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Status and Prospects for Mechanization of Turmeric Production and Postharvest Operations in Nigeria

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Abstract: *Apart from primary tillage operation, all other production processes (from planting to harvesting) of turmeric in Nigeria are done manually. This paper seeks to review the state and prospects of mechanization of turmeric (*Curcuma longa *Linn) production in Nigeria. Production of turmeric has been a challenge to farmers in Nigeria due to the absence of planting, harvesting and processing machines. Farmers are left to the traditional method of planting with hoes and cutlasses. This method is time consuming, costly, labour intensive, associated with human drudgery and a high demand for human energy. Increased cultivation of turmeric in Nigeria will help not only to meet its own turmeric requirements but also help the country to boost its export. Planting method and climatic conditions for optimum production were stated. Various uses of turmeric as well as prospects of mechanization of its production as highlighted in this paper have the potential of making a significant impact on the Nigerian economy. Strategies and recommendation for effective mechanization were also stated.*

Keywords: Turmeric, mechanization, planting, harvesting, prospects.

1. Introduction

Turmeric (*Curcuma Longa Linn*) is a stem tuber crop. It belongs to the same family as ginger (*Zingiberaceae*) and grows in the same hot and humid tropical climates. The rhizome is deep bright yellow in colour. Turmeric was derived from Latin word, *terra merita* (merited earth) (Nwakor *et al.*, 2014). In Nigeria, turmeric is cultivated mostly on subsistent bases in about 19 states and given different local names depending on the area. It is called *atale pupa* in Yoruba language; *gangamau* in Hausa; *nwandumo* in Ebonyi; *ohu bobochi* in Enugu (Nkanu East); *gigir* in Tiv; *magina* in Kaduna; *turi* in Niger State; *onjonigho* in Cross River (Meo tribe). (Nwaekpe, *et al.*, 2015). It is native to India and Southeast Asia. India is the largest producer, consumer and exporter of turmeric (Srinivasan and Dhandapani, 2013). To most people in India, from housewives to Himalayan hermits, turmeric affectionately called the "kitchen queen", the main spice of kitchen (Lal, 2012).

The underground rhizome impacts a distinctive flavour to food but it is also used to provide food with a deep indelible orange colour (FAO, 2004). Curcumin (Diferuloylmethane), the main yellow coloured bioactive component of turmeric has been shown to have a broad spectrum of biological actions. These include its anti-inflammatory, antioxidant, anticarcinogenic, antimutagenic, anticoagulant, antifertility, antidiabetic, antibacterial, antifungal, antiprotozoal, antiviral, antifibrotic, antivenom, antiulcer, hypotensive and hypocholesteremic activities. Its anticancer effect is mainly mediated through

induction of apoptosis (Dhinesh and Ananda 2016). Cureumin is a free radical scavenger and hydrogen donor, and exhibits both pro-and antioxidant activity (Nwakor *et al*., 2014). Modern medicine has begun to recognize its importance, as indicated by the over 3000 publications dealing with turmeric that came out within the last 25 years. This review first discusses in vitro studies with turmeric, followed by animal studies, and finally studies carried out on humans; the safety and efficacy of turmeric are further addressed (Sahdeo and Bharat, 2011).

2 Trend in Turmeric Production

India is the largest producer, consumer and exporter of Turmeric. It accounts for 78% of world output. Other major producers are China, Myanmar, Nigeria, Bangladesh, Pakistan, Srilanka, Taiwan, Burma, Indonesia, Malaysia, Vietnam, Thailand and Central America etc. Global production is around 8 to 9 lakh tonnes. Indian turmeric industry contributes about 78% of world production and 60% of the exports of Turmeric. Asian countries consume much of their own turmeric production nearly 90%.

Table 1: Percentage contribution to the world production of turmeric.

Entry	Country	Percentage contribution
1	India	78%
2	China	8%
3	Myanmar	4%
4	Nigeria	3%
5	Bangladesh	3%
6	Others	4%

Source: Nwakor *et al.* (2014).

