QUALITY EVALUATION OF TANNIA CORM (*Xanthosoma sagittifolium* (L.) Schott) AND ITS SUITABILITY FOR PRODUCT DEVELOPMENT

By

AMITHA ELIAS

(2016-16-003)

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Community Science
(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

Kerala Agricultural University
DEPARTMENT OF COMMUNITY SCIENCE
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680 656
KERALA, INDIA
2018

DECLARATION

I, hereby declare that the thesis entitled "Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development. " is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara

Date: 16-10-2015

AMITHA ELIAS

CERTIFICATE

Certified that the thesis entitled "Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development" is a bonafide record of research work done independently by **Ms. Amitha Elias** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara

Date : 16.10.2018

Dr. ANEENA E. R.

(Major Advisor, Advisory Committee)

Assistant Professor

Dept. of Community Science

College of Horticulture, Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Amitha Elias** (2016-16-003), a candidate for the degree of **Master of Science in Community Science** with major field in **Food Science and Nutrition**, agree that the thesis entitled "**Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development**" may be submitted by **Ms. Amitha Elias** in partial fulfilment of the requirement for the degree.

16.10.2018

Dr. Aneena E. R.
Major Advisor
Assistant Professor
Dept. of Community Science
College of Horticulture, Vellanikkara

16/10/2018

Smt. Norma Xavier C.
Assistant Professor and Head
Dept. of Community Science
College of Horticulture, Vellanikkara

16/10/18

Dr. Seeja Thomachan Panjikkaran
Assistant Professor
Dept. of Community Science
College of Horticulture, Vellanikkara

16/10/18

Dr. Sharon C. L.
Assistant Professor
Dept. of Community Science
College of Horticulture, Vellanikkara

16/10/18

Dr. C. George Thomas
Professor and Head
Department of Agronomy
College of Horticulture, Vellanikkara.

16.10.18

(EXTERNAL EXAMINER)
Dr. V. PREMALA PRIYADHARSINI

ACKNOWLEDGEMENT

To the almighty I am most grateful and put forward my praise and sincere gratitude for giving me strength to complete my work successfully.

I express my deep sense of gratitude, indebtedness and heartfelt thanks to my guide ***Dr. Aneena E. R.*** *Assistant Professor, Dept of Community Science, who with her enthusiasm, inspiration and effort to explain things clearly and simply, throughout my thesis period, encouraged me and provided lots of good ideas and sound advice. Under her guidance I successfully overcame many difficulties in my research work.*

I am very much obliged and grateful to ***Smt. Norma Xavier C.,*** *Assistant Professor and Head,* ***Dr. Seeja Thomachan Panjikkaran,*** *Assistant Professor, College of Horticulture, Kerala Agricultural University, Vellanikkara and* ***Dr. Sharon C. L****. Assistant Professor, College of Horticulture, Kerala Agricultural University, Vellanikkara and member of my advisory committee for unwavering encouragement, well timed support and critical scrutiny of the manuscript which has helped a lot for the preparation of the thesis.*

With great pleasure I extend my sincere thanks to ***Dr. C. George Thomas*** *Professor and Head, Department of Agronomy, College of Horticulture, Vellanikkara and member of my advisory committee for the valuable guidance, support and encouragement.*

I convey my special praise and heartfelt thanks to my seniors ***Ajisha, Reshma, Sruthy, Remya, Shahanas*** *and also my juniors* ***Tessa, Aiswarya, Sruthy and Lovely*** *for their assistance. I also thank* ***Kumari, Simya, Dhija, Reshma*** *and* ***Krishna*** *of Department of Community Science, for their support and help rendered during my study.*

Words seem inadequate to express my deep sense of gratitude and sincere thanks to my beloved friend ***Rammya Molu K****. for their generous help rendered to me during the research work.*

I express my sincere thanks to the ***Department of Soil Science, Department of Processing Technology, Department of Agronomy, Radio tracer***

laboratory and Kerala Veterinary and Animal Science University *for all the facilities provided, for their cooperation and support during the conduct of the research. I convey my sincere gratitude to* ***Dr. A. T. Francis,*** *Librarian for the support and guidance in organising research materials.*

Special thanks to ***Aravind chettan****, Student's Computer Club, College of Horticulture, Kerala Agricultural University, Vellanikkara for rendering necessary help. The award of* ***KAU Junior research fellowship*** *is gratefully acknowledged. I am thankful to* ***Kerala Agricultural University*** *for technical and financial assistance rendered in pursuit of my study and research work.*

Words have no power to express my love towards my most affectionate and beloved parents, ***Mr. Elias V.P. and Mrs. Mary Elias****, my siblings* ***Antony, Ashna*** *and* ***Shanto chettan*** *for being the pillars of unfailing encouragement. Their everlasting faith, love and mere presence in every aspect of my life, has meant everything to me and will always be cherished.*

Amitha Elias

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Introduction

1. INTRODUCTION

Roots and tubers are the third important food crops of humankind after cereals and pulses. Tuber crops are known as poor man's crop as it provides food of high calorific value and quality starch. The tropical tubers have served as subsidiary and sustenance food for millions all over the humid tropics. They provide starchy staples or subsidiary food for the one fifth of the world's population. Roots and tubers can occupy a remarkable position in the developing world due to its high calorie value and carbohydrate content and also offer numerous desirable nutritional and therapeutic benefits. Most of the species of tubers are nutritionally good and rich in starch which make them a very promising ingredient for more extensive uses. Root and tuber crops (RTCs), including cassava, sweet potato, yams, potato, cocoyams and other minor root crops are important to the agriculture and food security, of more than 100 countries in the world.

Demand for food grains would increase from 192 mt in 2000 to 345 mt in 2030 (CTCRI, 2016). Tubers have the potential to cope up with the challenge through its production and productivity capabilities (CTCRI, 2016). The higher biological efficiency and dry matter production per day per unit area make tuber crops important in food economy.

According to FAO (2012) 'nutrition-sensitive' growth in a country can be ensured by supporting, increased dietary diversity. The tropical tubers like cassava, sweet potato, elephant foot yams, taro, tannia, arrow roots etc. has become important for ensuring food and nutritional security of the country.

Tannia is an edible root crop grown in the tropics and sub tropics belonging to the family *Araceae*. Tannia corms and cormels contain good amount of digestible starch, proteins, vitamin C, thiamin, riboflavin and niacin. They are recognised as a cheaper carbohydrate source than grains or other tuber crops. Moreover, it also provides B- complex vitamins, potassium and zinc. According to De Almeida and Morita. (2013) tannia contains high amount of terpenoids,

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glycosides and tannins along with moderate amounts of flavonoids and alkaloids and trace amounts of saponins and steroids. Between corms and cormels, people have preference for cormels and corms are seldom consumed directly. However, starchy tannia corms can be used to develop several value-added food products. The problems associated with processing and utilization of tannia corms, include acridity, poor storage quality and bulkiness. Food usage of tannia is limited because of the acrid nature of corms due to its oxalate content. Monterey-Blase (2011) reported that oxalate concentration of raw unpeeled tubers ranges from 74.53 to 107.69 mg/100 g. Damage to tissues of corms while harvesting is followed by enzymatic browning reactions which results in discolouration. Through appropriate processing techniques, acridity factors of tannia corms can be minimised and browning can be prevented and good quality flour and starch powder can be prepared. The tuber flour and starch powder can be used as starch substitute for a variety of food products.

Instant mixes and ready to eat products are getting high demand as convenience foods in the market. Changes in daily life of average Indians due to urbanisation, changes in life style and increased number of working women caused increase in consumption of convenient foods (Anvita *et al.* 2001). Tannia corms have immense potential for the development of convenience foods. The texture of tannia corm is very much suitable for instant mixes. However, awareness about the variability of the tannia corm starch, flour properties and the knowledge about the innumerable products which can be produced from the corm flour and starch are scanty. There is limited scientific information on post-harvest properties and related commercial food applications of tannia corms. Hence, the present study was undertaken with the following objectives

- To evaluate nutritional, antinutritional and organoleptic qualities of tannia corm (*Xanthosoma sagittifolium)*
- To evaluate the quality aspects of the flour and starch powder
- To develop an instant mix using tannia corm flour and starch

Review of Literature

2. REVIEW OF LITERATURE

The literature pertaining to the study entitled "Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development" is presented under the following headings

2.1. Roots and tubers in food security

2.2. Tropical tuber crops - An overview

2.3. Nutritional and health benefits of roots and tubers

2.4. Food applications of tubers

2.1. Roots and tubers in food security

Roots and tubers are known as the energy bank of nature which serves as primary or secondary staple to meet the calorie needs of about one fifth of world population. Tuber crops hold a premier position among food crops. Root crops are the underground part of plants which include rhizomes, tubers, roots and stem. Root and tuber crops (RTCs), including cassava, sweet potato, yams, potato, cocoyams and other minor root crops are important to the agriculture and food security of more than 100 countries. Roots and tubers contribute towards the diet of 2.2 billion people globally. Attaining food security is a matter of prime importance for India, where more than one third of its population is estimated to be absolutely poor, and one half of its children were suffering from malnourishment. India produced a record 252 mt of food grains during 2011-2012. But, about 217 million of our people (17.50 per cent of total population) remained under- nourished during 2012 (FAO, 2012). Tropical root crops are widely recognized as important food security crops which offer adequate calories and nutrition for around 500 million people of the tropical belt (CTCRI, 2016).

Demand for food grains would increase from 192 mt in 2000 to 345 mt in 2030. In order to meet this challenging scenario, tuber crops could serve as the important link to fit the food security gap and have potential to cope up with the challenge through its production and productivity capabilities (CTCRI, 2016).

Roots and tubers have myriad and complex parts to play in feeding the world in the coming decades because they have immense potential to help to improve food security and eradicate poverty. Annual world production of root and tuber crops is about 765 mt consisting of potatoes (333 mt), cassava (237 mt), sweet potatoes (130 mt), yams (53 mt), and taro and other aroids (120 mt). The global consumption of tropical root and tuber crops is about 365kg/capita/year (FAO, 2012). According to FAOSTAT (2014) China contribute first position in total production (173 mt) followed by Nigeria (107 mt). India occupy third (55 mt) in world roots and tubers production. In Kerala, the total roots and tubers production is 8619 tonnes, of this cassava production is 67589 tonnes (78 %), taro 7546 tonnes of taro (8.75 %), elephant foot yam 7022 tonnes (8.14%), yam 1528 tonnes (1.77%), coleus 1382 tonnes (1.6%), sweet potato 330 tonnes (0.38%), lesser yam 226 tonnes (0.26%) and other tubers 568 tonnes (0.65%) (Department of Economics and Statistics, 2015).

Roots and tubers have many agronomic advantages which make them staple food. They are well adapted to diverse soil and environmental conditions and also to a wide variety of farming systems, high yield production potential, ease of cultivation and also least pest and diseases incidence. Some of these tuber crops may have a significant role in indigenous food systems. So that they are produced in greater extent than those are identified as major root crops. A good example of this is taro, which is planted in large scale in many south pacific countries, being a staple food and as an export item (Losefa and Rogers, 1999). Tuber crops have a higher biological efficiency and show the highest rate of dry matter production per day per unit area among all the crops. They are also recognised as the most efficient converters of solar energy (CTCRI, 2016).

Many of the developing countries are the poorest producers of cereals and pulses and most under nourished households depend on roots and tubers as a source of energy (Low and Jaarsveld, 2008). According to IPGRI (2002) underutilized tuber crops have significant contribution to the diet of rural households, particularly during drought, famine and the dry season. In general,

tuber crops are consumed as a cheap source of dietary energy either as a basic source or as a supplement to cereals (Peter and Palaniswami, 2008). Kana *et al.* (2012) opined that underutilized tubers are very vital in achieving food security and they play a significant role in the global food system. Tropical roots and tubers play an important role in food and nutrition security. These mainly include cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoeabatatas*), taro (*Colocasia esculenta*), yams (*Dioscorea* sp.), elephant foot yam (*Amorphophallus paeoniifolius*), arrowroot (*Maranta arundinacea*) and other minor root crops. Besides food value, the tropical root crops like cassava and sweet potato are of relevance for industrial uses like starch, dextrins, alcohol, high fructose syrup, noodles, sago and liquid glucose. Cassava and sweet potato account for about 30 per cent of the total production of root crops in the developing countries.

Food security needs has to be developed based on local resources because it will give more value for food diversification. In the present trend tuber crops are getting equal importance as grains and vegetables. According to FAO (2015) 'nutrition sensitive' growth in a country can be ensured by supporting increased dietary intake of roots and tubers. Hence, tropical tuber crops like cassava, sweet potato, elephant foot yams, taro, tannia, yam bean, arrowroot, canna etc. become important for ensuring food and nutritional security of the country. The earlier emphasis on cereals to cope up with the food production as alternate crops as sources of energy, tuber crops are an inevitable choice. Tuber crops also provide a vast scope for diversification and value addition, offering a great opportunity for non-traditional uses within the country and for exports (CTCRI, 2016)

2.2. Tropical tuber crops - An overview

The thickened underground part of a stem or rhizome or root, serving as a food are known as tubers. Cassava, sweet potatoes, potatoes, yams, aroids, tannia, gaint taro, elephant foot yam and lesser yams are the common tubers and these are classified as major and minor crops. Major root crops are those having high production, commercial demand and they contribute to agriculture economy. Minor tubers are not widely produced, but they are utilised locally and majority of

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them have medicinal values. Among tubers, cassava, sweet potato and yams are the major root crops and edible aroids and the lesser yams are considered as the minor crops.

Cassava or tapioca (*Manihot esculenta*) belonging to the family Euphorbiaceae, is a native of South America and is widely cultivated in the topics especially in South America, Mexico, Central America, the Caribbean Islands, Africa and also in Asian countries. In India, it occupies 0.24 m ha with a production of 5.1 mt. It is cultivated predominantly in the southern states of which Kerala and Tamil Nadu are responsible for 62 per cent and 28 per cent of area and 55 per cent and 41 per cent of production respectively (IPGRI, 2002). It is also grown in Andhra Pradesh, Assam, Karnataka, Madhya Pradesh, Pondicherry, Nagaland, Tripura, Mizoram and the Andaman Nicobar group of Islands. In 2014, global cassava production was 270.29 mt from an area of 24.22 million hectares. India has a leading position in global cassava scenario due to high productivity level of 35.31 tonnes per hectare compared to world average of only about 11.16 tonnes per hectare (FAO, 2015). Cassava is often grown on marginal soils, under hot, rainfed conditions with limited inputs. Cassava is usually grown in association with other commodities such as maize or groundnuts. The crop takes from 8 to 12 months, to mature and the roots may be left in the field for months after that as a form of in-ground storage. Cassava has the major food value in Kerala and north- eastern states of India. In other states like Maharashtra it's primary use is as an industrial raw material.

Sweet potato is the second most important root crop cultivated by 112 countries. It is originated from Central America and is distributed in many countries like Malaysia, Indonesia and America. In India, it is mainly cultivated in Orissa, West Bengal, Bihar and Uttar Pradesh. Sweet potato also holds enormous potential for industrial exploitation and as convenience food and its value as a health food due to its bioactive components like carotenes, anthocyanins, flavonoids etc. (Anbuselvi and Muthumani, 2014). It is largely grown for its large, starchy, sweet and tuberous roots. Based on flesh colour it is classified into

yellow, orange, red, cream and purple varieties. Sweet potato in Asia is cultivated predominantly under lowland conditions in different rotations with rice. In this system, the crop is irrigated and harvested at maturity after four to five months. Long grown as a food security or famine crop, sweet potato is increasingly cultivated for cash where both vines and roots are processed into feed or starch prior to sale. The orange coloured sweet potato contain high betacarotene (6 µg/100g) than other varieties. The purple fleshed sweet potato contain anthocyanin, which can be extracted and used in various food products.

Greater yam (*Dioscorea alata*) is the largest tuber among yam varieties and is also known as larger yam or water yam. It is originated in Asian tropics and is widely cultivated in America, Africa, Australia and India. In India, the production is high in Maharashtra, Andhra Pradesh and Kerala. It provides nutritional and food security to several millions of people especially in Africa. Tubers are cylindrical, branched and fan shaped (NIN, 2004)

White yam (*Dioscorea rotundata*) is originated from Africa and its widely cultivated at Ivory coast and Kerala. In India, its production and cultivation are high in Kerala, Tamil Nadu and Karnataka.White yam has been classified as one of the important staples in the diets of many tropical countries because of the carbohydrate composition.

Lesser yams (*Dioscorea esculenta*) are originated from the region of South East Asia and is cultivated and distributed in India, Vietnam and Philippines. In India, it is mainly distributed at Kerala, Goa and Maharashtra (Peter and Palaniswami, 2008). Lesser yam is the smallest tuber in yam family. It is grown as the sole crop or in various combinations with maize, vegetables, cassava, plantain, sorghum, or coffee. The crop matures in 7 to 12 months, depending on species and cultivar and the tubers may be stored in fresh form for over six months under ambient conditions.

Coleus (*Solenostemon rotundifolius)*, also known as Chinese potato, is a minor tuber crop of tropical regions of India. Its characteristic flavour have a special preference among customers. It is originated from tropical Africa and is

distributed mainly at India, Brazil, Nepal and Pakistan. In India, it is cultivated at Karnataka, Tamil Nadu and Kerala. Coleus is an important food item during lean periods in Africa. The aromatic flavour is due to presence of oligofructose inulin, a prebiotic compound (Peter and palanisami, 2008).

Taro (*Colocasia esculenta)* serves as staple food for many tropical and sub-tropical population (CTCRI, 2016). Taro is originated in Sri Lanka and is cultivated in South East Asia, Malaysia, Indonesia and America. In India, Uttar Pradesh, Bengal, Bihar and Madhya Pradesh are the main cultivars. Taro is a subsidiary food crop, which contains high potassium and low sodium content and is good for hypertensive patients. Taro is said to have sweet nutty flavour due to the compound alkyl pyrazines and this flavour enhances while cooking due to maillard reaction. Taro is locally important in many parts of the humid tropics and subtropics. Taro is often intercropped with corn, beans, sugarcane, fruit trees and vegetables in the rainfed and irrigated uplands, or with rice in the paddy fields, or is rotated with winter crops such as garlic and broad bean

Giant taro (*Alocasia macrorrhizos*) is one of the most important staple foods grown extensively in water logged regions of tropical countries. Giant taro is originated from Philippines and is cultivated throughout the world like Malaysia, Queensland and Pacific islands. In India its mainly cultivated in Orissa, Andhra Pradesh and Kerala. The outer surface of the tuber is marked by circular rings and the inner flesh is white to cream colour (CTCRI, 2016).

Tannia (*Xanthosoma sagittifolium* (L.) Schott) is an important edible aroid ranking next to taro and belonging to *colocasiae* with about 38 species. And it is originated from America. In India, Kerala and Maharashtra are the main cultivators of tannia. Tannia is a fairly extensive corm and produce latex. Tannia is nutritionally very similar to taro (Peter, 2008).

