physical qualities

(i) Easy and quick to prepare
(ii) Easy to consume
(iii) Adequate shelf-life
(iv) Made from local ingredients
(v) Affordable.
(vi) Safe microbiologically

These requirements are usually considered in the formulation of weaning foods. These have led to the evolution of many foods such as

(a) Formulation of foods from cereals and legumes to have balanced foods
(b) Foods formulated with germinated flours to improve the nutrient intake of the weaning child.
(c) Extruded foods to reduce viscosity of cereal gruels thereby enhancing their nutrient densities and causing increase in microbiological safety and shelf-life of the food (Jansen and Triblehorn, 1980; Khin *et al.*, 1993).

Nutritional value of root and tubers: The nutritional value of roots and tubers lies in their potential ability to provide one of the cheapest sources of dietary energy in the form of carbohydrates in developing countries. The energy is about one third of that of an equivalent weight of grain such as rice or wheat because tubers have a high water content. However, the high yields of most root crops ensure an energy out put per hectare per day which is considerabley higher than that of grains.

As with all crops the nutritional composition of roots and tubers and tubers varies form place to place depending on the climate, soil the crop variety and other factors (Woolfe, 1987). The nutritional composition of some tropical crops are presented in Table 2 and 3.

Protein: The protein content is low in almost all root crop, sulphur-containing amino-acids are limiting in the proteins as in legume proteins (Table 2, 3). Most root crops contain a reasonable amount of lysine though less than in legumes. Yams are rich in pheny lalanine and threonine but limiting in cystine, methionine and in trytophan (Table 3). Yams proteins can contribute about 6% of the daily protein intake while their chemical score range from 57-69 (Francis *et al.*, 1975).

The protein of sweet potato is also of acceptable nutritive value with a chemical score of 82 with sulphr amino-acids as limiting. The quality of the protein will depend on the severity of heat-treatment during the processing (Walter *et al.*, 1983) Cassava protein is lower in total essential amino-acids than the other root-crops.

Carbohydrates: Starches are the main sources of nutritive energy, the principal constituent of edible carbohydrate is starch together with some sugars, the proportion depending on the root crop. The physical properties of starch grains influence the digestibility and processing qualities of root crops. The starch granules of some varieties of cocoyam are very small about one-tenth of those of potato, which makes them more suitable for the diets of infants and invalids.

Table 2:Nutritive value of tropical crop per 100 edible portion

Crop	Food	M	P	F	P/E 100 Kcal	Fibre	Ash	Ca	P	Fe	K	Na	Car	Thi	AS mg	folic
Cass	565	65.5	1.0	0.2	7	1.0	0.9	26	32	0.9	394	2	0	0.05	34	212
Sweet potato	452	72.3	1.0	0.3	15	0.8	0.7	21	50	0.9	210	31	35	0.14	21	52
White yam	481	70.0	1.2	0.3	-	0.8	0.7	36	56	0.9	304	36	1680	0.12	30	
Potato	335	78.0	2.0	0.1	27	0.4	0.9	9	55	0.7	451	7	30	0.11	14	
Yam	452	71.8	2.0	0.1	21	0.5	1.0	22	39	1.0	294	10	0	0.10	8	
Taro and Tania	393	74.4	2.0	0.4	-	0.8	1.0	34	62	1.2	448	10	Tr	0.12		
Giant taro	255	8.3	0.6	-	-	-	-	50	50	1.0	-	-	0	0.05	5	

FAO, 1990

Table 3: Comparison of suggested amino acid requirement and amino acid content of tropical crops