In Nigeria, turmeric has not gained the desired popularity among other root and tuber crops. There is need therefore, to create awareness and increase the production of turmeric through mechanization. Turmeric is mostly cultivated by peasant farmers in small portion of land less than one hectare. This is as a result of drudgery associated with turmeric production. As an emerging crop in Nigeria, the need to develop efficient implements aimed at increasing turmeric production is paramount. There is an increase in the demand for processed products of turmeric in Nigeria which makes its large scale production attractive. In Nigeria, turmeric has not received the desired attention that will boost its large scale production. From the research carried out, turmeric has little or no mechanization in its production processes from planting to harvesting in Nigeria. The only mechanization of turmeric production in Nigeria is the land preparation (ploughing and harrowing). Turmeric, if fully mechanized will ensure timeliness of operation in the farm and reduce cost and drudgery associated with planting, mulching and harvesting.

Figure 1: Land preparation and planting of turmeric.

Source: National Root Crops Research Institute, Nyanya Sub Station farm, Abuja.

2.1 Land preparation

Land preparation starts with site selection and bush clearing. The bush cleared manually with cutlass or mechanically with tractor implements such as the jungle slasher. The trashes are allowed to dry, removed or incorporated to enrich the soil. Mechanized tillage involves ploughing, harrowing and ridging with tractor mounted implements. Beds of 1.0 m width, 30 cm height and of convenient length are prepared with spacing of 50 cm between beds. Planting is also done by forming ridges and furrows (Jayashree *et al*., 2015). Where there is no access to tractor, the beds, ridges and mounds are made manually using hoe, spade and shovels depending on the soil and culture of the people. Turmeric gives an optimum yield in a well-drained fertile, loamy soil which ranges from sandy to clay-loam (Nwakor *et al., 2014*).

Land preparation (clearing and ploughing) in Nigeria is mostly done manually as reflected in Figure 1. About 80% of turmeric farmers especially in the rural areas do not have access tractors services.

2.2 Planting of turmeric

Planting of turmeric has been a challenge to the farmers in Nigeria due to the absence of planting machine. The farmers are left to the traditional method of planting with hoes and cutlasses (Figure 2). This method is time consuming, costly, labour intensive, associated with human drudgery and a high demand for human energy. It was noted that *time is the essence of farming* and whatever helps to shorten the time required for planting will help overcome the effect of adverse weather (Ajit *et al*. 2006).

Figure 2: Established turmeric farm.

Source: National Root Crops Research Institute, Nyanya Sub-Station farm, Abuja.

2.3 Mulching

Mulching of the bed is very important in turmeric production. Two stages of mulching are required, first immediately after planting and the second mulching is done 8 weeks after planting. Mulching helps to conserve moisture, promote germination, suppress weed, regulate soil temperature, supply nutrients to the soil and improve soil physical fertility for maximum yield. The mulching is done with elephant grass at the rate of 12t/ha (Nwakor *et al.*, 2014).

2.4 Harvesting of turmeric

The rhizome bunches are carefully dug out manually with a spade, or the soil is first loosen with a small digger, and clumps manually lifted. It is better to cut the leaves before lifting the rhizomes (FAO, 2004). The harvest is carried out during January to March. It matures in about 9 months. The marketing season is from February to May. The leaves of crop turns dry and are light brown and yellowish in colour on maturity, height of crop around 1.5 feet after the complete growth with maximum 8-10 branches with cracks development on the soil signifies good yields of turmeric. The land is ploughed and the rhizomes are carefully lifted with a spade. Harvested rhizomes are cleaned of mud and other extraneous matter adhering to them (Lal, 2012). Harvesting of turmeric rhizome is one important aspect which requires immediate attention for developing appropriate mechanical technology. In India, turmeric harvester has been developed for the harvesting of turmeric. The harvester is attached to power tiller as source of power.