Elephant foot yam (*Amorphophallus paeoniifolius*) or white yam is an edible aroid belonging to the family Araceae. This is originated from South East Asia and is cultivated and distributed in Indonesia, India and Malaysia. In India it is mainly cultivated in Bihar, West Bengal and Kerala (Peter, 2008).

Arrowroot (*Maranta arundinacea) is* originated from South America and is distributed in Brazil, Philippines and Caribbean Islands. In India, it is cultivated in Kerala, Tamil Nadu and Karnataka (Kim and Fung, 2004). The term arrowroot is applied to many starch producing plants. Arrow root an be successfully grown as an inter-crop in coconut gardern as it tolerates partial shade.

Canna (*Canna edulis*) also known as Queensland arrowroot belonging to the family Cannaceae, is a perennial herb grown in many countries for its edible starchy rhizome. It is originated from America and distributed in Africa, India, Peru and Ecuador. In India it is mainly cultivated in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. Canna is an outstandingly versatile and one of the underutilised crops of tropics. It is grown rapidly and over a wide range of climatic conditions.

2.3. Nutritional and health benefits of roots and tubers

In India, tuber crops play a vital role in alleviating the hunger and malnutrition of a great majority of population and the tubers have the potential ability to provide the cheapest sources of dietary energy, in the form of carbohydrates. Among tubers, tannia is high in carbohydrate (93.62 g/100g) followed by cassava (38.1 g/100g), sweet potato (28.2 g/100g), lesser yam (25 g/100g) (Peter and Palaniswami, 2008). Among tubers, tannia is high in energy (298 Kcal) followed by cassava (157 kcal), white yam (142 Kcal), greater yam (140 Kcal), sweet potato (120 Kcal), lesser yam (112 Kcal). This energy is about one third of that of an equivalent weight of grain, such as rice or wheat, because tubers have high water content. The high yields of most root crops ensure an energy output per hectare per day which is considerably higher than that of grains.

Starch is one of the strategic materials of the future. Starch is predominant carbohydrate reserve in many plants and provides the main source of energy in the human diet. The most important source of starch are cereal grains (40-90%), tubers (65-85%) and pulses (30-70%). According to Horton (1988) root crops are starchy staples providing low cost energy. The starch contain linear amylose and branched amylopectin. Generally the amylose present in root and tubers

contribute the gel strength and amylopectin gives high viscosity. Cassava and to a small extent sweet potato are used for starch extraction in countries such as India, Brazil, Thailand, Indonesia, Philipianes and China (Moorthy, 2002). According to CTCRI (2016) the starch content of cassava (77.4 per cent), canna (77 per cent), yam (70.2 per cent), coleus (70 per cent) taro (65.4 per cent), sweet potato (64 per cent), arrowroot (62 per cent) and tannia (30 per cent) were reported. The starch content of aroids varies from 18 to 28 per cent fresh tuber weight in case of colocasia and 15 to 20 per cent in elephant foot yam.

Tannia is a good source of carbohydrate, protein and vitamins which can be a good substitute for major cereals (Moy *et al.* 1993). Chellammal (1995) reported that tannia and taro are rich source of starch which can be converted to sugar during storage. My *et al.* (2000) reported that taro can be provided as a good substitute for cereals because of its good starch, protein and vitamin content.

Peter and Palaniswami (2008) reported that among the tubers, the protein content is high in taro (3 g/100g) followed by tannia (2.8 g/100g) coleus (2.7 g/100g), elephant foot yam (2.2g/100g), giant yam (2.2g/100g), greater yam (2.06/100g), lesser yam (1.3 g/100g), canna (1.19 g/100g), white yam (1.1 g/100g), arrow root (1g/100g) and cassava (0.7g/100g). The fat content was comparatively low in tubers, (10.98g/100g) and tubers like tannia, canna, lesser yam, cassava, coleus, white yam, arrow root, elephant foot yam, gaint yam and taro contains 0.9g, 0.4g, 0.3g, 0.2g, 0.2g, 0.1g, 0.1g, 0.1g, 0.1g, 0.1g and 0.08g per 100g of fat respectively.

Besides being rich source of carbohydrates, most of the root and tuber crops are rich in vitamins and minerals too. Sweet potato is the richest source of β-carotene (6 mg/100g) among various tuber crops. Roots and tubers are rich in B vitamins also. Tannia is a rich source of thiamin (1.1 mg/100g) and elephant foot yam is rich in riboflavin (0.70 mg/100g). High niacin (1.7mg/100g) was observed in canna and vitamin B_6 in white yam(1.7 mg/100g).

Giant taro is one of the richest source of vitamin C, (76.5 mg /100g) which can compact disease like scurvy. Taro also contains greater amounts of vitamin B-

complex than whole milk. In addition, taro is especially useful to persons allergic to cereals and can be consumed by children who are sensitive to milk (CTCRI, 2016).

Lesser yam contains high amount of sugar than other yam species. Yams are considered to be the most nutritious of the tropical roots crops as these contain four times protein than cassava and high in essential amino acids, good source of vitamin A, vitamin C, fibre and minerals (Wanasundera and Ravindran, 2000). It stimulate the growth of beneficial microbes like *lactobacillus*. The tubers have high phenol content (0.13-0.22%) and hence darkening occurs rapidly on cutting or peeling (Peter and palanisami, 2008). Sweet potato is a good source of vitamin A, β-carotene and anthocyanin, which have the capacity to alleviate night blindness, coronary disorders and cancer (Anbuselvi and Muthumani, 2014).

According to Gopalan *et al.* (2012) calcium content of cassava, sweet potato, greater yam, white yam, lesser yam, coleus, taro, giant taro, tannia, elephant foot yam, arrowroot, canna was 50mg, 35mg, 8.2mg, 4.6 mg 7.5 mg, 17mg, 40mg, 46mg, 20mg, 50mg, 6mg, 20mg and iron content 0.9 mg, 0.2 mg, 0.60 mg, 0.60 mg, 0.8 mg, 6.0mg, 3.4mg, 0.5mg,1mg, 0.6mg, 2.2mg, and 0.41mg per 100g respectively.

Sodium content of cassava, sweet potato, coleus, taro, giant taro, tannia, arrowroot and canna were 14 mg, 55 mg, 3.3 mg, 17 mg, 3.1 mg, 4 mg, 7 mg, 30 mg per 100g respectively. Potassium content in the range of 22 mg to 150 mg was also observed in these tubers. The good sodium and potassium ratio of taro tubers regulate blood pressure level (Anbuselvi and Muthumani, 2014).

Potassium content of tannia and magnesium content of canna was not detected and potassium content of tubers like cassava, sweet potato, greater yam, white yam, lesser yam, coleus, taro, giant taro, elephant foot yam, arrowroot, canna were 271 mg, 337 mg, 318 mg, 361 mg, 303 mg, 3 mg 514 mg, 267 mg, 3.81 mg, 454 mg, 24. 6 mg per 100g respectively (Peter, 2008).

Magnesium content of cassava, sweet potato, greater yam, white yam, lesser yam, coleus, taro, giant taro, tannia were 21 mg, 25 mg, 17 mg, 23 mg, 26 mg, 1 mg, 33 mg, 33 mg, 52 mg per 100g respectively (Peter, 2008).

Estrogenic compounds present in yam tubers have anti hypertensive, bone protective, antimicrobial activities and also increase serum estrogen level especialy among middle aged women (Anbuselvi and Muthumani, 2014).

Roots and tubers have several health benefits due to the presence of vitamins, minerals, bioactive components like resistant starch, dietary fibre and phytochemicals. Resistant starch (RS) is defined as the fraction of starch, which resists digestion in the small intestine of healthy individual and is available for fermentation in large intestine (Englyst *et al.* 1992). Aprianita *et al.* (2009) observed that resistant starch in taro is (3.3 per cent), yam (13.2 per cent), sweet potato (10.2 per cent), canna (70.8 per cent), arrowroot (15.9 per cent) and cassava (10.4 per cent) and reported that the resistant starch in tubers have a positive role in reducing the digestibility and reduce the risk of obesity, diabetes and colon cancer.

Phytochemicals are the plant components that benificially effect our human health. The major phytochemicals present in roots and tubers are polyphenols, flavonoids, carotenoids, ascorbic acid, steroids, tri-terpenoids, anthocyanins and tannins. Carotenoids present in the tuber crops posses numerous bioactivities and play an important role in human health and nutrition, including provitamin activity, regulation of gene expression and induction of cell to cell communication (Chandrasekara and Kumar, 2016). Phytochemicals act as an antioxidant and antimicrobial agent and boost our immune system and also reduce the risk of non-communicable diseases like cardio vascular diseases, obesity diabetes etc. According to Senanayake *et al.* (2011) arrowroot contain high amount of polyphenols (13mg) and flavonoids (7 mg). Yam contain 11.6 mg of polyphenols and 5.46 mg of flavonoids, casava contain 9.83 mg per 100g of polyphenols and 2.47 mg per 100g of flavonoids, elephant foot yam contain 11 mg polyphenols and 2.47 mg per 100g flavonoids. The flavonoids of coleus have

been reported to lower blood cholesterol level and it have high antioxidant activity . The fibre content in elephant foot yam posses anti diabetic activity and reduce the risk of colon cancer (Arva *et al.* 2013). Elephant foot yam (*Chena*) have a unique and rich nutritional profile and offer a number of significant health benefits. Low fat content, coupled with the high fibre make it a healthy and nutritious tuber. It contains phytoestrogen which helps to maintain the hormonal balance. Acridity is an issue while processing of elephant foot yam. Acridity is due to presence of raphids which come under the group of oxalates.

Cellulose, hemicellulose and lignin are the insoluble fibres present in roots and tubers. According to Peter and Palaniswami (2008) dietary fibre content 0.6 to 1.9 g per 100g in various tubers. Greater yam is rich in non-starch polysaccharides such as cellulose (2.6%), hemicellulose (3.4%), and lignin (1.1%) (NIN, 2004). Yam contains high amount of mucilage (2.5%), which possess anti-tumor, anti-inflammatory, immune modulatory and anti-oxidant activities. According to Kim and Fung (2004) starch present in arrowroot is low in fibre which reduce the risk of celiac disease and also protects irritated and inflamated internal tissues of the body and hence is given in bowel complaints.

Arrowroot is having tremendous potential in food and pharmaceutical industries. Arrowroot starch is a popular, easily digestible food for children and people with dietary restrictions and is used for stomach and intestinal disorders, including diarrhoea. Arrowroot is used in diet in the form of biscuits, puddings, jellies, cakes, hot sauces etc. (Kim and Fung, 2004).

Canna has fleshy rhizomes with good flavor, its starch is easily digestible and has good potential in food application since it possesses high viscosity, gel strength and high phosphorus content. In Kerala, purple and green types of edible canna are seen (May *et al.* 2014).

2.4. Food application of tubers

Root crops are the edible energy rich underground plant structures developed from modified roots. In tropical and subtropical countries, tuber starch is important supplemental or survival food. The tubers represent the most

significant source of edible starches in human diet Amani *et al.* (2004). A shift in the consumer interest to novel and healthy foods, resulted in encouraging the use of tubers in a variety of food preparation as a substitute for cereal starch (FAO, 2007). Tubers are not potentially exploited for consumption and for processing purpose and their usage is restricted to some species. Tubers were identified as an alternative source of starch for the product development. Roots and tubers are used as fresh, boiled, rosted and fried form (Balagopalan, 2000). Scott *et al.* (2000) opined that use of tubers in Asia and North Africa increased with rise in consumer desire, urbanisation and income. Many researchers utilise tubers as an alternative source of wheat for product development.

Tuber flours are the primary product usually made from dried tubers. Flours can be used as starch substitute and a variety of food products can be prepared. Tuber starch have served as traditional staple for people all over the world especially at the time of shortage of food. Food diversification can be done with the substitution of tubers with cereals flour (Rufaidah and Dwiyitno, 2000). Lymo *et al.* (2007) described tubers as a main source of starch which can be utilised as a cereal starch substitute suitable for products like biscuts, cake, bread, noodles and cookies. Cassava flour and sweet potato flour is white in colour which can blend well with wheat flour for use in different food products (CTCRI, 2016).

Gari is crispy cassava product. Idusogie and Oliyide (1971) mentioned that the gari, dried cassava and starch are economic products of cassava tubers. *Gari* is an important product of West Africa from cassava roots that are crushed into a mash and fermented further sieved into small pieces, known as grits. Owusu *et al.* (2011) used cassava and sweet potato flour in the development of crackers with 100 per cent substitution. Adekunle and Mary (2014) prepared cookies from cassava flour with wheat flour and cowpea flour. Pasqualone *et al.* (2012) developed gluten free breads using cassava flour. Srivastava *et al.* (2012) observed biscuits prepared with 40 per cent sweet potato flour with wheat flour was organoleptically acceptable. Ammar and Paul (2009) reported the substitution of wheat flour with 10 per cent taro flour in bread resulted in bread with improved

rheological and organoleptic properties. Buns are the soft textured bakery products generally prepared from refined wheat flour. Anaveri (2016) standardised buns with 20 percent elephant foot yam flour and 80 per cent whole wheat flour with 2 per cent wheat bran, garden cress seed and flax seed had high acceptibilty and nutritional qualities Owusu *et al*, (2011).

Martin and Robert (2000) showed that the use of yam flour efficiently in products like cupcakes upto 50 per cent level. From yam, low cost products namely starch, pickle, sauce and infant gruel were developed (CTCRI, 2016). Amylose content is high in yam and was suitable for the preparation like cakes, puddings etc. and amylopectin content was high in cassava, which make it suitable for the preparation of soups and porridges (CTCRI, 2016).

Vattal and *murukku* are the traditional snack foods commonly prepared from rice flour and is widely consumed by people of Kerala. Simi (2014) prepared *vattal* and *murukku* using canna flour and found that the products prepared with 90 per cent and 80 per cent corn flour was highly acceptable.

Instant mixes are the right product for utilising the nutritional and health benefits of underexploited tuber crops. Instant soup mix, instant porridge mix, instant custard mix can be produced form tubers. Lymo *et al.* (2007) prepared instant porridge mix from yam, cassava and sweet potato with wheat and soya bean in the ratio of 50:20:30. Simi (2014) standardised custard mix from 90 per cent of canna starch and 10 per cent of corn starch and found it was a best combination for instant custard mix. Singh and Lakshmi (2015) prepared snack mix adding 88 per cent sweet potato flour and 8 per cent mushroom powder and found to be high in over-all acceptability and had a shelf life of two months. Elias *et al.* (2017) prepared custard mix from tannia corm starch blended with corn flour and found that 60 per cent tannia corm starch and 40 per cent of corn flour was found to be the best combination of instant custard mix.

Various tropical tubers are widely used in the development of extruded product like pasta, noodles etc. Jyothi *et al.* (2011) standardised protein enriched pasta from sweet potato flour (60 per cent) with whey protein concentrate, defatted soya flour, fish powder (10 per cent) and refined wheat flour (30 per

cent). Tuber based protein enriched pasta had all essential amino acids and these products can be considered as a complete protein food.

Sweet potato paste is a promising ingredient as wheat flour substitute in noodles. Ginting and Yulifianti (2015) prepared highly acceptable noodles from 60 per cent wheat flour and 40 per cent sweet potato paste. Blend of 60 per cent of wheat flour with 40 per cent of sweet potato paste could improve the noodle colour and acceptance. Sweet potato flour fortified with legume starches have high resistant starch and were used to make noodles. The product developed had medium glycemic index and high resistant starch content (CTCRI, 2016). Reddy (2011) standardised highly acceptable extruded snack with 60 per cent corn flour, 20 per cent bengal gram flour and 20 per cent yam, taro and sweet potato flour.

Probiotics are microbial supplement that can improve our health and immunity. Many probiotic food preparations have been developed based on tubers. Sweet potato curd was prepared in various combinations of milk and tuber, by fermenting a mixture of milk and β-carotene rich sweet potato puree with curd inoculum. Sweet potato provided additional minerals, dietary fibre, vitamin C and starch which functioned as a thickener and stabiliser. On the basis of nutritive value, curd prepared with 40 per cent sweet potato was highly acceptible. Enriching curd with β-carotene rich sweet potato will boost the consumers as a functional food and would alleviate many physiological disorders such as night blindness (Mohapatra *et al.* 2007). Megan and Colleen (2015) standardised yogurt with of sweet potato puree and found that sweet potato yogurt was highly acceptable. *Fufu* is fermented cassava flour and the food in West Africa, Ghana and Nigeria. *Fufu* is sour in taste, creamy white in colour and smooth in texture.

According to Amagloh (2012) the sweet potato-based formulations were superior to enriched weaning mix as complementary foods for infants in low-income countries, based on the fructose and phytate levels.

Papad is a popular food adjuct in Indian meal. Parvathi and Subbulakshmi (2016) prepared *papad* by using different proportion of taro, elephant foot yam and found that 30 per cent incorporation of elephant foot yam and taro provided

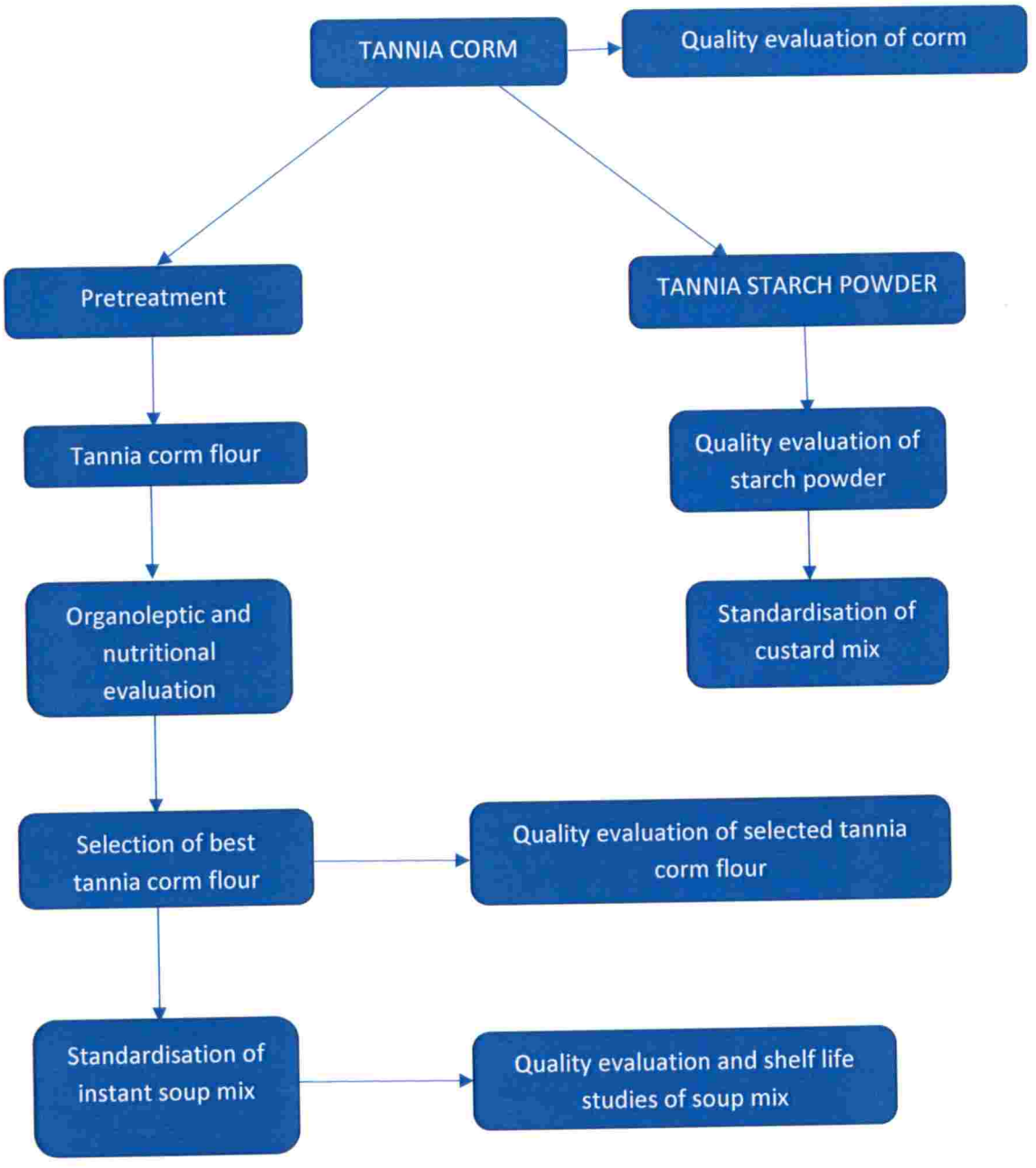
higher acceptability to *papad*. Based on mineral content, taro *papad* showed high mineral content than elephant foot yam *papad*.