Amino Acid mg/g	Infant meat	FAO ref	Pres 2-5 yrs	Sco. 10-12 yrs	Adult	Egg	Potato	Sweet potato	Cassava	Cocoyam	Yam
His	26			19	16	22	20	13	21	18	19
He	46	42	19	28	13	54	39	37	28	35	37
Leu	93	49	28	44	19	86	59	54	40	74	65
Lys	66	42	66	22	16	70	60	34	41	39	41
Met+Ly	42	40	58	22	17	57	30	28	27	40	28
Pho+Tyr	72	56	25	28	19	93	78	62	41	87	80
Three	43	28	63	9	9	47	39	38	26	41	36
Tryp	17	14	34	25	5	17	14	14	12	14	13
Val	55	42	11	241	13	66	51	45	33	61	47
Total			35	222	177	512	382	325	269	409	366
Inc his	460	-	339		111	490	363	312	248	391	347
Chem. Score				-	-	100	53	82	85	70	74
Limit A/A							SAA	SAA	AA	AAA	SAA

Salp AA FAO, 1990, Met+Lys, Arom Amino-phe+Try

Yams give viscous paste with much higher gel strength than that of other crops. Cassava starch is readily gelatinized by cooking with water and the solutes are stable, it does not retrogradate.

Roots crops also contain some non-starch polysaccharides known as dietary fibre. Sweet potato is a significant source of dietary fibre, its pectin content can be as high as 5% fresh weight or 20% of the dry matter (Collins and Walter, 1982).

Lipids: All the roots exhibit a very low lipid (0.12-2.7%) content it may affect the palatability of the crop.

Vitamins: Roots and tubers are not rich sources of fat-soluble vitamin. Most roots and tubers contain only negligible amounts of beta carotenes with the exception of selected varieties of sweet potato: sufficient and regular ingestion of sweet potato leaves with the tubers can meet the consumer's daily requirement of vitamin A. Some yam varieties has beta-carotene in quantities of 0.14-1.4mg per 100g (Murtin and Ruberte, 1972).

Vitamin C occur in appreciable amounts in several root crops and when correctly prepared can make a significant contribution to the vitamin C content of the diet. Yam contains 6-10mg of vitamin C per 100gm, 100gm of potato boiled with the skin is sufficient to provide 80% of the vitamin C requirement of a child and 50% of an adult.

Most of the root crops contain small amounts of vitamin B group sufficient to supplement normal dietary sources.

Minerals: Potassium is the major mineral in most roots crops while sodium tends to be low. Thus makes some root crops particularly valuable in the diets of patients with high blood pressure who have to restrict their sodium intake (Meneely and Battarble, 1976). The high vitamin C concentration in some root crop may help to render soluble the Iron and make it more available than in cereals and other vegetable, the Iron supply from potato ranks third of individual food sources in U.K True *et al.* (1978) found that 150g of potato will supply 2.3 to 19.3 percent of the dietary requirement for Iron recommended by the Food and Nutrition Board of the Natural Research Council of America. Potato can significantly contribute Zn and Iodine due to low levels of phytates. Yam can supply a substantial portion of the manganese and phosphorous requirement of adults and to a lesser extent the copper and magnesium.

The roots and tubers as weaning food: The Nutritional qualities of roots and tubers especially the low protein content, low energy content on wet basis and of course the low nutrient density seems to make it inadequate for weaning food formulations. However if properly processed and complemented, it could be used as weaning food.

The traditional weaning foods in West Africa are usually made from various foods. Infants are commonly given gruels from cereals especially from maize/sorghum. They could also be given mashed food from cereals such as rice and roots and tubers. This traditional weaning foods have been implicated in the aethology of protein-energy malnutrition in children during weaning (Naismith, 1973).

Development of weaning foods high in nutritive value from roots and tubers: Several strategies may be used to improve the nutritional value of weaning foods from roots and tubers. Such strategies may include:

Combination with other food: Absorption of micronutrients is strongly influenced by the combination of foods eaten in a given meal. Composite flours could be prepared from root crops and cereals. The addition of germinated cereals to cassava flour increases the energy density of the meal germination reduces their viscosity of cereals through the action of amylolytic enzymes (Khin *et al.*, 1993).

However the use of fresh cassava products as weaning foods should be discouraged because of probable toxicity, low protein content and energy density.