Nigeria is yet to develop an indigenous turmeric harvesting machine/device that will help Nigerian farmers in the production of turmeric. The machine will reduce losses caused by damages on the rhizomes as a result of manual harvesting techniques. Conventional method of harvesting turmeric rhizome is labour intensive, requiring skilled men labour to dig out the crop. The non-availability of such skilled labour and the high wages demanded by them to harvest the crop, the high field losses and damage to the crop by manual harvesting, necessitate the need to develop a suitable mechanical harvester for turmeric.

3. Soil and Climatic Requirements

Turmeric is known to grow well on a well-drained, sandy or clay-loam soil (Rema and Madan, 2001). Improvement of crop cultivation technology for local climatic and edaphic factors is important for successful production (Amzad, *et al.*, 2005). Turmeric can be cultivated in diverse tropical conditions up to 1,600 meters from the sea level, with temperatures varying from 20-40 °C (Table 2), and rainfall above 1500 mm (Lal, 2012). It grows in irrigated and rain fed conditions, black, clayey looms and red soils having natural drainage. Crops cannot withstand water logging or alkalinity (Srinivasan and Dhandapani, 2013). Turmeric thrives in tropics and subtropics where it requires hot, moist climates. Turmeric is a sterile plant and does not produce seed. It is produced through vegetative propagation (Nwakor *et al.*, 2014). Adequate soil moisture is the most significant factor affecting rhizome yield. Turmeric needs plenty of moisture, but does not like to sit in wet soil.

Table 2: Temperature requirements for turmeric production.

SN.	Required temperature	Stage of growth
1	High temperature 30°C to 35°C	Sprouting
2	25°C to 30°C	Tillering
3	20°C to 25°C	Rhizome development
4	18°C to 20°C	Enlargement

Source: Nwaekpe *et al.* (2015).

4. Economic Importance of Turmeric

Turmeric is a tuber crop of high economic and medicinal significance. The processing of the rhizome involve boiling, drying and grinding into powder. Turmeric is common, inexpensive and provides a potent means for you to increase your overall health and biological functioning. With its regular application in your diet or daily supplement routine, you can expect to begin reaping its many health benefits (FAO 2004). Turmeric can be best described as a wonder tuber crop owing to its great potential both in food industries and in the prevention/treatment of various health disorders. Curcumin has a surprisingly wide range of beneficial properties, including anti-inflammatory, anti-oxidant, chemo-preventive and chemotherapeutic activities. Turmeric is produced for both local use and for export.

4.1 Food industry

Turmeric is widely used as food additive for products that are specially packaged to protect from sunlight. It is also used in mustard, pickles for compensating fading colour (Dhinesh and Ananda, 2016). As a result of Indian influence, turmeric has made its way into Ethiopian cuisine. In South Africa, turmeric is traditionally used to give boiled white rice a golden color. Turmeric is also used in manufactured food products such as canned beverages, dairy products, baked products, ice cream, yellow cakes, yogurt, orange juice, biscuits, popcorn, sweets, cake icings, cereals, sauces, and gelatins. It is a significant ingredient in most commercial curry powders (Sahdeo and Bharat, 2011). It is also used as a natural colouring agent in foods (Nepal Value Chain, 2011). Recently the powder has also been used as a colorant in cereals (FAO 2004).

4.2 Natural dye and cosmetics

Turmeric is used to manufacture various sunscreen, fairness creams and lotions. The anti-oxidant properties help to lighten the skin. It is a natural dye of cloth, leather, silk, palm fibre, wool and other fabrics. Turmeric rhizomes yield 2-6 per cent orange-yellow essential oil (curcumin, upon oxidation becomes vanillin), which is used in perfumery (Nepal Value Chain, 2011).