Sago is an important product manufactured using cassava starch. The yield of sago is around 25 per cent of the fresh root weight. It contains about 12 per cent moisture, 0.2 per cent protein, 0.2 per cent fat, 87 per cent carbohydrate and has a calorific value of 351 calories per 100g. Sago is used mainly in infant formulas, pudding, pappad etc. (Balagopalan *et al.* 1987).

Modified starch are used in food industries as thickner, filler, binder and stabiliser in instant mixse like puding, soups, gravies, custard and jellies starch for food purpose. Cassava starches are most used as modified starches because of high gel stability and cassava strarches are also like to improve its vicosity stability to suit specific applications.

Materials and Methods

SCHEMATIC DIAGRAM OF RESEARCH DESIGN



2. MATERIALS AND METHODS

The present study entitled 'Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development' was proposed to evaluate the nutritional, antinutritional and organoleptic qualities of tannia corm (*Xanthosoma sagittifolium* (L.) Schott). The study also aims to evaluate the quality aspects of the flour, starch powder and to develop an instant soup mix using tannia corm. The materials used and the methods followed in the study are given under the following headings.

3.1. Collection of raw materials

3.2. Quality evaluation of tannia corm

- 3.2.1. Organoleptic qualities
- 3.2.2. Nutritional qualities

3.3. Preparation of tannia corm flour

3.4. Quality evaluation of tannia corm flour

- 3.4.1. Organoleptic qualities
- 3.4.2. Nutritional qualities

3.5. Preparation of starch powder

3.6. Quality evaluation of selected flour and starch powder

- 3.6.1. Physical qualities
- 3.6.2. Shelf life qualities
- 3.6.3. Sensory qualities

3.7. Standardisation of soup mix with tannia corm flour

- 3.7.1. Preparation of vegetable mix
- 3.7.2. Preparation of spice mix
- 3.7.3. Standardisation of soup mix

3.8. Shelf life studies of instant soup mix

3.9. Standardisation of custard mix with tannia corm starch

3.10. Cost of production of the developed instant mixes

3.11. Statistical analysis

3.1. Collection of raw materials

Fresh mature tannia (*Xanthosoma sagittifolium* (L.) Schott) corms were collected from the Agronomy Research Farm, College of Horticulture, Kerala Agricultural University. Selected tannia plants along with fresh corms are shown in Plate.1. All other ingredients required for the study were procured from the local market.

3.2. Quality evaluation of tannia corm

3.2.1. Organoleptic qualities

The organoleptic qualities of the cooked corms have been conducted by score card method using nine-point hedonic scale by a panel of fifteen selected judges. The raw tannia corm and cooked tannia corm are shown in Plate-2

3.2.1.1. Selection of judges

A series of organoleptic trials were carried out using simple triangle test at laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellinek (1985).

3.2.1.2. Preparation of score card

The sensory evaluation of the products was carried out using score card method (Swaminathan, 1974). Score card contains six quality attributes like appearance, colour, flavour, texture, taste and overall acceptability was prepared for the evaluation of the tannia corm. Each of the above-mentioned qualities were assessed by a nine-point hedonic scale. The score card for the evaluation of tannia corm is given in Appendix-I

3.2.2. Nutritional qualities

Fresh corms were analysed for the following chemical constituents. Following analysis were carried out in triplicate samples.

3.2.2.1. Moisture

3.2.2.2. Starch

3.2.2.3. Total sugar

3.2.2.4. Carbohydrates

3.2.2.5. Protein

Plate.1- Tannia plants and corms selected for the study

Plate. 2- Cooked tannia corm

3.2.2.6. Fibre

3.2.2.7. Total ash

3.2.2.8. Acidity

3.2.2.9. Calcium and Iron

3.2.2.10. Phosphorus

3.2.2.11. Sodium and Potassium

3.2.2.12. Polyphenols

3.2.2.13. *In vitro* digestibility of starch

3.2.2.14. *In vitro* availability of calcium, iron and zinc

3.2.2.15. Oxalate content

3.2.2.1. Moisture

Moisture content of tannia corm was estimated by the method of A.O.A.C (1980). To determine the moisture content of the products, five gram sample was taken in a petri dish and dried at 60^0C to 70^0C in a hot air oven, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample were calculated from the loss in weight during drying and expressed in percentage.

$$\text{Moisture content (\%)} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

3.2.2.2. Starch

Starch was estimated calorimetrically using anthrone reagent as suggested by Sadasivam and Manickam (1992). Weighed 0.5 g of the sample and extracted with 80 per cent ethanol to remove the sugars. The residue was dried over a water bath and added 5 ml water and 6.5 ml of 52 per cent perchloric acid and extracted at 00c for 20 minutes. The supernatant was pooled and made up to 100 ml. Pipetted out 0.2 ml of the supernatant and made up to one ml with water and 4 ml of anthrone reagent, heated for 8 minutes, cooled and read the OD at 630 nm.

A standard graph was prepared using serial dilutions of standard glucose solution. From the graph, glucose content of the sample was obtained and the value was multiplied by a factor of 0.9 to arrive at the starch content and expressed in g per 100g of sample

3.2.2.3. Total sugar

From the clarified solution used for the estimation of reducing sugar, 50 ml was taken and boiled gently after adding 5g citric acid and 50ml of water. This solution was neutralized with sodium hydroxide (1N) with few drops of phenolphthalein indicator until colourless solution. An aliquot of this solution was titrated against standard Fehling's solution A and B by adding methylene blue indicator (Ranganna, 1997). The total sugars present in tannia corm were computed using the formula as follows.

$$\text{Total sugars (\%)} = \frac{\text{Fehling's factor x 250 x dilution x 100}}{\text{Titre value x 50 x weight of the sample}}$$

3.2.2.4. Total carbohydrate

The total carbohydrate content of tannia corm was estimated by the method suggested by Sadasivam and Manickam (1992). Fifty milligram of sample was hydrolysed with 5ml of 2.5N HCl for 3 hours and cooled to room temperature. Then residue was neutralized with solid sodium carbonate until effervescence ceases. The volume was made up to 100 ml and centrifuged. The supernatant (0.2ml) was made up to 1ml and then 4 ml of anthrone reagent was added and heated for 8 minutes, cooled rapidly and the intensity of green to dark colour was read at 630nm. A standard graph was prepared using standard glucose at serial dilutions. From the standard graph, the amount of total carbohydrate present in sample was estimated and expressed in gram per 100 g of sample.

3.2.2.5. Protein

The protein content of corm was estimated using Lowry's method given by Sadasivam and Manickam (1992). Five hundred milligram of sample was extracted using 5 to 10 ml of buffer (Tris buffer GR – tris hydroxymethyl amino methane) and centrifuged. The supernatant (0.1ml) was taken in a test tube and 5ml alkaline copper solution was added. Mixed well and allowed to stand for 10 minutes. Later 0.5 ml of Folin-Ciocalteau reagent was added and incubated at room temperature in the dark for 30 minutes and the developed blue colour was read at 660nm. A standard graph was prepared using alkaline copper solution and Folin-Ciocalteau reagent at serial dilutions. From the standard graph, the amount

of total protein present in sample was estimated and expressed in gram per 100g of sample.

3.2.2.6. Crude fibre

The crude fibre content of tannia corm was estimated using the method given by Sadasivam and Manickam (1992). Two grams of dried and powdered sample was boiled with 200 ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200 ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and residue was washed with 25 ml of boiling 1.25 per cent of sulphuric acid, three 50 ml portion of water and 25 ml of alcohol. Then obtained residue was taken in an ashing dish (W_1) dried at 130^0C for 2 hours. Cool the dish in a desiccator and weighed (W_2). The residue was again ignited in muffle furnace at 600^0C for 30 minutes, cooled in a desiccator and reweighed (W_3).

3.2.2.7. Total ash

The ash content of the tannia corm was estimated using the method given by ISI (1980). Five grams of sample was taken in a crucible and then was ignited at 550- 600^0C in a muffle furnace for 5 to 6 hours. Cooled in a desiccator at room temperature and weighed. The ash content of sample was expressed in percentage.

3.2.2.8. Total acidity

Acidity was estimated by titration. The sample were mix thoroughly and pipette 17.6 ml of sample and two drops of phenolphthalein indicator solution were added to the sample and titrate the sample with the N/10 sodium hydroxide solution (0.1 Normal NaOH) while stirring the sample with the glass rod. Look for the appearance of a faint pink colour which signals the endpoint. Recorded the number of ml of NaOH used to reach the endpoint.

Total acidity = 0.5 × titre value

3.2.2.9 Calcium and iron

The calcium and iron contents of tannia corm were estimated by Atomic Absorption Spectrophotometric method using diacid extract prepared from the sample (Perkin – Elmer, 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100ml and used directly in Atomic Absorption Spectrophotometer for the estimation of calcium and iron and expressed in mg per 100 g of the sample.

3.2.2.10. Phosphorus

The phosphorus content was analysed calorimetrically as suggested by Jackson (1973), which gives yellow colour with nitric acid vandate molybdate reagent. To 5 ml predigested aliquot, 5 ml of nitric acid vandate molybdate reagent was added and made up to 50 ml with distilled water. After 10 minutes, the OD was read at 420 nm. A standard graph have plotted by serial dilution of standard phosphorus solution. The phosphorous content was expressed in mg per 100g.

3.2.2.11. Sodium and potassium

The fresh tannia corms were estimated for sodium and potassium contents by using flame photometer as suggested by Jackson (1973). One gram of the sample was digested using diacid solution and made up to 100ml with distilled water. From this made up solution, one ml was directly fed in to the flame photometer and reading was taken. The sodium and potassium contents were expressed in mg per 100g of the sample.

3.2.2.12. Total phenols

Total phenol estimation was carried out with Folin – Ciocalteau reagent as suggested by Sadasivam and Manickam (1992). One gram of the sample was ground well using a mortar and pestle with 10 to 15 ml of 80 per cent ethanol. It was centrifuged and the residue was re-extracted twice and pooled. The supernatant was evaporated to dryness. The residue was dissolved with 5 ml of distilled water. The supernatant used for the estimation of total phenol was pipetted out into a series of test tubes. Sample extracts (0.2ml) were pipetted out in other test tubes. To each test tube including blank, 3 ml of distilled water was

added. It was mixed well with 0.5 ml Folin-Ciocalteau reagent and allowed to stand for 3 minutes. Later to all test tubes, 20 per cent sodium carbonate solution (2ml) was added, mixed thoroughly and the tubes were kept in boiling water bath for exactly one minute and cooled. Optical density was recorded in a spectrophotometer at 650 nm. A standard graph was drawn using different concentration of catechol and the amount of total phenol in the sample was calculated and expressed in mg per 100g of sample.

3.2.2.13 *In vitro* digestibility of starch

One gram of sample in 100 ml water was gelatinized and boiled for one hour and filtered. One ml of the gelatinized solution was taken and one ml of the enzyme solution (saliva diluted with equal quantity water). The mixture was incubated at 37°C for 1-2 hours; the reaction was stopped by adding one ml of sodium hydroxide. Later the glucose was estimated.

3.2.2.14 *In vitro* availability of minerals

HCl extractability

The sample was extracted with 0.03N hydrochloric acid by shaking the contents at 37°C for 3 hours. The clear extract obtained after filtration with Whatman No.42 filter paper was oven dried at 100°C and wet acid digested. The amount of the HCl extractable calcium, phosphorus, iron, potassium and zinc in the digested sample were determined by the methods as described for the estimation of minerals.

$$\text{Mineral extractability} = \frac{\text{Mineral extractability in 0.03N HCl}}{\text{Total mineral}} \times 100$$

3.2.2.15. Oxalate

Oxalate content of the tannia corm was analysed by the procedure suggested by Marderosin *et al.* (1979). Weighed 2g of sample in a 250 ml volumetric flask, add 190ml of distilled water and 10 ml of 6N HCl. Boiled the contents on a water bath and make up the volume and filtered. The precipitate was washed in between to make the volume to about 125ml. added 3-4 drops of methyl red to filtrate followed by concentrated ammonia till the solution turns to faint yellow. Heated the content to 90-100^{0}C and filter it in No.41 filter paper

after washed to remove impurities. Added 10 ml of 5 per cent $CaCl_2$ and allow to stand for 24 hrs, then filtered through Whatsman No.41 filter paper and washed the precipitate several times with hot water to make it free from Ca ions. Transferred the precipitate to the original beaker by washing with distilled water. Then added dilute H_2SO_4(1:4) till the precipitate is completely dissolved and warmed the content to 70^0C and titrate with N/20 $KMnO_4$ near to end point and stir the filter paper to remove the side contents of beaker, wash with hot water and complete the filtration.

$$\text{Oxalate g/100g} = \text{N/20 } KMnO_4 \text{ used (ml)} \times 0.00225 \times \frac{250}{50} \times \frac{100}{2}$$

3.3. Preparation of tannia corm flour

The fresh mature corms were peeled, washed with water, cut in to pieces of 1 cm thickness and suitable pretreatments was given to remove oxalate content and to prevent browning. The treatments are detailed below.

T_0 - Control (without pretreatments)

T_1 - Boiling in water at 90^0C for 60 minutes

T_2 - Pressure cooking for 5 minutes

T_3 - Soaking in 1 % potassium metabisulphate for 30 minutes

T_4 - Soaking in 2 % citric acid for 30 minutes

T_5 - Soaking in 2 % tartaric acid for 30 minutes

T_6 - Soaking in 2 % baking soda in cold water for 30 minutes

T_7 - Soaking in 2 % ascorbic acid for 30 minutes

T_8 -Soaking in 2 % citric acid + 2 % ascorbic acid for 30 minutes

The treated samples were dried at 50^0C for 5-6 hours in a dryer. The dried slices were ground and sieved to get uniform flour. The preparation of tannia corm flour is shown in Plate-3.

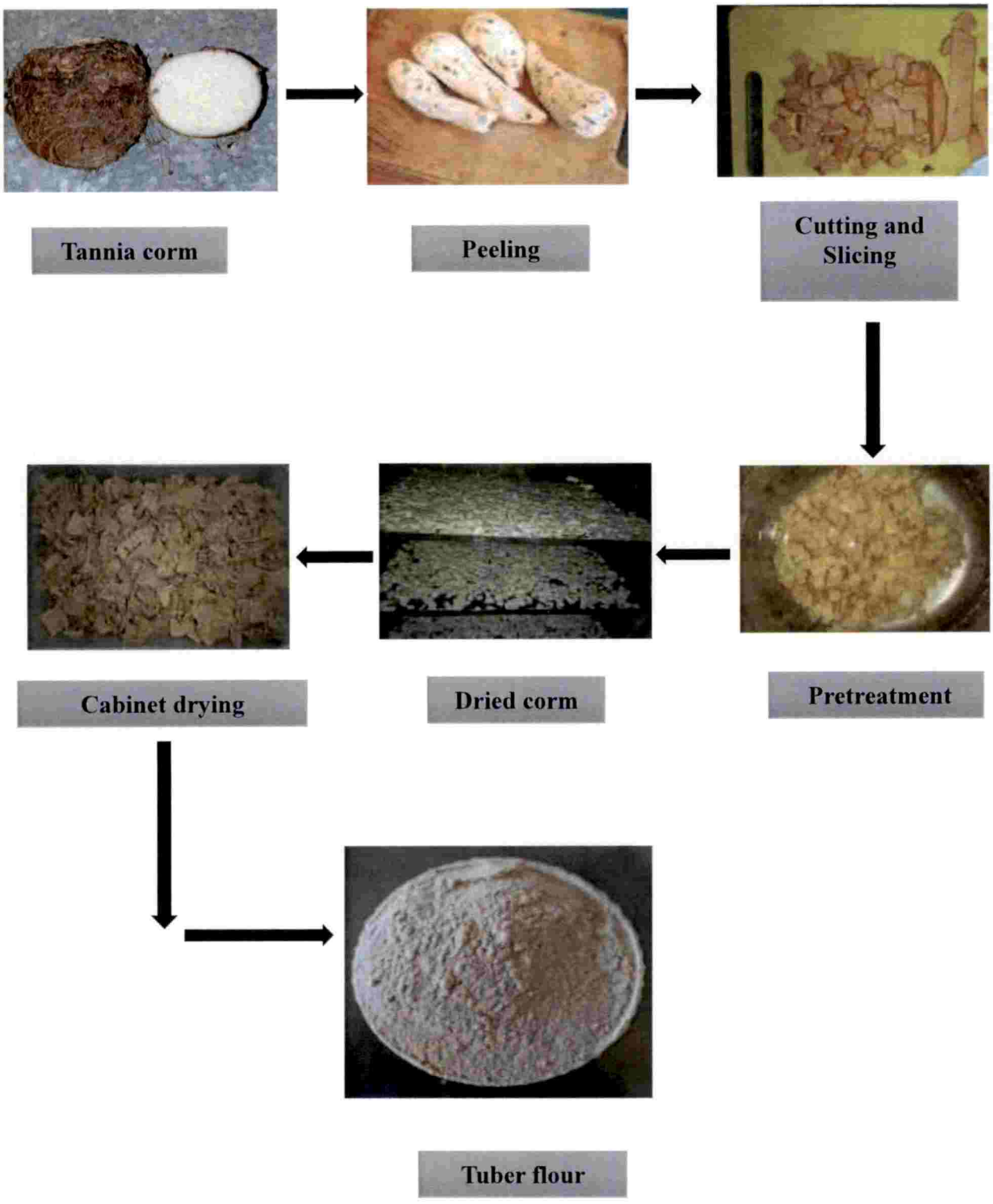
3.4. Quality evaluation of tannia flour

3.4.1. Organoleptic qualities

Organoleptic qualities of treated tannia flours were evaluated by preparing porridge. Porridge was prepared using pretreated tannia corm flour, adopting the standard procedure of Thajudeen (2000) and was organoleptically evaluated based

40

Plate. 3 – Preparation of tannia corm flour



on the procedure explained in 3.2.2. Organoleptically acceptable treatments were selected for quality evaluation.