Pure cassava flour is unsuitable as the main source of energy for the young child because of its low protein content, low Iron and vitamins that is why supplementation with cereals and legumes is important (FAO, 1990).

Food processing and preparation: Certain food preparation and processing method need to be promoted at the house-hold level to reduce the level of absorption inhibitors or increase the content of absorption enhancers and thus improving the bioavailability of Fe, Zn and provitamin, A eliminate the toxic component in roots and tubers. Food processing methods such as germination, malting and fermentation have been found to be very effective in enhancing Fe absorption by increasing vitamin C content or by lowering the tannin or phytic acid content (Gibson *et al.*, 1998). The cyanide in cassava can be totally removed by fermentation (Bourdoux *et al.*, 1983). Food preparation methods such as boiling or mild heat treatment can also be effective. Toxic factors in potatoes, cocoyam can be removed by such treatments. Some legumes could be extruded to produce food for children. Cocoyam flour with the advantage of high digestibility because of small particle size could be extruded with protein concentrate, or isolate.

Food fortification: Fortification is defined by the Codex Alimentraius as the addition of one or more essential nutrients to a food, whether or not it is normally contained in the food (Zlotkin and Melody, 2003). A new form of supplementation in powder form called, "sprinkles" have been developed by Zlotkin: (Zlotkin and Melody, 2003).

Sprinkles are a home fortification or a complementary food supplement. Sprinkles contains micro-encapsulated ferrous fumarate. The Iron in sprinkles is encapsulated with a Soya based hydrogenated lipids to prevent any interaction with the food there by avoiding any changes in colour, taste or texture. It is packaged in single-dose sachets which need to be sprinkled once daily into infants, weaning food immediately before feeding (Nestle *et al.*, 2003; Zlotkin *et al.*, 2001).

Sprinkles have several advantages

(i) Other micronutrients such as V it A, C and D folic acid, iodine or Zn could be added to the sachets.
(ii) The sachets are light weight and are simple to store, transport and distribute
(iii) The sachets are easy to produce.
(iv) The potential for overdose is unlikely.
(v) The use does not require any change in food practices. And can help promote the transition from exclusive breastfeeding to complementary foods at six months of age. Moreover sprinkles can provide the daily dose of micronutrients to each child regardless of the quantity of complementary food that is fed.

Food modification: The quality of foods can be improved using biotechnology and genetic modification techniques. In developing countries, the challenges of protein malnutrition protein malnutrition as well as inadequate vitamin and mineral intake especially in children is enormous. Biotechnology techniques that have been used for other purposes than improvement in food functionality are mutation breeding, improved conventional breeding, transgenic modification,

D NA insertion, gene transfer and somatic hybridization. (Lorraine, 2003). Modification have been developed for improvement in the oil content and composition of oil seeds (Mazur, 2001; Uzogara, 2000).

Improvement in soybean oil quality by increasing the levels of yields of carbohydrates and dry matter of food plants and of course modification and improvement of starch and carbohydrate quality.

Roots and tuber crops such as cassava and yams are typically high in amylopectin with lower ratios of anmylose, modifications of starch to increase the amylose to amylopectin ratios would be greatly useful in improving glycemic index and physiological responses to the starchy foods. Improving the glycemic indices of staple starchy food crops such as cassava, yams and potatoes will improve their nutritional quality.

Genetic modification can also be applied to improve the availability and quality of protein in food crops. This is primarily by modification of the amino acid composition and amounts (Lorraine, 2003).

Also micro-nutrient content of products can be increased by insertion of genes that produce the desired nutrient. This could be used to improve the availability of minerals such as iron, Zn, Iodine and potassium in roots and tubers.

Conclusion: Roots and tubers though very poor in some major nutrients are potentials crops for the formulation of adequate weaning foods. It is important to begin to explore the possibility of its use in weaning food formulation because the commercial weaning food is gradually getting out of the reach of the average people in most developing countries. Nutrition education is also indispensable for mothers and caregivers to effectively utilize these roots and tuber crops.

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