4.3 Medicinal and industrial uses

Turmeric has been traditionally used for curing a number of diseases. It is popular for its anti-bacterial, anti-fungal, anti-ulcer and anti-tumoral effects. Its use is reputed to alleviate asthma, cough, jaundice, and also used for treating skin inflammations (Nepal Value Chain, 2011). Constituents of turmeric block the replication of HIV, enhances wound healing, protects against cataract formation in lenses, exert several protective effects on the gastrointestinal tract. It also used for prevention/cure for Chronic Inflammation, Rheumatoid Arthritis and Pain, Depression and Diabetes, cancer, Turmeric is extremely healing for the brain and for increasing memory function. Turmeric is also used for both traditional and modern medicine (Lal, 2012). It is also used for digestive disorders; to reduce flatus, jaundice, menstrual difficulties, and colic; for abdominal pain and distension (Bundy *et al.*, 2004); and for dyspeptic conditions including loss of appetite, postprandial feelings of fullness, and liver and gallbladder complaints. It has anti-inflammatory, choleretic, antimicrobial, and carminative actions (Mills and Bone, 2000). Ayurvedic doctors prescribe it for boils, biliousness, bruises, dyspepsia, dysuria, elephantiasis, inflammations, leucoderma, scabies, smallpox, snakebite and swellings. Boiled with milk and sugar, it is used as a remedy for colds. As the global scenario is now changing towards the use of non-toxic plant products, development of modern drugs from turmeric should be emphasized for the control of various diseases (Hamid *et al.*, 2014). Many industries in Nigeria depend on agricultural produce for their raw materials. Mechanization of turmeric in Nigeria holds a great future for the pharmaceutical and food industries in the production of drugs, food supplements and spices.

5. Consumption and nutritional values

More than 100 components have been isolated from turmeric. The main component of the root is a volatile oil, containing turmerone, and there are other coloring agents called curcuminoids in turmeric (Sahdeo and Bharat, 2011). Nutritional analysis (Table 3) shows that 100 g of turmeric contains 390 kcal, 10 g total fat, 3 g saturated fat, 0 mg cholesterol, 0.2 g calcium, 0.26 g phosphorous, 10 mg sodium, 2500 mg potassium, 47.5 mg iron, 0.9 mg thiamine, 0.19 mg riboflavin, 4.8 mg niacin, 50 mg ascorbic acid, 69.9 g total carbohydrates, 21 g dietary fiber, 3 g sugars, and 8 g protein (Balakrishnan, 2007; Sahdeo and Bharat, 2011; Amadi *et al.*, 2015).

Table 3: Nutritional composition of turmeric.

Entry	Constituents	Quantity per 100g
1	Ascorbic acid (g)	50.0
2	Ash (g)	6.8
3	Calcium (g)	0.2
4	Carbohydrate (g)	---
5	Fat (g)	8.9
6	Food energy (K Cal)	390.0
7	Iron (g)	47.5
8	Niacin (mg)	4.8
9	Potassium (mg)	200.0
10	Phosphorus (mg)	260.0
11	Protein (g)	8.5
12	Riboflavin (mg)	0.19
13	Sodium (mg)	30.0
14	Thiamine (mg)	0.09
15	Water (g)	6.0

Source: Lal (2012).

Proximate analysis of turmeric rhizomes indicate that it contains: moisture (8.6%), crude protein (14%), crude fibre (8.63%), fat (3.82%), total ash (6.97%) and starch (57%) (Nwakor *et al.*, 2014). The reported consumption of turmeric in Asian countries in humans is in the range of 200–1000 mg/day or 160–440 g/person/year. Intake in urban areas is lower (200 mg/day) than in rural areas (600 mg/day/person (Sahdeo and Bharat, 2011).