3.4.2. Nutritional qualities

The major nutritional qualities like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron and zinc of the samples were analysed. Oxalate content also has been analysed (as per the procedures from 3.2.1 to 3.2.15. respectively). The product recovery was also noticed.

Based on the nutritional qualities and organoleptic scores, the best treatment was selected for further studies. The selected flour was stored in polyethylene covers (200 gauge) for a period of three months.

3.5. Preparation of starch powder

Tannia corm starch was extracted and dried using standard procedure suggested by Moorthy (2002). Tannia corms were washed, peeled and pulped in a Remi blender with 10 volumes of water. The pulp was mixed with 5 volume water, strained through a 150-mesh sieve and allowed to settle. Resuspension and resettling were carried out several times and the deposited cake was dried in sunlight and stored in airtight glass container for three months. The product recovery was also noticed as mentioned in 3.6.1.2. The starch powder was packed in polyethylene covers (200 gauge) and stored for a period of three months. The preparation of starch powder was showed in plate.4

3.6. Quality evaluation of selected flour and starch powder

The following quality aspects of the selected flour and starch powder was studied on monthly basis till the end of the three months of the storage period using standard procedures.

Plate.4 - Preparation of starch powder from tannia corm

Cleaning and peeling

Chopping

Soaking in 1% KMS

Grinding and stirring with water

Filtration

Decantation

3.6.1. Physical qualities

3.6.1.1. Moisture

3.6.1.2. Product recovery

3.6.1.3. Bulk density

3.6.1.4. Water absorption index and Water solubility index

3.6.1.5. Oil absorption capacity.

3.6.2. Shelf life qualities

3.6.2.1. Enumeration of microbial population

3.6.2.2. Insect infestation

3.6.3. Sensory qualities

Appearance, colour, flavour, texture, taste and overall acceptability

3.6.1. Physical qualities

3.6.1.1. Moisture

The moisture content of the tannia corn flour and starch powder was determined as per the procedure mentioned in 3.2.1.

3.6.1.2. Product recovery

Weight of tannia corm flour and starch powder prepared from 50g fresh tannia corm slices, were recorded in an electronic balance and product recovery was calculated

$$\text{Product recovery (\%)} = \frac{\text{Weight of flour (g)}}{\text{Weight of raw tannia corm slices before frying (g)}} \times 100$$

3.6.1.3. Bulk density

The bulk density of the flour and starch powder was determined by the method described by Okaka and Potter (1977). Fifty-gram sample was put into a 100 ml graduated cylinder. The cylinder was tapped 50 times and the bulk density was calculated as weight per unit volume of the sample.

3.6.1.4. Water absorption index (WAI) and Water solubility index (WSI)

WAI and WSI of flour and starch powder were determined by the method of Anderson *et al.* (1969). The sample (2.5g) was mixed with 30 ml distilled water using a glass rod and cooked at 90^0 C for 15 minutes in a water bath. The cooked paste was cooled to room temperature and transferred to centrifuge tubes and centrifuged for 10 minutes at 3000rpm. WAI and WSI were calculated by the expressions.

$$WAI = \frac{\text{Weight of the sediment}}{\text{Weight of the dry solids}}$$

$$WSI = \frac{\text{Weight of the dissolved solids in supernatant}}{\text{weight of the dry sample}}$$

3.6.1.5. Oil absorption capacity

Oil absorption capacity is the quantity of oil added to the sample by a known volume of supernatant. The standard procedure given by Ranganna (1997) was used to determine oil absorption capacity. One-gram sample was mixed with 10 ml of oil for 30 seconds. The sample was allowed to stand at room temperature for 30 minutes. It was then centrifuged at 3000 rpm for 30 minutes. The volume of supernatant was noted in a 10 ml graduated cylinder.

Oil absorption capacity = Initial volume of oil added to the sample – Volume of the supernatant

3.6.2. Shelf life qualities

3.6.2.1. Enumeration of microbial population

The tannia corm flour and starch powder was evaluated for the presence of bacteria, yeast and fungi initially and at monthly interval for three months. The method suggested by Agarwal and Hasija (1986) were microbe's serial dilution and plate count method. Ten grams of sample was added to 90 ml of sterile water and shaken for 20 minutes. From that 1 ml of solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4},

10^{-5} and 10^{-6} dilutions were also prepared. Enumeration of total micro flora was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungi and Sabouraud's dextrose agar media for yeast. The dilution for bacteria was 10^{-6} and for yeast 10^{-3} and for fungi 10^{-3}.

3.6.2.2. Insect infestation

Presence of storage insects was assessed by examining the flour and starch under the microscope. Flour was sieved first with 60 BL sieve and observed under microscope. The insect infestation in stored products was assessed initially and after a period of three months by visual examination

3.6.3. Sensory qualities

Sensory qualities like colour, flavor and texture of corm flour and starch powder were assessed by visual observation. Taste and overall acceptability were also evaluated.

3.7. Standardisation of soup mix with tannia corm flour

An instant soup mix were standardized by incorporating selected tannia corm flour and corn flour in varying proportions. All other ingredients were used as per the standard procedure (Senanayake *et al.* 2013).

3.7.1. Preparation of vegetable and spice mix

Carrot and beans were shredded and blanched in boiling water containing potassium metabisulphite (0.2 per cent) for 3 minutes. This was dried in a dryer. The dried vegetable was mixed together and this mix was used in soup mix. Onion, garlic and ginger were peeled, sliced and blanched in boiling water containing potassium metabisulphate (0.2 per cent) for 3 minutes. This was then ground to a paste and dried in a dryer.

3.7.2. Standardisation of soup mix

The treatment adopted for the standardisation are detailed below. Soups were prepared using the developed instant soup mixes and the organoleptic evaluation were conducted according to the procedure explained in 3.2.2. The most acceptable instant soup mix was selected for storage studies. The standardization of instant soup mix are shown in table .1

Table 1. Quantity of ingredients used for the standardisation of instant soup mix from tannia corm flour

Ingredients (g)	Treatments										
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Tannia corm flour	-	70	63	56	49	42	35	28	21	14	7
Corn flour	70	-	7	14	21	28	35	42	49	56	63
Vegetable mix	12	12	12	12	12	12	12	12	12	12	12
Spice mix	2	2	2	2	2	2	2	2	2	2	2
Pepper powder	1	1	1	1	1	1	1	1	1	1	1
Salt	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9	10.9
Sugar	4	4	4	4	4	4	4	4	4	4	4
Citric acid	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

3.8. Shelf life studies of instant soup mix

Selected instant soup mix were packed in metallised polyethylene pouches and stored for a period of three months under ambient conditions to evaluate:

3.8.1. Organoleptic qualities

Organoleptic qualities of treated tannia soup mix has been evaluated initially and on monthly basis till the end of the three months of the storage period.

3.8.2. Peroxide value

Peroxide values of soup mix was estimated to find the rate of rancidity during storage. It was estimated by the procedure given by Sadasivam and Manickam (1992). One gram of extracted sample was taken in a boiling tube and

to that one gram of potassium iodide and 20 ml solvent mixture (glacial acetic acid and chloroform) were added. The tube was placed in boiling water for 30 seconds and the contents were transferred to a conical flask containing 20 ml of 5 per cent potassium iodide solution. The tubes were washed twice with 25 ml water and collected in a conical flask. This was titrated against N/500 sodium thiosulphate solution until yellow colour disappears. Later 0.5ml of starch solution was added and titrated till the appearance of blue colour. A blank solution was also prepared and peroxide value was calculated and expressed in milli equivalent per kg of the sample.

3.8.3. Microbial enumeration

Microbial enumeration was done initially and on monthly basis till the end of the three months of the storage period as per the procedure shown in 3.6.2.1.

3.9. Standardisation of instant custard mix with tannia corm starch

An instant custard mix were standardized by incorporating tannia corm starch and corn starch in varying percentages. All other ingredients were used as per the standard procedure by Simi (2014)

Table-2. Quantity of ingredients used for the standardisation of ready to use custard mix from tannia starch powder.

Ingredients (g)	Treatment			
	T_0	T_1	T_2	T_3
Starch powder	-	35	28	21
Corn flour	35	-	7	14
Milk powder	15	15	15	15
Sugar	45	45	45	45
Cashew nuts	5	5	5	5

Custard was prepared using the developed instant custard mixes and organoleptic evaluation were conducted according to the procedure explained in 3.2.2.

3.10. Cost of production of the developed instant mixes

Cost of the developed instant mixes were estimated based on the expenses incurred for the preparation of the products. The cost of production was computed based on the market price of the ingredients used for preparation of products. The cost was calculated for 100g of the product and the details are presented in Appendix II.

3.11. Statistical analysis

The observations recorded were tabulated and data was analysed by using t test, two factor analysis and Kendall's Coefficient of Concordance (W).

Results

4. RESULTS

The results followed in the study 'Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development' are given under the following headings.

4.1. Quality evaluation of tannia corm

4.1.1. Organoleptic qualities of cooked tannia corm

4.1.2. Nutritional qualities

4.2. Quality evaluation of tannia corm flour

4.2.1. Organoleptic qualities of tannia corm flour

4.2.2. Nutritional qualities of tannia corm flour

4.3. Selection of the tannia corm flour

4.4. Quality evaluation of the selected flour and starch powder

4.4.1. Physical qualities

4.4.2. Shelf life qualities

4.4.3. Sensory qualities

4.5. Standardisation of soup mix with tannia flour

4.6. Shelf life qualities of selected tannia corm flour based instant soup mix

4.7. Standardisation of custard mix with tannia corm starch

4.8. Cost of production of selected soup mix and custard mix

4.9. Statistical analysis

4.1. Quality evaluation of tannia corm

4.1.1 Organoleptic qualities of cooked tannia corm.

Raw corms were cooked (Plate-2) and the organoleptic qualities of cooked corm were assessed. The results are presented in Table.3

The mean scores obtained for organoleptic qualities were in the range of 7.35 to 7.71 for different quality attributes. For appearance, mean score obtained was 7.71. For colour and taste the mean score of 7.66 each was recorded. The mean scores of 7.53, 7.35 and 7.60 were obtained for flavour, texture and overall acceptability respectively.

Table-3. Mean score for organoleptic qualities of cooked corm

Quality parameters	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
Mean scores	7.71	7.66	7.53	7.35	7.66	7.6

Table -4. Nutritional composition of fresh tannia corm

Nutritional constituents per 100g of raw sample	**Mean value**
Starch (g)	30
Total sugars, (g)	0.48
Carbohydrates (g)	72
Protein (g)	8.48
Fibre(g)	3.20
Total ash (g)	6.12
Acidity	0.02
Calcium (mg)	8.20
Iron (mg)	0.42
Phosphorus (mg)	40
Sodium (mg)	12.37
Potassium (mg)	28
Polyphenols (mg)	0.73
In vitro digestibility of starch	20
In vitro availability of calcium	7.36
In vitro availability of iron	0.20
In vitro availability of zinc	0.05
Oxalate (g)	1.03

Mean of three replication

4.1.2. Nutritional qualities

The nutritional constituents of the raw tannia corm were estimated. The constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron, zinc and oxalate content of the samples were analysed. The results pertaining to nutritional constituents of fresh corm are presented in Table.4

The mean moisture content in raw tannia corm was found to be 70 per cent. The starch content was found to be 30 per cent and the mean protein content in fresh corm was found to be 8.48 per cent with the mean total carbohydrate and fibre of fresh corm was recorded as 72g and 3.2g/ 100g respectively. The total ash and total sugar were recorded as 6.12g and 0.48g respectively. The calcium, iron, sodium content in 100 gram of sample was recorded as 8.2 mg, 0.42 mg and 8.2 mg. Tannia corm had good amounts of phosphorus (40 mg $100g^{-1}$) and potassium (28 mg $100g^{-1}$). The polyphenol content was recorded as 0.73 mg $100g^{-1}$ and the oxalate content was found to be 1.5 g per 100g of corm on fresh weight basis.

4.2. Quality evaluation of tannia corm flour

4.2.1. Organoleptic qualities of tannia corm flour

Various pretreatments were given to raw tannia corm to remove oxalate content and to prevent browning. The treated tannia corms were dried and powdered. Organoleptic qualities of the pretreated tannia flours were evaluated by preparing porridge. The mean score obtained for the different pretreated tannia corm flour porridges are given in Table. 5

The mean score for appearance of porridges varied from 1.57 to 7.8 with a mean rank score in the range of 1.03 to 9. The porridge prepared with potassium metabisulphite treated flour (T_3) had a maximum score of 7.8 with a highest mean rank score of 9.00 for appearance. The mean score obtained for appearance of porridge prepared with different pretreated flours were found to be 1.57 (T_8), 2.09 (T_7), 3.75 (T_6), 4.02 (T_5), 6.48 (T_4), 6.84 (T_2), 6.73 (T_1) and 6.11 (T_0). The mean rank score of the above treatments were 1.03, 2.00, 3.30, 3.67, 6.53, 7.20, 6.87 and 5.40 respectively.

Table. - 5 Mean scores for organoleptic qualities of tannia corm flour porridge

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0	6.11 (5.40)	5.31 (5.23)	5.77 (5.77)	6.55 (6.63)	6.66 (6.63)	6.4 (6.03)
T_1	6. 73 (6.87)	6.64 (6.73)	5.95 (6.03)	6.46 (6.07)	6.51 (6.07)	6.55 (6.40)
T_2	6.84 (7.20)	6.82 (7.20)	6.64 (7.73)	6.66 (7.43)	7 (7.43)	7.04 (7.43)
T_3	7.8 (9.00)	7.93 (9.00)	7.42 (8.93)	7.71 (9.00)	7.95 (9.00)	7.93 (8.97)
T_4	6. 48 (6.53)	6.37 (6.53)	5.91 (6.43)	4.97 (5.87)	6.4 (5.87)	6.42 (6.17)
T_5	4. 02 (3.67)	3.55 (3.37)	3.62 (4.00)	3.28 (3.93)	3.53 (3.93)	3.11 (3.80)
T_6	3.75 (3.30)	4.02 (3.90)	2.95 (3.10)	3.24 (2.87)	2.88 (2.87)	2.6 (3.03)
T_7	2.09 (2.00)	1.93 (1.73)	1.73 (1.70)	1.93 (2.03)	2.13 (2.03)	2.09 (1.80)
T_8	1.57 (1.03)	1.71 (1.30)	1.53 (1.30)	1.95 (1.17)	1.46 (1.17)	1.88 (1.37)
Kendall's w	.956*	.926*	.942*	.946*	.946*	.939*

Value in parenthesis is mean rank score based on Kendall's W which was significant at 1% level

Among the different treatments, porridges prepared with potassium metabisulphite treated flour (T_3) obtained the highest mean score of 7.93 and mean rank score of 9 for colour followed by T_2 (6.82).

The maximum mean scores for flavour (7.42) and texture (7.71) with the mean rank scores of 8.93 and 9.00 was obtained for porridge with treatment T_3. The mean scores for flavour of porridges for various treatments were found to be 6.64 (T_2), 5.95 (T_1), 5.91 (T_4), 5.77 (T_0), 3.62 (T_5), 2.95 (T_6), 1.73 (T_7), 1.53 (T_8). For texture the mean scores were 7.71 (T_3) 6.66 (T_2), 6.55 (T_0), 6.46 (T_1), 4.97 (T_4), 3.28 (T_5), 3.24 (T_6), 1.93 (T_7), 1.95 (T_8). The mean rank scores of porridges prepared with different pretreated tannia corm flour varied from 1.30 to 8.93 for flavour and 1.17 to 9 for texture.

Mean score for taste was found to be high (7.95) for porridge prepared with treatment T_3 followed by T_2 (7.0), T_0 (6.66), T_1 (6.51), T_4 (6.4), T_5 (3.53), T_6 (2.88), T_7 (2.13), T_8 (1.46) The mean rank scores were (T_2) 7.43, (T_0) 6.63, (T_1) 6.07, (T_4) 5.87, (T_5) 3.93, (T_6) 2.87, (T_7) 2.03, (T_8) 1.17. The mean score for overall acceptability of porridge prepared with treatment T_3 (7.93) was found to be the highest with a mean rank score of 8.97. The mean score obtained for T_0, T_1, T_2, T_4, T_5, T_6, T_7 and T_8 was found to be 6.4, 6.55, 7.04, 6.42, 3.11, 2.6, 2.09, 1.88 with rank score of 6.03, 6.40, 7.43, 6.17, 3.80, 3.03, 1.80 and 1.37

Tannia corm flour prepared after soaking the tannia corm pieces in 1% potassium metabisulphite for 30 minutes (T_3) was found to be the best in organoleptic qualities. The treatment, T_3 obtained mean score of above 7 for all quality parameters. Pretreatments like precooking tannia corms for 5 minutes and boiling in water at 90^0C for 60 minutes was also found to be good in organoleptic qualities. Porridge prepared by T_1 and T_2 obtained mean scores of 6.55 and 7.04 respectively for overall acceptability. But the pretreatments like T_4, T_5, T_6, T_7, and T_8 resulted in products with poor organoleptic qualities.

The organoleptic scores of different quality attributes namely appearance, colour, flavour, texture, taste, and overall acceptability were analysed using Kendall's (W) test and found to be significant. Hence, the mean scores were taken to differentiate the preference of the judges with regard to the quality attributes of

different treatments. The porridge prepared with different pretreated tannia corm flour is presented in Plate-5.

As pretreatments like T_4, T_5, T_6, T_7, T_8 resulted in products with poor sensory qualities, these treatments were found to be not effective in preventing browning reaction hence, tannia corm flour with pretreatment T_1, T_2 and T_3 were selected for further studies.

4.2.2. Nutritional qualities of tannia corm flour

The nutritional constituents of the selected pretreated tannia corm flours were estimated. The constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron, zinc and oxalate content of the samples were also analysed. The moisture content of the pretreated tannia corm flour T_1, T_2 and T_3 were 11.76 g, 10.03 g and 9.70 g per 100g respectively. The acidity of all the selected pretreated tannia corm flours were the same (0.01 per cent) whereas in the control it was 0.02 per cent. The starch content was high in T_0 (30.66 g per 100g) and in T_1, T_2, T_3 the starch content were 28g, 28.10g and 30.16g per 100g respectively. The total sugar content in T_0 was 0.42 g per 100g and in pretreated samples like T_1, T_2 and T_3 it was 0.30g, 0.32 g and 0.34 g per 100g respectively. The carbohydrate content of the control (72.50g/ 100g) was on par with that of pretreated samples T_1 (71.40g/100g), T_2 (72.50g/100g) and T_3 (70.20g/100g). The protein content was high (7.80g/100g) for control sample followed by T_3 (7.50g/100g), T_1 (6.80g/100g) and T_2 (6.40g/100g). The fibre content was high in T_1 (3 g/100g) followed by T_2 (2.80 g/100g) and T_3 (2.80 g/100g). The total ash content of tannia corm flour were in the range of 4.5 to 5.6 g per 100 g. The minerals like calcium, iron, phosphorus, sodium and potassium content of tannia corm flour were also analysed and observed a low mineral content in the pretreated tannia corm flours when compared to control. The calcium content was 8.10 mg per 100 g in control and in pretreated samples it was in the range of 7.03 mg to 7.53 mg per 100 g. The iron content in the control was 0.42 mg per 100g and there was no significant difference in the iron content in the pretreated flours. The phosphorus content of

Plate. 5- Porridge prepared with pretreated tannia corm flour

T_0

T_1

T_2

T_3

T_4

T_5

T_6

T_7

T_8

the tannia corm flour in control sample was 39 mg per 100 g and in pretreated flours it was in the range of 34.8 mg per 100 g (T_3) to 39.03 mg per 100 g (T_1). Sodium and potassium content of the control sample were 12.16mg and 43.06 mg per 100 g and the sodium content of pretreated flours were in the range of 9.86 mg (T_2) to 10.43 mg (T_1) and the potassium content was in the range of 40.03 mg (T_1) to 42.16 mg per 100g (T_3).

The *in vitro* digestibility of starch was assessed in all the selected tannia corm flours. In control, the *in vitro* digestibility of starch was 18.10 g per 100 g where as a higher *in vitro* digestibility of starch was observed in T_3 (20.70 g per 100g) followed by T_2 (20.30 g per 100g) and T_1(19.23 g per 100g). The *in vitro* availability of calcium, iron and zinc were analysed in which the availability of calcium in control was 6.76 mg per 100 g. The *in vitro* availability of calcium in the pretreated flours are in the range of 6.26 to 6.91mg per 100 g. The *in vitro* availability of iron in control was 0.17 mg per 100 mg and in pretreated flours, it was 0.22 mg (T_3), 0.25 mg (T_2) and 0.28 mg (T_1). The *in vitro* availability of zinc was observed as 0.013g per 100 g in control sample. Higher *in vitro* availability of zinc was observed in T_2 (0.60mg/100g) followed by T_3 (0.40 mg/100g) and T_1 (0.023 mg/100g).

Antinutrients like oxalate and polyphenols were also analysed and the oxalate content of control was 1.03g per 100g which decreased after preatreatments (0.20g/100g each). The polyphenol content of control was 0.60g per 100g and it is 0.76 g per 100 g in T_3 and 0.71 in T_2 and 0.57 in T_1.

The results pertaining to nutritional constituents of tannia corm flour are presented in Table. 6a, 6b, 6c and 6d

4.3. Selection of the tannia corm flour

From the various pretreatments tried for the selection of flour, the most acceptable treatment was selected for developing instant soup mix. The mean scores obtained for various organoleptic qualities and nutritional qualities were taken in to account to select the most acceptable treatment. For all quality parameters, the treatment T_3 obtained high mean scores and it was nutritionally on par with T_0. The oxalate content was also comparatively low for this treatment.

Table.6a. Nutritional composition of pretreated tannia corm flour

Treatments	Nutritional qualities of tannia corm flour						
	Moisture (g)	Acidity	Starch (g)	Total sugars(g)	Carbohydrate (g)	Protein (g)	Fibre (g)
T_0	10.00	0.02	30.66	0.42	72.50	7.80	2.23
T_1	11.76	0.01	28.00	0.30	71.40	6.80	3.00
T_2	10.03	0.01	28.10	0.32	72.50	6.40	2.80
T_3	9.70	0.01	30.16	0.34	70.20	7.50	2.80
CD value	0.094*	0.12*	0.05*	NS	NS	0.054*	0.054*

Significant at 1% level

Table.6b. Nutritional composition of pretreated tannia corm flour

Treatments	Nutritional qualities of tannia corm flour					
	Total ash (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)	Sodium (mg)	Potassium (mg)
T_0	5.60	8.10	0.42	39	12.16	43.06
T_1	4.50	7.10	0.41	39.03	10.43	40.03
T_2	5.60	7.03	0.38	38.10	9.86	41.83
T_3	5.10	7.53	0.37	34.80	10.13	42.16
CD value	0.05*	0.43*	NS	0.054*	0.172*	0.144*

Significant at 1% level

Table.6c. Nutritional composition of pretreated tannia corm flour

Treatments	Nutritional qualities of tannia corm flour			
	In vitro digestibility of starch	*In vitro* availability of calcium	*In vitro* availability of iron	*In vitro* availability of zinc
T_0	18.1	6.76	0.17	0.013
T_1	19.23	6.26	0.28	0.023
T_2	20.30	6.33	0.25	0.60
T_3	20.70	6.91	0.22	0.40
CD value	0.15*	0.09*	0.012*	NS

Significant at 1% level

Table.6d. Nutritional composition of pretreated tannia corm flour

Treatment	Quality parameters of tannia corm flour	
	Oxalate (mg/100 g)	**Polyphenol (mg/100 g)**
T_0	1.03	0.60
T_1	0.21	0.57
T_2	0.10	0.71
T_3	0.20	0.76
CD value	0.05*	NS

Significant at 1% level

Hence, T_3 (tannia corm flour prepared by soaking in 1 % KMS) was selected as the best treatment to prepare product and also for further studies.

The selected tannia corm flour and starch powder were packed in aluminium poly ethylene covers (200 gauge) and stored for three months.

4.4. Quality evaluation of selected flour and starch powder

4.4.1. Physical qualities of tannia corm flour and starch powder

Selected flour and starch powder prepared from tannia corm were evaluated for various physical qualities initially and monthly intervals for three months of storage. Physical qualities like moisture, bulk density, water absorption index (WAI), water solubility index (WSI) and oil absorption capacity (OAC) were estimated and the product recovery of both the flour and starch powder were also assessed. The product recovery of tannia corm flour was 60 per cent and the product recovery of starch powder was 24 per cent.

The moisture content of corm flour was found to be 9.8 per cent initially and it increased to 11.1 per cent after three months of storage. In starch powder the moisture content was found to be 15.2 per cent initially and it increased to 16.8 per cent after three months of storage. Initially, the bulk density of corm flour was found to be 0.63 g per cc and it decreased to 0.60 g per cc after three months of storage. In starch powder, the bulk density was 0.54 g per cc initially which decreased to 0.50 g per cc after three months of storage.

Water absorption index in corm flour and starch powder was found to be 15.5 and 17.8 respectively. After three months of storage, it decreased to 14.82 in corm flour and to 16.8.

Initially, the water solubility index of corm flour was found to be 0.18 and in starch powder it was 0.15. After three months of storage the water solubility index decreased to 0.12 in corm flour and to 0.11 in starch powder. Oil absorption capacity (OAC) of corm flour was 0.92 g/g initially and 0.86 g/g after three months of storage. In the case of starch powder, it was 0.53 g/g initially and 0.48 g/g after three months of storage. The physical qualities of tannia corm and starch powder are shown in Table. 7

Table 7. Physical qualities of tannia corm flour and starch powder during storage

Physical qualities	Tannia corm flour				Starch powder			
	Initial	1st month	2nd month	3rd month	Initial	1st month	2nd month	3rd month
Moisture (%)	9.8	10.01	10.5	11.1	15.2	15.8	16.2	16.8
Bulk density (g/cc)	0.63	0.63	0.62	0.60	0.54	0.52	0.52	0.50
WAI	15.5	15.02	14.9	14.82	17.8	17.2	17.01	16.8
WSI	0.18	0.18	0.16	0.12	0.15	0.14	0.14	0.11
OAC (g/g)	0.92	0.92	0.88	0.86	0.53	0.52	0.50	0.48

WAI- Water absorption index

WSI- Water solubility Index

OAC- Oil Absorption Capacity

4.4.2. Shelf life qualities of tannia corm and starch powder

4.4.2.1. Microbial qualities

The corm flour and starch powder were evaluated for bacteria, fungi, and yeast initially and monthly intervals of storage and result pertaining to microbial enumeration are given in Table 8 and 9 respectively. The bacterial count in corm flour was found to be 0.4 $\times 10^5$ cfu g^{-1} initially which increased to 2.2×10^5 cfu g^{-1} at the end of three months of storage period.

In starch powder the fungal growth was not detected initially. But a fungal count of 1.20×103 cfu g^{-1} was observed in corm flour at the end of second month and 1.2×10^3 cfu g^{-1} at the end of third month of storage. Yeast growth was not detected in corm flour initially and at the end of storage.

The fungal growth was found to be 0.6 $\times 10^3$ cfu g^{-1} initially in flour and it increased to 1.4 $\times 10^3$ cfu g^{-1} at the end of storage. The initial yeast growth in starch powder was not detected but a yeast count of 1.2 $\times 10^3$ cfu g^{-1} were observed at the end of storage period

4.4.2.2. Insect infestation

Insect infestations in corm flour and starch powder was evaluated initially and at the end of three months of storage. Insect infestation was not detected in both corm flour and starch powder during storage.

4.4.3. Sensory qualities

Sensory qualities of the starch and flour was analysed initially and monthly intervals and it was found that there is no significant difference in the sensory qualities like appearance, colour, flavour, texture, taste and overall acceptability of both starch and tannia corm flour during three months of storage. The mean values of sensory evaluation is shown in the Table-10 and 11

Appearance was analysed by visual observation and it was found that there was no significant changes in appearance of both the flour and starch powder initially and by the end of storage. The mean score for acceptability was 7.72 and 7.7 respectively and it was 7.68 and 7.68 at the end of third month of storage.

No change in colour was observed for both tannia flour and starch powder throughout the storage period. The mean score obtained for the colour was 7.62

Table 8. Microbial count in corm flour during storage

Tannia corm flour	Microbial population (cfu g-1)		
	Bacteria×10^5	Fungi×10^3	Yeast×10^3
Initial	0.4	ND	ND
1st month	1.3	ND	ND
2nd month	1.5	0.2	ND
3rd month	2.2	1.2	ND

ND- Not detected

Table 9. Microbial count in starch powder during storage

Starch powder	Microbial population (cfu g-1)		
	Bacteria×10^5	Fungi×10^3	Yeast×10^3
Initial	0.82	0.6	0.5
1st month	1.2	0.8	0.6
2nd month	1.8	1.2	1
3rd month	2.5	1.4	1.2

ND- Not detected

Table 10. Mean scores for the sensory qualities of tannia corm flour on storage

Tannia corm flour	Quality parameters					
	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Initial	7.72	7.62	7.60	7.50	7.20	7.70
1st month	7.70	7.62	7.58	7.40	7.10	7.60
2nd month	7.70	7.60	7.57	7.30	7.20	7.60
3rd month	7.68	7.60	7.58	7.40	7.10	7.60

Table 11. Mean scores for the sensory qualities of tannia corm starch on storage

Starch powder	Quality parameters					
	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Initial	7.70	9	8	7.60	8.10	7.70
1st month	7.80	9	7.80	7.40	8	7.70
2nd month	7.70	9	7.80	7.50	8.30	7.60
3rd month	7.68	9	7.70	7.40	8.20	7.50

and 9 for tannia corm flour and starch powder initially and it was 7.6 and 9 at the end of three months. The mean score was 7.6 and 8.0 for flavour at the initial month of storage respectively and it was 7.58 and 7.7 at the end of three months.

Texture of rhizome flour was slightly rough and starch powder was found to be fine. The starch powder and flour were uniform in nature and caking was practically absent in flour and starch powder during the entire storage period. Mean score obtained for texture of the starch and flour was 7.2 and 8.1 respectively at the initial month and it was 7.1 and 8.2 at the final month of storage.

The taste of the starch powder and flour was analysed by judging its taste at monthly intervals and it was found that there is no significant change in taste during storage period. Initially the mean score obtained for flour and starch powder for taste were 7.5 and 7.6 respectively and it was 7.4 and 7.4 at the end of three months.

The overall acceptability of flour and starch powder was good throughout the storage it was 7.7 and 7.7 at the initial month for flour and starch powder respectively and it was 7.6 and 7.5 at the end of three months.

4.5. Standardisation of instant soup mix with tannia flour

The mean scores obtained for the different organoleptic quality attributes of soup prepared using different combinations of tannia corm flour and corn flour are given in Table 12.

The mean score for appearance of soup varied from 4.88 to 7.5 with a mean rank score in the range of 2.30 to 10.52. the soup prepared with 10 per cent of tannia corm flour and 90 per cent of corn flour and the soup prepared with 20 per cent tannia corm and 80 per cent corn flour have got high mean score of 7.5 and 7.2 respectively and mean rank score of 10.52 and 10.50 respectively. In control (T_0) the mean score of appearance was 8.17 with a mean rank score of 8.77. The mean scores obtained for appearance of soup prepared with different proportion of tannia corm flour and corn flour were found to be 6.51 (T_7), 5.46(T_5), 5.44 (T_4), 5.44 (T_6), 5.33 (T_1) and 4.88 (T_3). The mean rank scores of the above treatments were 6.87, 3.83, 3.57, 3.57, 3.93, and 5.57 respectively.

Table 12. Mean score for the organoleptic qualities of soup mix

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0 (100% CF)	8.17 (8.77)	8.15 (9.23)	8.22 (9.83)	8.2 (9.97)	8.31 (8.96)	8.33 (8.83)
T_1 (100% TF)	5.33 (3.93)	5.33 (3.70)	5 (2.93)	5.82 (2.47)	5.33 (3.61)	5.33 (4)
T_2 (90% TF+10% CF)	4.88 (2.30)	4.44 (1.93)	5.97 (4.3)	5.51 (4.31)	5.57 (3.89)	5.62 (4.20)
T_3 (80% TC + 20% CF)	5.57 (3.93)	5.57 (4.07)	5.6 (2.97)	5.71 (2.94)	5.51 (3.46)	5.57 (3.67)
T_4 (70% TF + 30% CF)	5.44 (3.57)	5.64 (3.77)	5.84 (4)	5.71 (3.84)	5.51 (3.54)	5.37 (2.87)
T_5 (60% TF + 40% CF)	5.46 (3.83)	5.68 (4.17)	5.73 (3.50)	5.71 (4)	5.42 (3.4)	5.48 (3.73)
T_6 (50% TC+ 50% CF)	5.44 (3.57)	5.64 (3.77)	5.84 (4)	6.57 (3.84)	5.51 (3.54)	5.37 (2.87)
T_7 (40% TF + 60% CF)	6.51 (6.87)	6.4 (6.60)	6.55 (6.30)	6.66 (6.59)	6.6 (6.93)	6.37 (6.67)
T_8 (30% TF+ 70% CF	7.2 (8.23)	7 (8.60)	7.66 (10.17)	7.88 (10.41)	7.9 (11)	7.9 (11)
T_9 (20% TF+ 80% CF)	7.2 (10.50)	7.2 (9.33)	7.1 (9.17)	7.7 (8.59)	7.8 (8.04)	7.6 (8.17)
T_{10} (10% TF+ 90% CF)	7.5 (10.52)	7.2 (10.83)	7.3 (8.83)	7.6 (9.03)	7.8 (10)	7.42 (10)
Kendall's w	0.899*	0.860*	0.818*	0.854*	0.869*	0.864*

Figures in parenthesis indicate mean rank scores **significant at 1% level

CF- Corn flour

TF- Tannia corm flour

Among various treatments, soup mix prepared with 10 per cent tannia corm flour and 90 per cent corm flour T_{10} obtained the highest mean scores (7.2) for colour with mean rank score of 10.82. The mean score for colour of soup prepared with corm flour and corn flour in different proportions varied from 4.44 to 7.2. The maximum mean score for flavour (7.66) and texture (7.88) was obtained for soup prepared with 30 per cent corm flour and 70 per cent corn flour (T_8). The mean scores for flavour of soup for various treatments were found to be 8.22 (T_0), 7.1 (T_9), 7.3 (T_{10}), 6.55 (T_7), 5.97 (T_2), 5.84 (T_4), 5.84 (T_6), 5.73 (T_5), 5.6 (T_3), 5 (T_1) For texture the score were 8.2 (T_0), 7.7 (T_9), 7.6 (T_{10}), 6.66 (T_7), 6.57 (T_6), 5.82 (T_1), 5.71 (T_3), 5.71 (T_4), 5.71 (T_5), 5.51 (T_2), and the mean rank scores on the basis of Kendall's co efficient of variation with respect to texture and flavour of soup prepared with 30 per cent corm flour were found to be 0.854 and 0.869 respectively. The mean rank scores of soup prepared as different treatments varied from 2.93 to 10.17 for flavour. Mean score for taste was found to be 8.31 for control (T_0). In pretreated samples, the taste is high (7.9) for soup prepared with 30 per cent corm flour followed by T_9 (7.8), T_{10} (7.8), T7 (6.6), T_2 (5.57), T_3 (5.51), T_4 (5.51), T_6 (5.51), T_5 (5.42), and T_1 (5.33).

The overall acceptability of soup prepared with 30 per cent tannia corm flour was found to be 7.9 with a mean rank score of 11. The mean score obtained for T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_9 and T_{10} was found to be 8.33, 5.33, 5.62, 5.57, 5.37, 5.48, 5.37, 6.37, 7.6, and 7.42. With mean rank score of 8.83, 4, 4.20, 3.67, 2.87, 3.73, 2.87, 6.67, 11, 8.17, 10. The organoleptic scores of different quality attributes namely appearance, colour, flavour, texture, taste, and overall acceptability were analysed using Kendall's (W) test and found to be significant. Hence, the mean scores were taken to differentiate the preference of the judges with regard to the quality attributes of different treatments. Soup prepared with different proportions of tannia corm flour and corn flour are depicted in plate 6.

From the various treatments adopted for the standardization of soup mix, the most acceptable treatment was selected for storage studies. The mean scores obtained for organoleptic qualities were taken in to account to select the most acceptable treatment. More importance was given for the mean scores obtained

Plate.6 – Soup prepared with instant soup mix

T_0

T_1

T_2

T_3

T_4

T_5

T_6

T_7

T_8

T_9

T_{10}

for colour, flavour, texture and taste and it was seen that highest scores for these quality attributes were obtained for soup prepared with 30 per cent corm flour and 70 per cent corn flour (T_8). In this, the mean scores for flavour, texture, taste and overall acceptability were found to be 7.66, 7.88, 7.9 and 7.9 respectively. Hence, T_8 was selected as the most acceptable treatment for the preparation of soup mix.