6. Processing and Utilization

The harvested turmeric rhizomes before entering into the market are converted into a stable commodity through a number of post-harvest processing operations like boiling, drying and polishing. Boiling of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter take a little longer to cook. The dry recovery of the different turmeric varieties vary widely ranging from 19 to 23% (Jayashree *et al.*, 2015). The processing of turmeric in Nigeria is hampered by unavailability of machines and equipment to carry out various processing tasks. The engineering properties of turmeric rhizomes are yet to be properly evaluated, and as such there is no empirical data to develop required processing equipment. The physical properties of some turmeric varieties were determined by Athmaselvi and Varadharaj, 2002; Balasubramanian, *et al.*, 2012; Dhinesh and Ananda, 2016. The data obtained can be used to design a turmeric chipping machine, turmeric planting machine, as well as turmeric harvesting machine. It has been observed that the need to determine the engineering properties to enhance postharvest operations of turmeric is important and it cannot be over emphasized (Athmaselvi and Varadharaj, 2002). The turmeric promotion and awareness program under National Root Crops Research Institute, Nyanya Sub-station, Abuja has identified various value added products of turmeric to include: turmeric oleoresin, volatile oils, and curcumin pigments with high commercial value. The value addition will increase consumption by different categories of people, increase production and reduce spoilage.

6.1 Cleaning and processing

Turmeric being a natural produce, is bound to gather contaminants during various stages of processing. The spice is also cleaned to remove such foreign materials. A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter. (Jayashree *et al.*, 2015). Harvested turmeric rhizomes (75-80%) are cleaned by fresh water under pressure for removal of soil and other foreign matter. Processing of farm products leads to enhanced form-utility. Processing helps in the marketing of farm products by making them more edible, palatable and attractive. In addition, it adds to convenience in use, storage and transit. It helps extend the availability of the product over a longer period of time (FAO, 2004).

6.2 Slicing of turmeric rhizomes

Slicing the rhizomes reduces drying time and yield turmeric with lower moisture content as well as better curcuminoid extractability. In rural Bolivia, slicing the boiled rhizomes is done by women. The "Fundación Poscosecha", with the support of FAO has developed a slicing machine in order to ease the women's work. The slicing machine has a simple design, is easy to use, and can be made at a low cost (FAO,2004). In Nigeria, from planting to post-harvest operations are done manually, thereby making turmeric production difficult. Absence of these machines, discourage many farmers who want to venture into massive production, proccessing and packaging of turmeric.

6.3 Curing of turmeric rhizomes and its benefits

Curing involves boiling of rhizomes in fresh water and drying in the sun. Cleaned rhizomes are boiled uniformly in hot water. It is performed to gelatinize the starch for a more uniform drying, and to remove the fresh earthy odour. boiling in water lasts for about 45 minutes to 1 hour, until froth appears at the surface and the typical turmeric aroma is released. The colour deteriorates as a results of over-cooking, but that the rhizome becomes brittle when undercooked. Optimum cooking is attained when the rhizome yields to finger pressure and can be perforated by a blunt piece of wood. For the curing process, it is important to boil batches of equal size rhizomes since different size material would require different cooking times. (FAO, 2004). The rhizomes are removed from the water and dried in the sun immediately to prevent overcooking. The final moisture content should be between 8% and 10% (wet basis) (Prasad and Aggarwal, 2011).

Curing is more uniform when done with small batches at a time. It is recommended to use perforated containers that allow smaller batches of 50 to 75 kg, which are immersed in the boiling water; by using this method, the same water may be used for cooking several batches Curing should be done two or three days after harvest, and should not be delayed to avoid rhizome spoilage. The quality of cured rhizomes is negatively affected for material with higher initial moisture content (FAO, 2004).

During this process, the colouring material is diffused uniformly through the rhizome. Cured rhizomes are then poured to a bamboo basket to drain the water and dried in yards. This process gives attractive colour and characteristic aroma to turmeric. Boiling kill the growth of fresh rhizomes, eliminates the odour, reduces the time of drying, ensures even distribution of

colour and gives better quality product by gelatinisation of starch in rhizomes.

No chemical should be used for processing. The cleaned rhizomes are boiled in copper or galvanized iron or earthen vessels, with water just enough to soak them. Boil till the fingers/mother rhizomes become soft. The cooked turmeric is taken out of the pan by lifting the troughs and draining the water into the pan itself. The same hot water in the pan can be used for boiling the next lot of raw turmeric. The cooking of turmeric is to be done within 2-3 days after harvest (FAO, 2004).