4.6. Shelf life qualities of selected tannia corm flour based instant soup mix

The organoleptic qualities of soup mix during storage were evaluated by preparing soup and the mean scores for different quality attributes are shown in Table 13.

The mean score for the appearance of soup slightly decreased from 7.2 to 6.89 by the end of third month of storage. Initially, the mean score obtained for colour of the soup was 7.00 which have no change until the end of three months of storage. Regarding flavour, the initial mean score of 7.66 decreased to 7.40 after three months of storage. The mean score for the texture of soup, decreased from the initial mean score of 7.90 to 7.67 after three months of storage. The mean score for taste of the soup mix was 7.90 initially and which decreased to 7.60 after three months of storage. Overall acceptability of the soup mix was decreased from 7.90 to 7.80 at the end of the storage period.

The result pertaining to the microbial growth in instant soup mix during three months of storage are furnished in the Table 14.

In soup mix, the initial bacterial count was found to be 0.66×10^5cfu g^{-1} which increased to 1.6×10^5 cfu g^{-1} at the end of third month of storage. Initially, the fungal count of soup mix was not detected but at the end of three month it was found to be 0.5×10^3 cfu g^{-1} at the end of three months of storage. Yeast growth was also not detected in soup initially and at the last month of storage.

The peroxide value of soup was estimated initially and at the end of three months of storage and the results are given in Table 15.

Initially, the peroxide value of soup mix was found to be 0.005 meq kg^{-1}which increased to 0.02 meq kg^{-1} at the end of storage.

Table 13. Mean score for the organoleptic qualities of soup mix during storage

Starch powder	Quality parameters					
	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Initial	7.20	7.00	7.66	7.90	7.90	7.90
1st month	7.15	7.00	7.48	7.98	7.71	7.90
2nd month	7.13	7.00	7.46	7.89	7.68	7.88
3rd month	6.89	7.00	7.40	7.60	7.67	7.8

Table 14. Microbial count in soup mix during storage

Starch powder	Microbial population (cfu g-1)		
	Bacteria$\times 10^5$	Fungi$\times 10^3$	Yeast$\times 10^3$
Initial	0.66	ND	ND
1st month	0.70	ND	ND
2nd month	1.50	ND	ND
3rd month	1.60	0.50	ND

Table 15. Peroxide value of instant soup mix during storage

Product	Peroxide value (meq kg-1)				
	Initial	1st month	2nd month	3rd month	CD Value
Soup mix	0.005	0.008	0.01	0.02	00.012

Table 16. Standardisation of custard mix

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0	7.2 (1.33)	6.93 (1.27)	7.08 (1.43)	7.33 (1.67)	7.26 (1.6)	7.31 (1.67)
T_1	8.08 (2. 73)	8.13 (2.82)	7.82 (2.57)	8.06 (2.53)	8.08 (2.57)	7.9 (2.33)
T_2	7.64 (2)	7.53 (2)	7.45 (2)	7.7 (2)	7.67 (2.03)	7.6 (2)
T_3	8.5 (3.93)	8.53 (3.92)	8.64 (4)	8.6 (3.8)	8.64 (3.8)	8.5 (4)
Kendall's w	.872*	.902*	.775*	.567*	.721*	.599*

Figures in parenthesis indicate mean rank scores **significant at 1% level

T_0- 100% Starch powder

T_1- 100% Corn flour

T_2- 80% Starch powder+ 20% corn flour

T_3- 60% Starch powder+ 40% corn flour

4.7. Standardisation of custard mix with tannia corm starch

Custard mix were standardised using different proportion of starch powder and corm flour and the mean scores of the organoleptic qualities of custard mix were given in the Table 16.

Among the four treatments tried, custard prepared with 60 per cent corn flour and 40 per cent starch powder have got the highest mean score of 8.5 with a mean rank score of 3.93 for appearance. Custard prepared exclusively with tannia corm starch powder (T_0) obtained a mean score of 7.2 and rank score of 1.33. The mean score for appearance of custard prepared as T_1 (80 % TCF+ 20 % CN) was found to be 8.08 and 7.64 (T_2) respectively.

The mean score for colour and flavour of custard containing 60 per cent corn flour with 40 per cent starch powder (T_3) was found to be 8.53 and 8.64 respectively. Custard prepared with 100 per cent starch powder obtained a mean score of 6.93 for colour and 7.08 for flavour. The mean scores for colour of other two treatments were 8.13(T_1) and 7.82 (T_2) with a mean rank scores of 2.8 and 2 respectively. The mean scores for flavour of this two custard were 7.82 (T_1) and 7.45 (T_2) with a mean rank scores of 2.57 and 2.

The mean score for texture was high (8.6) for custard prepared with 60 per cent corn flour and 40 per cent starch powder (T_3). The mean rank score of custard prepared as T_3 was found to be 3.8. Custard prepared with 100 per cent starch powder obtained a mean score of 7.33 with a rank score of 1.67 for texture. The mean scores for texture of T_1 and T_2 were 8.06 and 7.7 with mean scores of 2.53 and 2 respectively.

For taste, custard prepared as T_3 obtained a mean score of 8.64 with a rank score of 3.8. Custard prepared exclusively with starch powder had a mean score of 7.26 with a rank score of 1.6. The mean score for taste of T_1 and T_2 were 8.08 and 7.67 with a mean rank score of 2.57 and 2.03 respectively. The overall acceptability of custard prepared as T_3 have got a highest mean score of 8.5 With a mean and rank scores of 4.The overall acceptability of custard prepared exclusively with starch powder was found to be 7.31 and mean rank score of 1.67.

The mean rank scores of T_1 and T_2 were 2.33 and 2 with a mean rank score of 2.33 and 2.

4.8. Cost of production of soup mix and custard mix

The cost of production of soup and custard mix were worked out based on the various ingredients required for the preparation of products. The cost of production of 100g of soup mix were found to be Rs.42.00. The cost of production of 100g of custard mix were 65.00. The cost of production of soup mix and custard mix was worked out and is mentioned in Appendix II.

Discussion

5. DISCUSSION

The discussion pertaining to the study entitled 'Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development' is presented in this section under the following heads.

5.1. Organoleptic and nutritional qualities of tannia corm

5.2. Quality evaluation of tannia corm flour

5.3. Quality evaluation of selected flour and starch powder

5.4. Standardisation and quality evaluation of instant mixes

5.5. Cost of production of the developed instant mixes

5.1. Organoleptic and nutritional qualities of tannia corm

The organoleptic evaluation of cooked tannia corm revealed mean score in the range of 7.35 to 7.71 for different quality attributes. Arbizu (1994) reported that the tannia have acceptable flavour and taste. Herman (1996) observed that tannia tubers are similar in structure and in taste to taro and are palatable.

The mean moisture content in raw tannia corm was 70 per cent. Gopalan *et al.* (2012) reported that moisture content of 73 percent in tannia corm.

In the present study, the starch content observed was 30 per cent. According to CTCRI (2016) the starch content of the tannia was 30 per cent and it also in the line with the study by Sefa-Dedeh and Agyir-sackey (2002) who reported that the cocoyam species contain 12.2 to 36 per cent of starch.

The sugar content of tannia was 0.48 g per 100g. According to FAO (2003) the sugar content of tannia corm was 0.42 g per 100g and it is similar to the value obtained in this study. Carbohydrate content of tannia corm was found to be 72 g for 100 g of sample.

In the present study, protein content of fresh corm observed was 8.48 g per 100g. This is almost similar to the observations of Akpan and Umoh (2004) who reported that the crude protein is 8.83 per cent in tannia and Sefa-Dedeh and Agyir-sackey (2002) reported a range of protein content in tannia from 2.98 to

8.50g per 100g. FAO (2015) reported a protein content of 2.15 g per 100 g and 2.24 g per 100g in taro and elephant foot yam are less when compared to the protein content of tannia corm in this study. In the present experiment crude protein was reported on fresh weight basis and it is lower in the studies of FAO (2015) and Gopalan *et al.* (2012) as they were estimated on dry weight basis. Gopalan *et al.* (2012) reported a protein content of 3g per 100g and 1.2g per 100g in colocasia and sweet potato.

The fiber content in the tannia corm was 3.2 per cent. Sefa-Dedeh and Agyir-sackey (2002) reported that tannia contain 1.11 to 3g per 100g crude fibre. Akpan and Umoh (2004) found that crude fibre content in tannia was 0.88 per cent. FAO (2015) reported fibre content of 1.34g and 1.99g per 100g in taro and elephant foot yam and is less when compared to the fibre content of tannia corm in this study. Gopalan *et al.* (2012) reported fibre content of 1g each in 100g of and elephant foot yam

The total ash content in this study was observed to be slightly higher (6.12 g per 100g). Sefa-Dedeh and Agyir-sackey (2002) reported that the ash content of tannia were 1.56 to 2.98g per 100g and in another study by Sefa-Dedeh and Agyir-sackey (2002) it was found to be 1.74 per cent.

Calcium in tannia corm was found to be 8.2 mg per 100g and similar results were reported by FAO (2015) in which it was found that the calcium content of tannia corm were 8.5 to 16 mg per 100 g. Ukpong *et al.* (2014) reported a calcium content of 17.66mg per 100g. Akpan and Umoh (2004) reported that calcium content was 18.64mg in 100g of tannia. Gopalan *et al.* (2012) reported a very high calcium content of 40mg and 35mg per 100g in colocacia and elephant foot yam.

In the present study the iron content observed was 0.42 mg per 100g and it was found to be almost same as reported by Akpan and Umoh (2004). FAO (2015) reported iron content of 1.5 and 1.8 mg per 100g in taro and arrow root and is high when compared to the iron content of tannia corm in this study. Gopalan *et al.* (2012) reported an iron content of 0.42 mg and 0.6 mg per 100g in colocacia and elephant foot yam. In the present study, the phosphorous content was 40 mg

per 100g and Ukpong *et al.* (2014) reported that the phosphorus content of tannia corm was 44.43mg per 100g and in another study Sefa-Dedeh and Agyir-sackey (2002) found pH content in the range of 41.6 to 63.1 µg per 100g. FAO (2015) reported phosphorous content of 55 and 88.5 mg per 100g in taro and arrow root and is high when compared to the phosphorous content of tannia corm in this study. Gopalan *et al.* (2012) reported high phosphorous content of 140 mg and 34 mg per 100g in colocasia and elephant foot yam.

In this study, sodium and potassium contents found were 12.37 mg per 100g and 28 mg per 100g in tannia corm. This in the line with the observations of Ukpong *et al.* (2014) who observed a sodium content in the range of 10.2mg to 19.33 mg and potassium content in the range of 12 mg to 52. 99 mg per 100g. Gopalan *et al.* (2012) reported potassium content of 9mg per 100g each for colocasia and elephant foot yam. The polyphenols and oxalate content of tannia corms found were 0.73 mg and 1.5 mg per 100g. Sefa-Dedeh and Agyir-sackey (2002) reported high oxalate content of 3.5 to 5 mg per 100 g and the polyphenol was found to be 0.65mg per 100g in tannia. Mohan and Kalidass (2010) reported that canna rhizome contain 0.94 per cent oxalates.

The *in vitro* availability of calcium, zinc and iron were 7.36g, 0.05 and 0.02 g per 100g and they were comparatively low. According to Lowell (2007) the *in vitro* availability of iron, calcium and zinc were reported to be 182.25 ± 8.75 mg/kg, 5150 ± 50 mg/kg and 6 g/kg

5.2. Quality evaluation of tannia corm flour

Various pretreatments were given to raw tannia corm to remove oxalate content and to prevent browning. The treated tannia corms were dried and powdered. Organoleptic qualities of the pretreated tannia flours were evaluated by preparing porridge.

The mean score for appearance of porridges varied from 1.57 to 7.8 with a mean rank score in the range of 1.03 to 9. The porridge prepared with potassium metabisulphite treated flour (T_3) had a maximum score of 7.8 with a highest mean rank score of 9.00 for appearance. This same treatment (T_3) obtained the highest

mean score of 7.93 for colour, 7.42 for flavor, 7.71 for texture and 7.95 for taste. The treatments with 1 per cent potassium metabisulphite was effective in removing browning and provided desirable properties to the flour. The acid treated tannia corms had dark colour when porridges prepared with their flour.

According to Mohan and Kalidass (2010), in acid or alkali treated tubers the pH would change and a precipitation of calcium oxalate might occur. This precipitated calcium oxalate might have contributed to the dark colour development when porridges were prepared.

The moisture content of the sample (T_0) without pretreatment was 10 per cent. A slight increase in the moisture content was observed in cooked samples. The observed increase in moisture in the cooked samples may be due to the effect of boiling which probably softened the tissue, thereby increasing the water absorption and water-retention capacity of the tubers due to increased permeability of the cell membrane to water (Mbajunwa, 1995). Acidity showed no considerable variation for T_1, T_2 and T_3 from the control. Starch content in control was 30.66 per cent which decreased to 28 per cent in cooked corm. The observed decrease may be due to the gelatinisation and solubilisation of starch granules on treatments. Around 70 per cent carbohydrate was observed in all the treatments. The protein content was 7.8g per 100g in T_0 which decreased in T_1 and T_2 to 6.80g and 6.40g per 100g respectively. This may be due to the denaturation of protein during heating. However, Debre and Brindza (1996), reported that the crude protein content may vary widely depending on the genotype and growing conditions.

In this study, fibre content of 2.23g per 100 g was observed in untreated tannia flour. A slight increase in fibre content in pretreated flour with the maximum increase in fibre content (2.8 g per 100g) was observed in tannia corm flour prepared after boiling for 60 minutes (T_1). This may be due to the degradation of cell wall due to prolonged heating. A fraction of starch was converted in to resistant starch due to prolonged cooking (Mbajunwa 1995). A decrease in mineral content like calcium, iron, phosphorus, sodium, potassium

was observed in pretreated tannia corm flour when compared to control. This decrease may due to the leaching out of minerals in pretreatments. According to Njoku and Ohia (2007) cocoyam contain significant amount of minerals, which decreased due to the leaching out after pretreatments. The oxalate content was 1.03g per 100g in untreated tannia corm flour, which decreased to 0.20g per 100g after pretreatments. Considerable decrease in oxalate content was observed in pretreated samples. According to Deshpande *et al.* (1982) boiling or blanching effectively reduced oxalate content of tannia. Alcantara *et al.* (2013) reported that raw taro had the highest oxalate content (156.33mg) which significantly decreased when processed into powder (35.67mg), cookies (32.21mg) and noodles (29.96mg).

In this study, the *in vitro* digestibility of starch was around 20 per cent in all the treatments. The *in vitro* availability of minerals was observed as higher than 50 per cent for all treatments. According to Sebnam (2015), in taro corms the *in vitro* digestibility of starch was around 20 per cent in pretreated sample. It was also indicated that pretreatments like boiling and pressure cooking improved the digestibility of starch.

5.3. Quality evaluation of tannia corm flour and starch powder

Physical qualities of selected corm flour (T_3) and starch powder were assessed initially and at monthly intervals for three months. Moisture is an important parameter which determines the shelf life of a product and levels greater than 12 per cent allow microbial growth. Low levels are favourable to give relatively longer shelf life (Aryee *et al.* 2006).

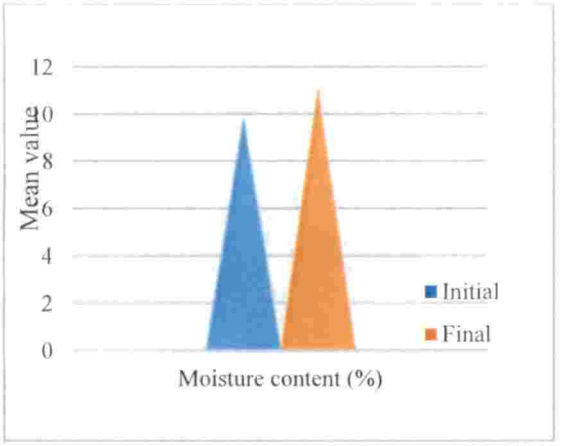
In the present study the observed moisture content of corm flour was 9.8 per cent initially, which increased to 11.1 per cent after three months of storage. Soni *et al.* (1990) reported moisture content of 11 per cent in tannia flour. Gopalan *et al.* (2012) observed slightly higher moisture content of 16.5 per cent in arrowroot rhizome flour. Adegunwa *et al.* (2011) reported moisture content of 15.71 per cent in the sun-dried white yam flour. In the starch powder, the moisture content was 15.2 per cent initially which increased to 16.8 per cent after three

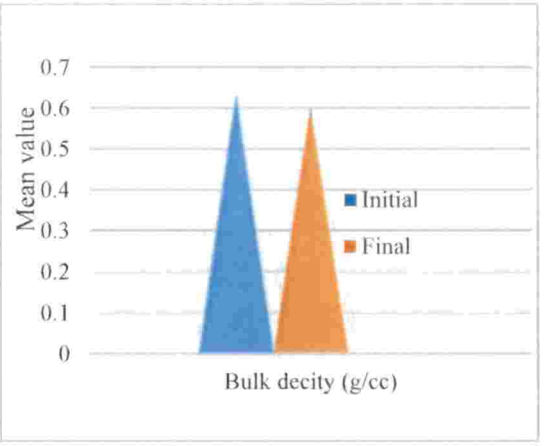
months of storage. The increase in the moisture content of the flour and starch powder during storage may be due to the moisture pick up by the flour during storage and due to higher relative humidity in the storage vicinity as suggested by Balasubramanyam (1995) and Sharif *et al.* (2003). Similar findings were reported by Chellammal (1995) in sweet potato flour and Liya (2001) in taro flour. Adegunwa *et al.* (2011) suggested that flour and starch powders containing more than 12 per cent moisture had less storage stability. During storage, changes in moisture content occur due to the hygroscopic properties of flour as reported by Kirk and Sawyer (1991) and Rehman and Shah (1999). Raj (2011) observed increase in moisture content in weaning foods based on grain amaranth flour during storage. The changes in physical qualities of corm flour and starch powder during storage are illustrated in Fig.1. and Fig.2

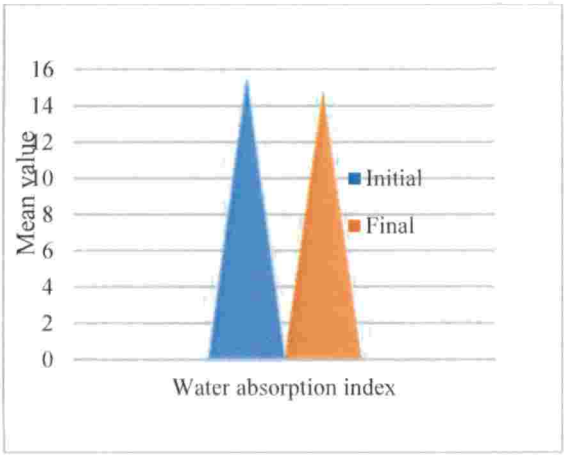
In the present study, the bulk density of corm flour was found to be 0.63 g/cc initially which decreased to 0.60 g/cc after three months of storage. In starch powder, the bulk density was 0.54 g/cc initially which decreased to 0.50 g/cc after three months of storage. Karolin (2004) indicated a bulk density in the range of 0.539 to 0.998 g/cc in different tuber flours. Adejumo *et al.* (2013) observed a bulk density of 0.43 g/cc g per ml for yam flour. The Bulk density of taro flour and potato flour was 0.689 g per ml and 0.585 g/cc respectively were indicated by Kaur *et al.* (2013).