The cooked fingers/mother rhizomes are spread on bamboo mats or cement floor under the sun for drying. The rhizomes are spread in 5-7 cm thick layers for desirable colour of the dried product. During night time the material should be heaped or covered. It may take 10-15 days for the rhizomes to become completely dry. Artificial drying using cross-flow hot air at a maximum temperature of 60°C is also found to give a satisfactory product. In the case of sliced turmeric, artificial drying has a clear advantage giving brighter coloured product than sun drying which tends to suffer from surface bleaching. The recovery of dry product varies from 20-25%

depending upon the variety and the location where the crop is grown. Dried turmeric has a poor appearance and rough dull colour outside the surface with scales and root bits. Smoothening and polishing the outer surface by manual or mechanical rubbing improves the appearance.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. The improved method is by using hand-operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal mesh. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against the mesh as well as by mutual rubbing against each other as they roll inside the drum. The turmeric is also polished in power-operated drums. The colour of the turmeric always attracts the buyers. In order to impart attractive yellow colour, turmeric suspension in water is added to the polishing drum in the last 10 minutes. When the rhizomes are uniformly coated with suspension they may be dried in the sun.

Besides turmeric powder, cured turmeric is used for producing several useful products such as, turmeric oleoresin, volatile oils, and curcumin pigments with high commercial value.

Benefits of curing turmeric include reduction of the drying time, and a more attractive product (not wrinkled) that lends itself to easier polishing. However, it was reported that while the total volatile oil and color remained unchanged, curcuminoid extractability might be reduced. The curing by boiling process has the advantage of sterilizing the rhizomes before drying (FAO,2004).

6.4 Drying and polishing

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor. A thin layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the material should be heaped or covered. It may take 10-15 days for the rhizome to become completely dry. The bulbs and fingers are dried separately, the former takes more time to dry (Jayashree *et al.*, 2015).

The moisture content of the dried turmeric is kept at 8%-10% for better storage. Artificial mechanical drying using cross flow heated air dryers at 65 degrees centigrade is also used and found to provide best products, particularly for sliced turmeric, giving a brighter coloured product than the sun dried material.

Polishing of rhizomes is done by rubbing with hand under several folds of gunny cloth or using a polishing drum.

6.5 Colouring and Grading

To impart uniform bright yellow colour to the turmeric, the polished rhizomes are treated with an emulsion or mixture of turmeric powder and alum under continuous shaking in a basket.

Grading refers to the process of 'sorting of products into different lots on the basis of similar quality. Turmeric is graded into bulbs and fingers in different fractions, based on their size. It is done either manually, which is time consuming or using a mechanical

reciprocating type grader. Bulk rhizomes are graded into fingers, bulbs and splits (FAO, 2004)

6.6 Milling and Packaging

Milling is a simple process that involve cutting and crushing the rhizomes into small particles, then sifting through a series of several screens. Depending on the type of mill, and the speed of crushing, the spice may heat up and volatiles be lost. In the case of turmeric, heat and oxygen during the process may contribute to curcumin degradation (FAO, 2004)

Usually, turmeric is milled on home scale in flour mills. Milling is done in two stages, namely breaking into small pieces and powdering them to the desired fineness.

Packaging is defined by Acharya and Agarwal (1999), as the 'putting of content in the market in a size and pack which are convenient for the buyers'. Well cured turmeric is kept in double burlap new gunny bags which are properly fumigated prior to packaging. Turmeric powder is packed in fibre board drums, multi wall bags and tin containers.