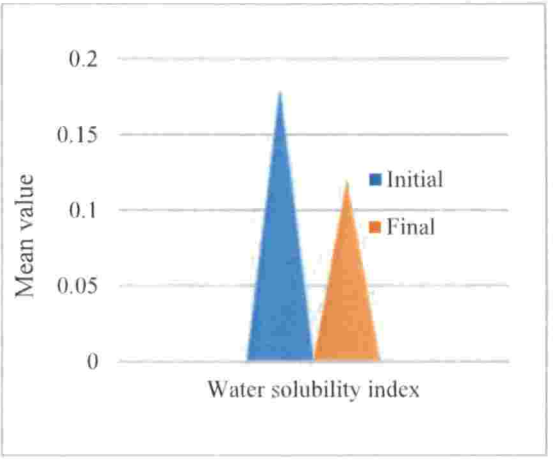
Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting (Singh, 2001). In this study, water absorption index in corm flour and starch powder was 15.5 and 17.8 respectively. After three months of storage, it decreased to 14.82 in corm flour and 16.8 in starch powder. Water absorption index observed in the present study was higher than the water absorption index of potato flour as reported by Moorthy *et al.* (2010). Singh *et al.* (2003) and Kaur *et al.* (2013) reported that taro flour exhibited higher water absorption capacity followed by potato flour and corn flour.

Fig.1- Changes in physical qualities of tannia corm flour during storage









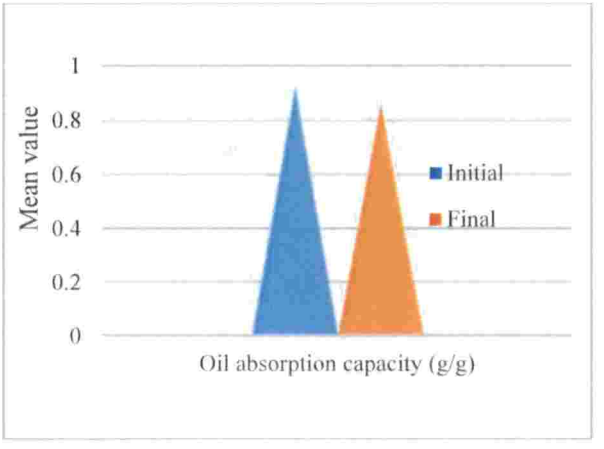
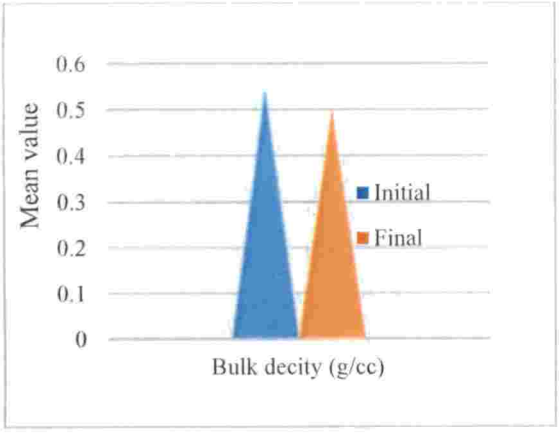
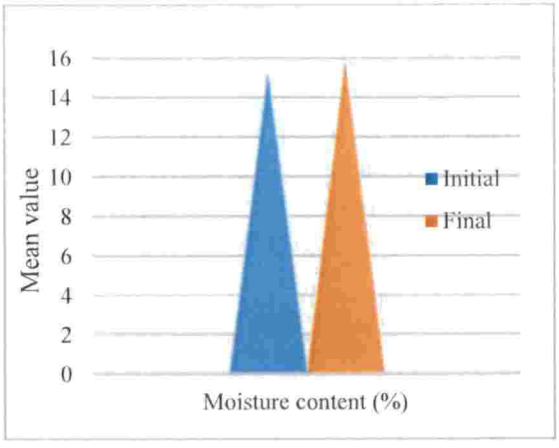
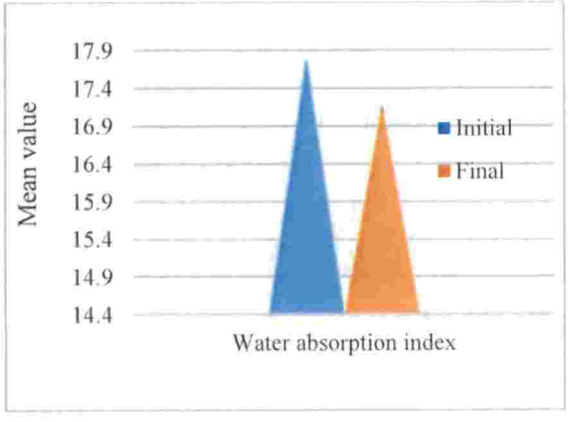
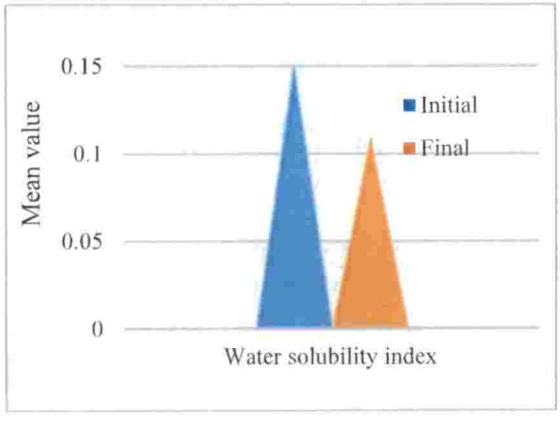


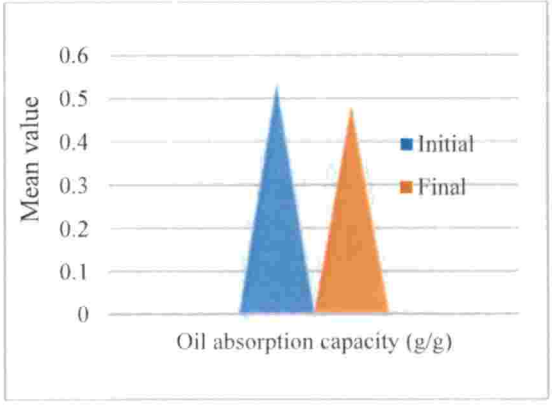
Fig.2- Changes in physical qualities of tannia corm starch powder during storage











Initially, the water solubility index of corm flour was 0.18 and in starch powder it was 0.15. After three months of storage the water solubility index decreased to 0.12 in corm flour and to 0.11 in starch powder. According to Santacruz *et al.* (2009), water absorption index of canna starch is 1.8 per cent and water solubility index is 1.0 per cent.

Oil absorption capacity (OAC) of corm flour was 0.92 g/g initially and 0.86 g/g after three months of storage. In the case of starch powder, it was 0.53 g/g initially and 0.48 g/g after three months of storage which indicates its suitability for fried products. Kaur *et al.* (2013) reported an oil absorption capacity of 1.04 g/g in taro flour and also in potato flour. The author also indicated an oil absorption capacity of 2.51 g/g in corn flour.

Corm flour and starch powder obtained from tannia corm were evaluated for bacteria, fungi and yeast initially and at monthly intervals of storage. The bacterial count in corm flour was found to be 0.4 $\times 10^5$ cfu g^{-1} initially which increased to 2.2×10^5 cfu g^{-1} at the end of three months of storage period.

Simi (2014) reported that bacterial count in canna rhizome flour was 1×10^5 cfu g^{-1} which increased to 2×10^5 cfu g^{-1} at the end of three months of storage. The initial bacterial load in canna starch powder was 2.66×10^{-5} cfu g^{-1} which increased to 3.44×10 cfu g^{-1} after three months of storage. As reported by Bhaskar (2000) bacterial load was 6×10^6 cfu g-1 in banana powder. Lakshmi (2003) observed bacterial count in the range of 2.33 to 11.33×10^6 cfu g^{-1} in different varieties of banana flour. Misra and Kulshrestha (2002) detected total bacterial count of 1.71×10^3 cfu g^{-1} in potato flour which gradually increased to 1.88×10^3 cfu g^{-1}. Tsav-Wvo *et al.* (2004) also noticed a bacterial count in the range of 1.2 to 2.7×10^7 cfu g^{-1} in fermented cassava flour. Bhatiwada (2007) observed bacterial count of 2.6×10^6 cfu g^{-1} initially in grain amaranth flour which increased gradually during storage. Raj (2011) reported that initial bacterial count in the range of 0.33 to 2.66×10^5 cfu g^{-1} in weaning flour increased to 1.00 to 4.33×10^5 cfu g-1 at the end of storage. In mango seed kernel flour, Hanmant (2010) observed an increase of 2.03×10^6 cfu g^{-1} to a maximum count of

4.24 x 10^6 cfu g-1during storage. An increase in the bacterial count from 1 x 10^5 cfu g^{-1} to 2 x 10^5 cfu g^{-1} in unroasted bamboo seed flour was noticed by Kunhimon (2010) after three months of storage. Lijitha (2012) observed a bacterial load of 3.44 x 10^5 cfu g^{-1} in cycas seed flour initially, which increased to 4.44x105 cfu g^{-1}, after three months of storage.

Fungal growth was not detected initially. However, fungal count of 1.20×10^3 cfu g^{-1} was observed in corm flour at the end of second month and 1.2×10^3 cfu g^{-1} at the third month of storage. Yeast growth was not detected in corm flour initially and at the end of storage.

Fungal colonies were 0.6 ×103 cfu g^{-1} initially which increased to 1.4 ×10^3 cfu g^{-1} at the end of storage. Initially, yeast growth in starch powder was not detected but yeast count of 1.2 ×10^3 cfu g^{-1} were observed at the end of storage period.

The increase in fungal count during storage can be attributed to the increase in moisture content of the flour during storage as reported by Kapoor and Kapoor (1990). According to Simi (2014) fungal growth was not detected in canna rhizome flour initially, but fungal count of 1×103 cfu g-1 was observed in rhizome flour at the end of storage. In starch powder, fungal count increased to 2.33×103 cfu g-1 at the end of storage from the initial count of 1.66×103 cfu g-1 as reported by Simi (2014). Different studies conducted by Sharon (2003), Bhatiwada (2007), and Hanmant (2010) indicated an increase in the fungal count of bread fruit flour, grain amaranth flour and mango seed kernel flour during storage. Raj (2011) observed increase in fungal count in weaning foods from 0.33 to 2.00 x10^3 cfu g-1 to 1.66 to 3.66 x10^3 cfu g^{-1} at the end of storage. Even though microbial population increased during storage, total microbial count was within the safe limits upto the end of storage. According to Jey (2000) the product is microbially safe if the microbial count of dehydrated soups is less than 2 x10^4. The Jey also point out that total bacterial count of their formulated soup is 3.8 x10^3 cfu g^{-1}.

Sensory qualities of the starch and flour were analysed initially and monthly intervals and it was observed that there are no considerable changes in the sensory qualities like appearance, colour, flavour, texture, taste and overall acceptability of both starch and tannia corm flour during three months of storage. The mean scores for appearance of flour and starch powder were 7.72 and 7.7 respectively which decreased to 7.68 in both at the end of three months of storage.

Tannia corm flour produced was off-white in colour and starch powder was pure white in colour. No change in colour was observed for both tannia flour and starch powder throughout the storage period. The mean score obtained for colour was 7.62 and 9 for tannia corm flour and starch powder initially and it was 7.6 and 9 at the end of three months. Bhatiwada (2007) also did not notice any change in the colour of grain amaranth flour after third month of storage. Contradictory to this, Bhaskar (2000) and Sharon (2003) indicated slight discolouration in banana and breadfruit flours during later period of storage.

Flavour was analysed by judging the aroma of the flour. The corm flour and starch powder were bland and there was no detectable changes throughout the storage period. The mean score for flavour in corm flour and starch powder was 7.6 and 7.8 respectively at the initial month of storage respectively which decreased to 7.58 and 7.7 at the end of three months.

Texture of corm flour was slightly coarse and the starch powder was fine. Initially, the mean scores obtained for texture of starch and flour was 7.2 and 8.1 respectively and it was 7.1 and 8.2 at the final month of storage. Starch powder and flour were uniform in nature and caking was practically absent in flour and starch powder during the entire storage period. Similar observations were reported in canna flour and starch powder by Simi (2014) also.

The taste of the starch powder and flour was analysed by judging its taste at monthly intervals and there was no significant change in taste during storage period. Initially, the mean score obtained for flour and starch powder for taste were 7.5 and 7.6 respectively and it was 7.4 and 7.4 at the end of three months.

Fig.3. Organoleptic qualities of tannia corm flour during storage

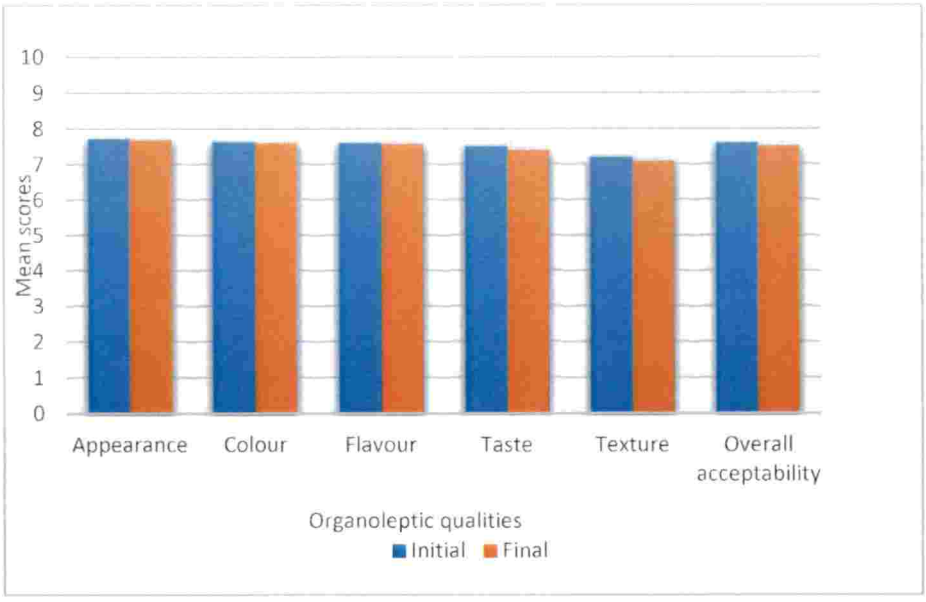
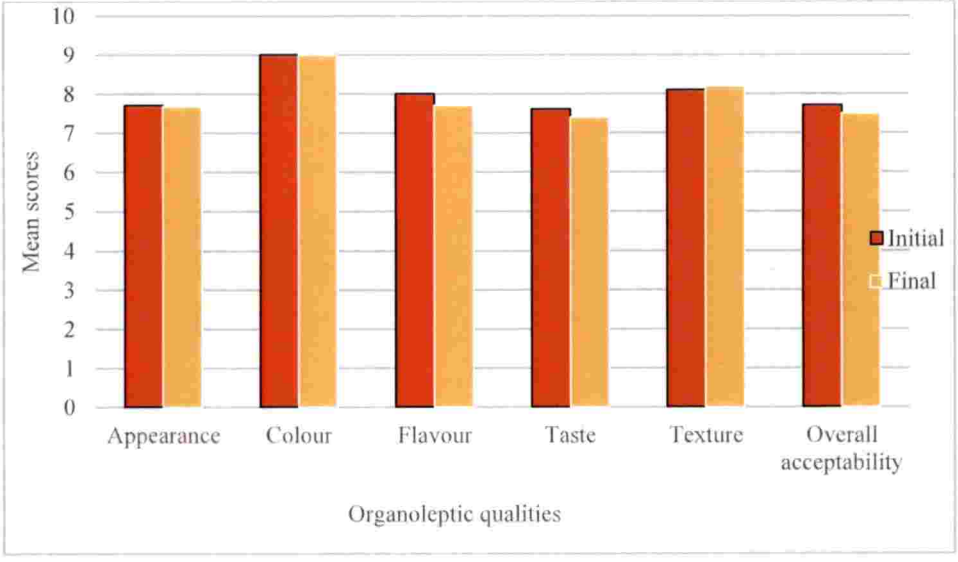


Fig.4-Organoleptic qualities of tannia corm starch powder during storage



The overall acceptability of flour and starch powder was good throughout the storage, which was 7.7 initially for both flour and starch powder and it was 7.6 and 7.5 at the end of storage period. A slight decrease in organoleptic qualities were observed throughout storage. But by the end of storage period both corm flour and starch powder maintained mean scores above 7 which indicate that they are acceptable. The changes in the organoleptic qualities of tannia corm flour and starch powder are illustrated in Fig. 3 and Fig.4

5.4. Standardisation and quality evaluation of instant mixes

5.4.1. Standardisation of instant soup mix

From the various treatments adopted for the standardization of instant soup mix, the most acceptable soup was that prepared with 30 per cent tannia corm flour and 70 per cent corn flour (T_8). The mean scores obtained for organoleptic qualities were taken in to account to select the most acceptable treatment. The mean scores for flavour, texture and taste were 7.66, 7.88, 7.9, and 7.9 respectively. Hence, T_8 was selected as the most acceptable treatment for the preparation of soup mix. Lymo *et al.* (2007) prepared instant porridge mix using yam, cassava and sweet potato in the ratio of 50:20:30. and reported that flour from roots and tuber crops can be effectively utilised to prepare instant mixes.

This study showed that up to 30 per cent substitution of tannia corm flour was effective for preparing instant soup mix. Senanayake *et al.* (2010) prepared soup mix using different proportion of modified sweet potato starch and corn starch and observed that the sensory quality parameters like taste, texture, flavor, and overall acceptability of soup mix of 100 per cent sweet potato starches have high mean scores than corn starch soup mix. Therefore, modified starches of tuber flours can be successfully substituted to corn starch as a thickner with higher level of sensory acceptability.