6.7 Storage

Cured turmeric bags are stored in a pit made on a raised ground with sides and the bottom padded with a thick layer of paddy straw. The stores should be clean and free from infestation of pests and harborage of rodents. It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests (Jayashree *et al.*, 2015).Turmeric pigment is highly unstable as compared to the yellow synthetic colorant, tartrazine. However, if protected from light and humidity, the curcuminoid pigments in turmeric powder and oleoresin are stable. Therefore, turmeric rhizomes and powder should be stored away from light and in a very dry environment. Additionally, all water or ethanol solvent should be removed from the oleoresin to assure pigment stability (FAO 2004).

7. Strategies to Effective Mechanization of Turmeric Postharvest Operations

For effective mechanization of turmeric crop in Nigeria, the following strategies should be adopted (Amadi *et al.*, 2015):

a. The engineering properties of turmeric should be properly evaluated in order to generate data needed to develop required processing equipment.
b. To encourage more research and extension of improved turmeric processing and storage technologies.
c. The design and manufacturing engineers should start from fundamental principles to generate data for development of turmeric planting and processing machines.
d. Research institutes, educational institutions and government establishments should be empowered by international donors to develop machines for mechanization of turmeric production.
e. Collaborative work amongst all the stakeholders in turmeric production including farmers, extension workers, agronomists /scientists, design engineers, processors, research institutes, universities and the government should be encouraged.
f. The development of simple indigenous machines for mechanization of turmeric production operations should be encouraged.
g. To enhance diffusion and adoption of improved turmeric postharvest technologies.
h. Funding support for various levels of turmeric research should be substantially increased so as to close gaps in the knowledge of the crop.
i. Regular power supply is paramount in order to maintain the optimum safe storage conditions for turmeric.

8. Prospects of Turmeric Mechanization in Nigeria

There are high potentials in the modern techniques being used in agricultural production. Turmeric, as an emerging crop with many usefulness holds a great prospect. Its full mechanization will increase the production output and income generation of the farmers. Mechanization of the production processes of turmeric will help to reduce associated drudgery. Development of farm tools and implements for planting, weed control and harvesting will lead to great increase in the production of turmeric. Low level of mechanization of agriculture in Nigeria has led to the decrease in farm produce. This has discouraged many youths from taking agriculture as an occupation.

The increasing demand for natural products as food additives makes turmeric an ideal candidate as a food colourant, thus increasing its demand. Additionally, recent medical research demonstrating the anti-cancer and anti-viral activities of turmeric may also increase its demand in Western countries (FAO, 2004). Increased cultivation of turmeric in Nigeria will help not only to meet its own turmeric requirements but also help the country to boost its export. To achieve food security through large scale production (mechanization) of crops with high potentials and prospects such as turmeric, there is much need to provide a planting aid to Nigerian farmers to alleviate their suffering.

Curcumin as a spice, exhibits great promise as a therapeutic agent. As the global scenario is now changing towards the use of non-toxic plant products, development of modern drugs from turmeric should be emphasized for the control of

various diseases (Hamid *et al*., 2014). However, the increasing demand for natural products as food additives makes turmeric an ideal candidate as a food colourant, thus increasing demand for it.

Turmeric can be best described as a wonder tuber crop owing to its great potential both in food industries and in the prevention/treatment of various health disorders. Curcumin has a surprisingly wide range of beneficial properties, including anti-inflammatory, anti-oxidant, chemo preventive and chemotherapeutic activity. Turmeric is produced for both local use and for export.

9. Conclusion

There is no form of mechanization of turmeric production from planting to harvesting in Nigeria. All activities in the production of turmeric are done manually with cutlasses, hoes and spade. The little aspect of mechanization in few areas where tractor is available is land preparation (land clearing and ploughing). Turmeric production is costly, associated with drudgery and high requirement for human energy. Turmeric, being a crop with high potentials and prospects both in food industries and medicine requires mechanization in its production processes for increased production for domestic uses and export. It is therefore recommended that the Federal Ministry of Agriculture and National Root Crops Research Institute, Umudike which has the National mandate to research into the crop should intensify effort in developing machines and other equipment for mechanization of turmeric production in Nigeria.

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