The mean score for the appearance of soup slightly decreased from 7.2 to 6.89 by the end of third month of storage. Initially, the mean score obtained for colour of the soup was 7 which have no change until the end of three months of storage. Regarding flavour, the initial mean score of 7.66 decreased to 7.40 after

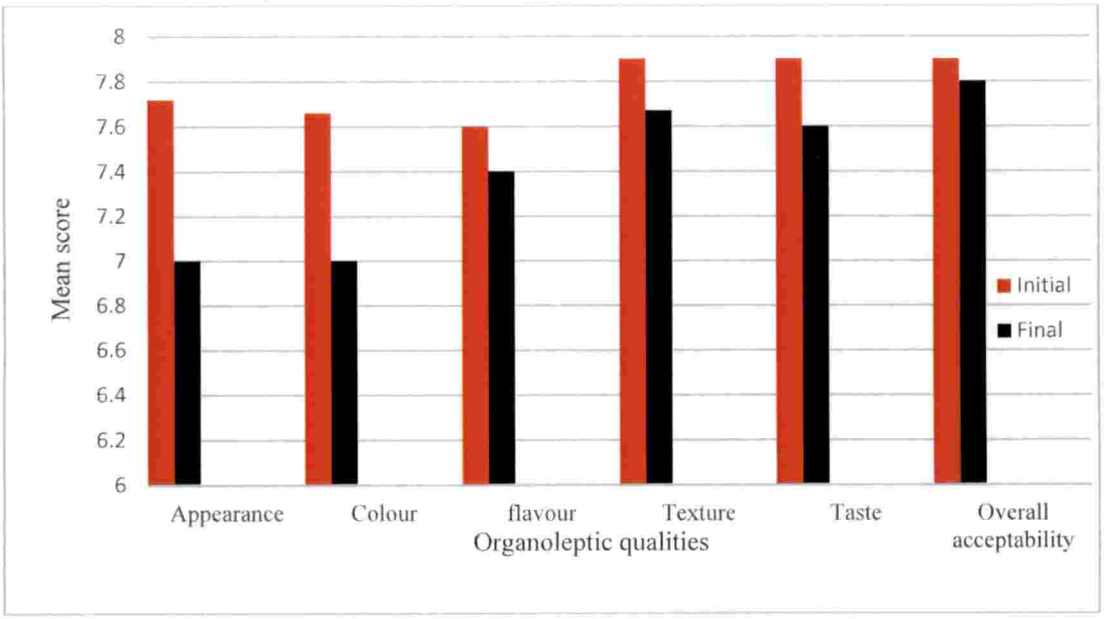
three months of storage. The mean score for the texture of soup, decreased from the initial mean score of 7.88 to 7.67 after three months of storage. The mean score for taste of the soup mix was 7.9 initially which decreased to 7.6 after three months of storage. Senanayak *et al.* (2010) developed an instant soup mix using different proportion of sweet potato starch and corn starch and according to the study, the instant soup mix prepared with sweet potato starch were shelf stable up to 6 month of storage period. The standardized tannia corm corm soup mix had an overall acceptability of 7.8 at the end of storage period, which indicate that the product is acceptable even after 3 months of storage. According to Senanayak *et al.* (2010) modified sweet potato starch soup mix have high mean scores for the sensory qualities during the storage period of 6 months. The changes in the organoleptic qualities of tannia corm flour soup during storage are illustrated in Fig. 5

In soup mix, the initial bacterial count was 0.66×105cfu g^{-1} which increased to 1.6×10^5 cfu g^{-1} at the end of third month of storage. Initially, the fungal count of soup mix was not detected but at the end of three months it was 0.5×10^3 cfu g^{-1}. Yeast growth was also not detected in soup mix initially and during storage. The increase in microbial count during storage might be due to the increase in moisture content of the flour during storage as reported by Kapoor and Kapoor (1990). Initially, the peroxide value of soup mix was 0.005 meq kg^{-1}which increased to 0.02 meq kg^{-1} at the end of storage. According to Bhatiwada (2007) the peroxide vale of wheat flour is .003 meq kg^{-1}. The peroxide value of soup was estimated initially and at the end of three months of storage. Initially, the peroxide value of instant soup mix was found to be 0.005 meq kg^{-1}which increased to 0.02 meq kg^{-1} at the end of storage. Wadud *et al.* (2004) observed a peroxide value of 0.72 to 3.10 meq Kg^{-1} in the weaning foods prepared using corn, soya, rice and wheat.

5.5. Standardisation of custard mix

Custard mix was standardised using different proportion of starch powder and corm flour. Among the four treatments tried, custard prepared with 60 per

Fig.5.Mean scores for organoleptic qualities of soup mix during storage



cent corn flour and 40 per cent starch powder obtained the highest mean score of 8.5 with a mean rank score of 3.93 for appearance. The mean score for colour and flavour of custard containing 60 per cent corn flour with 40 per cent starch powder (T_3) was 8.53 and 8.64 respectively. The highest mean score for texture (8.6), taste (8.64) and overall acceptability (8.5) was also observed in cusurd prepared with 60 per cent + 40 per cent (T_3). Tannia starch is having excellent thickening power. A study conducted by Marwaha and Sandhu (1999) on potato custard powder indicated that the addition of starch or starch flour combination acted as thickeners and were effective in bringing the desired consistency for the custard. Shabina (2011) noticed highest mean scores for colour, texture and taste in custard prepared with 10 percent pumpkin powder and 25 percent corn flour.

5.6. Cost of production of the developed instant mixes and custard mix

The cost of production of 100g instant soup mix was Rs.42.00. cost of production of various instant soup mixes available in the market are in the range of Rs 50 to 90, when compared to this, the cost of production of tannia corm instant soup mix was low. The main ingredient of the soup mix available in the market is corn flour. While, the major ingredients in the standardized soup mix in the present study were tannia corm flour and vegetable mix. The cost of production of 100g of custard mix were 65.00. Various custard mixes are available in the market at the range of Rs.100 to Rs.180 per 100g when compared to their mix the cost of production of tannia corm instant custard mix is low.

Summary

SUMMARY

The present study entitled 'Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development' was undertaken with the aim of evaluating the nutritional, antinutritional and organoleptic qualities of tannia corm (*Xanthosoma sagittifolium* (L.) Schott). The study also aims to evaluate the quality aspects of the flour, starch powder and to develop an instant soup mix using tannia corm.

The nutritional constituents of the raw tannia corm were estimated. The constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron, zinc and oxalate content of the samples were analysed.

The mean moisture content in raw tannia corm was found to be 70 per cent. The starch content in fresh corm was found to be 30 per cent and the mean protein content was 8.48 per cent. The mean total carbohydrate and fibre of fresh corm was recorded as 72g and 3.2g/ 100g respectively. The total ash and total sugar were recorded as 6.12g and 0.48g per 100g respectively. The calcium, iron, sodium content was recorded as 8.2 mg, 0.42 mg and 5.6 mg/ 100g respectively. Tannia corm had good amounts of phosphorus (40 mg $100g^{-1}$) and potassium (28 mg $100g^{-1}$). The polyphenol content was recorded as 0.73 mg $100g^{-1}$ and the oxalate content was found to be 1.5 g per 100g of corm on fresh weight basis.

The organoleptic qualities of cooked corm was conducted. For appearance of the cooked corms, the mean score obtained was 7.71. For colour and taste, the mean score of 7.66 each was recorded. The mean scores of 7.53, 7.35 and 7.6 were obtained for flavour, texture and overall acceptability respectively. The organoleptic qualities indicated that the cooked corms were acceptable.

Various pretreatments were given to raw tannia corm to remove oxalate content and to prevent browning. The treated tannia corms were dried and

powdered. Organoleptic qualities of the pretreated tannia flours were evaluated by preparing porridge. Tannia corm flour prepared after soaking the tannia corm in 1 per cent potassium metabisulphite for 30 minutes (T_3) obtained mean score of above 7 for all quality parameters and was found to be the best in organoleptic qualities. Porridge prepared by T_1 (boiling in water at 90^0 C for 60 minutes) T_2 (pressure cooking for 5 minutes) and T_3 (1 per cent potassium metabisulphite for 30 minutes) obtained mean scores of 6.55, 7.04 and 7.93 respectively for overall acceptability. Soaking in 1 per cent potassium metabisulphite for 30 minutes was found to be the most effective pretreatement in preventing browning and improving sensory qualities of tannia corm flour. Pretreatments like precooking tannia corms for 5 minutes and boiling in water at 90^0C for 60 minutes also improved organoleptic qualities of tannia corm flour. But the pretreatments like T_4, T_5, T_6, T_7, and T_8 resulted in products with poor organoleptic qualities. As pretreatments like T_4 (Soaking in 2 % citric acid for 30 minutes), T_5 (Soaking in 2 % tartaric acid for 30 minutes), T_6 (Soaking in 2 % baking soda in cold water for 30 minutes), T_7 (Soaking in 2 % ascorbic acid for 30 minutes), T_8 (Soaking in 2 % citric acid + 2 % ascorbic acid for 30 minutes) resulted in products with poor sensory qualities. These treatments were found to be not effective in preventing browning reaction, and resulted in a dark product may be due to the precipitation of calcium oxalate hence, tannia corn flour with pretreatment T_1, T_2 and T_3 only were selected for further studies.

The nutritional constituents of the selected pretreated tannia corm flours were estimated. The constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron, zinc and oxalate content of the samples were also analysed. The starch content of the selected treatments were in the range of 28 to 30 g per 100g. The carbohydrate content was around 70g per 100g and protein content was around 7g per 100g. The oxalate content of the selected pretreated tannia corm were 0.20 for all the treatments and it was decreased when compared to the raw tannia corm oxalate content.

From the various pretreatments tried for the selection of flour, the most acceptable treatment was selected for developing instant soup mix. The mean scores obtained for various organoleptic qualities and nutritional qualities were taken in to account to select the most acceptable treatment. For all organoleptic quality parameters, the treatment T_3 obtained high mean scores and was nutritionally on par with T_0 its oxalate content (0.20 mg per 100g) was also comparatively low. Hence, T_3 (tannia corm flour prepared by soaking in 1 % KMS) was selected as the best treatment to prepare product and also for further studies. Tannia corm starch was extracted and dried using standard procedure suggested by Moorthy (2002). Selected flour and starch powder were packed in poly ethylene covers (200 gauge) and stored for three months.

Selected flour and starch powder prepared from tannia corm were evaluated for various physical qualities initially and monthly intervals for three months of storage. Physical qualities like moisture, bulk density, water absorption index (WAI), water solubility index (WSI) and oil absorption capacity (OAC) were estimated and product recovery of flour (60 per cent) and starch powder (24 per cent) were also assessed.

The moisture content of corm flour was found to be 9.8 per cent initially and it increased to 11.1 per cent after three months of storage. In starch powder the moisture content was found to be 15.2 per cent initially and it increased to 16.8 per cent after three months of storage. Initially, the bulk density of corm flour was found to be 0.63 g per cc and it decreased to 0.60 g per cc after three months of storage. In starch powder, the bulk density was 0.54 g per cc initially which decreased to 0.50 g per cc after three months of storage.

Water absorption index in corm flour and starch powder was found to be 15.5 and 17.8 respectively. After three months of storage, it decreased to 14.82 in corm flour and to 16.8.

Initially, the water solubility index of corm flour was found to be 0.18 g per 100g and in starch powder it was 0.15g per 100g. After three months of storage the water solubility index decreased to 0.12g in corm flour and to 0.11g in starch

powder. Oil absorption capacity (OAC) of corm flour was 0.92 g per 100g initially and 0.86 g per 100g after three months of storage. In the case of starch powder, it was 0.53 g per 100g initially and 0.48 g per 100g after three months of storage.

The corm flour and starch powder were evaluated for bacteria, fungi and yeast initially and monthly intervals of storage and result pertaining to microbial enumeration are given in Table 8 and 9 respectively. The bacterial count in corm flour was found to be 0.4 ×105 cfu g^{-1} initially which increased to 2.2×105 cfu g^{-1} at the end of three months of storage period.

The fungal growth was not detected initially. But a fungal count of 1.20×103 cfu g^{-1} was observed in corm flour at the end of two month and 1.2×103 cfu g^{-1} at the third month of storage. Yeast growth was not detected in corm flour initially and at the end of storage.

The fungal growth was found to be 0.6 ×103 cfu g^{-1} initially and it increased to 1.4 $\times 10^3$ cfu g^{-1} at the end of storage. The initial yeast growth in starch powder was not detected but a yeast count of 1.2 $\times 10^3$ cfu g^{-1} were observed at the end of storage period. Insect infestation was not detected in both corm flour and starch powder during storage.

Sensory qualities of the starch and flour was analysed initially and at monthly intervals and it was found that there was no considerable change in the sensory qualities like appearance, colour, flavour, texture, taste and overall acceptability of both starch and tannia corm flour during three months of storage. Initially the mean score for appearence was 7.72 and 7.7 respectively and it was 7.68 and 7.68 at the end of three month.

The tannia corm flour was found to be off in colour and starch powder was pure white in colour. The mean score obtained for the colour was 7.62 and 9 for tannia corm flour and starch powder initially and it was 7.6 and 9 at the end of three months. No change in colour was observed for both tannia flour and starch powder throughout the storage period.

The corm flour and starch powder were found to be bland and there was no detectable change throughout the storage period. Initially the mean score for flavour of the tannia corm flour and tannia starch powder was 7.6 and 7.8 respectively and it was 7.58 and 7.7 at the end of the storage period.

Texture of rhizome flour was slightly coarse and starch powder was found to be fine. The starch powder and flour were uniform in nature and caking was practically absent in flour and starch powder during the entire storage period. Initially the mean score obtained for texture of the starch and flour was 7.2 and 8.1 respectively and it was 7.1 and 8.2 by the end of storage period. There was no considerable change in mean scores of taste also during storage. Initially, the mean score obtained for flour and starch powder for taste were 7.5 and 7.6 respectively and it was 7.4 and 7.4 at the end of three month of storage.

The overall acceptability of flour and starch powder was good throughout the storage and obtained mean scores of above 7 which is considered as acceptable at the end of three months of storage.

An instant soup mix were standardized by incorporating selected tannia corm flour and corn flour in varying proportions. All other ingredients were used as per the standard procedure (Senanayake *et al.* 2013). From the various treatments adopted for the standardisation of soup mix based on organoleptic qualities, the most acceptable treatment was selected for storage studies. The highest scores for these quality attributes were obtained for soup prepared with 30 per cent corm flour and 70 per cent corn flour (T_8). In this, the mean scores for flavour, texture and taste were found to be 7.66, 7.88, 9, and 7.9 respectively. Hence, T_8 was selected as the most acceptable treatment for the preparation of instant soup mix.

Self-life studies of this soup mix were conducted for three months. The organoleptic qualities of the instant soup mix during storage were evaluated by preparing soup. No considerable change in organoleptic qualities were noticed in the instant soup mix during storage. For appearance, the instant soup mix retained a mean score of 7.89 at the end of storage period. Mean score of 8, 8.40, 8.67,

8.91 and 8.8 was obtained for colour, flavour, texture, taste and overall acceptability respectively for the product at the end of storage period. This indicate that the sensory qualities are in acceptable range and product can be stored up to three months without change in sensory qualities.

In instant soup mix, the initial bacterial count was found to be 0.66×105cfu g^{-1} which increased to 1.6×10^5 cfu g^{-1} at the end of third month of storage. Initially, the fungal count of soup mix was not detected but at the end of three month it was found to be 0.5×10^3 cfu g^{-1}. Yeast growth was also not detected in soup initially and at the last month of storage.

Initially, the peroxide value of soup mix was found to be 0.005 meq kg^{-1} which increased to 0.02 meq kg^{-1} at the end of storage.

A custard mix was standardised using different proportion of starch powder and corm flour. Among the four treatments tried, custard prepared with 60 per cent corn flour and 40 per cent starch powder have got the highest mean score of 8.5 with a mean rank score of 3.93 for appearance. The tannia corm starch powder was found to be suitable for the preparation of custard mix.

The cost of production of soup mix were worked out based on the various ingredients required for the preparation of products. The cost of production of 100g of soup mix were found to be Rs.42.00.

The present study showed that tannia corms contain good amount of starch, carbohydrate, protein and mineral constituents like sodium, phosphorus, calcium and potassium. Oxalate content and browning reactions were reduced by various pretreatments. The present study found that good quality flour and starch powder could be prepared from tannia corms. Tannia corm flour and starch powder were of good sensory qualities and can be used to prepare acceptable products like instant soup mix. The tannia corm flour and starch powder could be effectively utilised for the development of instant mixes and is very much suited for various food applications.

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QUALITY EVALUATION OF TANNIA CORM (*Xanthosoma sagittifolium* (L.) Schott) AND ITS SUITABILITY FOR PRODUCT DEVELOPMENT

By

AMITHA ELIAS

(2016-16-003)

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Community Science
(FOOD SCIENCE AND NUTRITION)

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF COMMUNITY SCIENCE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR – 680 656

KERALA, INDIA

2018

Abstract

Tuber crops are known as poor man's crop as it provides cheap food of high calorific value and quality starch. Tannia is an edible root crop belonging to the family *Araceae* grown in the tropics and sub tropics. Tannia corms are mainly used as planting material and excess corms are left unharvested. Its acridity, poor storage quality, browning reactions and bulkiness limits the use of tannia corms. Through appropriate processing techniques, these problems can be minimised. The present study entitled 'Quality evaluation of tannia corm (*Xanthosoma sagittifolium* (L.) Schott) and its suitability for product development' was conducted to evaluate the nutritional, antinutritional and organoleptic qualities of tannia corm. The study also evaluated the quality aspects of flour, starch powder and an instant soup mix developed using tannia corm.

Constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, oxalates, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron and zinc of the raw tannia corm were analysed. The starch and carbohydrate content of the corm was 30 % and 72 % respectively and the protein content was 8.48 mg/100g. The content of calcium, iron, phosphorus in 100 g of tannia corms were as 8.2mg, 0.42mg, and 40 mg respectively. Organoleptic qualities of cooked rhizomes obtained a mean score of above 7.00 for all parameters. The oxalate content of raw tannia corm was found to be 1.03 g/100g.

Various pretreatments were given to tannia corm for reducing the oxalate content and to reduce browning reactions. Organoleptic qualities of pretreated tannia corm flours were evaluated and found that treatment with one per cent potassium metabisulphite (T_3) was effective in preventing browning reactions. For all organoleptic quality parameters, the treatment T_3 obtained mean score of above 7 and the oxalate content reduced to 0.20 mg/100g

Pretreatments like precooking tannia corms for 5 minutes and boiling in water at 90^0C for 60 minutes was also found to be good in organoleptic qualities. Porridge prepared by T_1 (boiling in water at 90^0 C for 60 minutes) and T_2 (pressure

cooking for 5 minutes) were obtained mean scores of 6.55 and 7.04 respectively for overall acceptability. But the pretreatments like $T_{4\,()}$, T_5, T_6, T_7, and T8 resulted in products with poor organoleptic qualities. As pretreatments like T_4 (Soaking in 2 % citric acid for 30 minutes), T_5 (Soaking in 2 % tartaric acid for 30 minutes), T_6 (Soaking in 2 % baking soda in cold water for 30 minutes), T_7 (Soaking in 2 % ascorbic acid for 30 minutes), T_8 (Soaking in 2 % citric acid + 2 % ascorbic acid for 30 minutes) resulted in products with poor sensory qualities, these treatments were found to be not effective in preventing browning reaction hence, tannia corm flour with pretreatment T_1, T_2 and T_3 only were selected for further studies.

The nutritional constituents of the selected pretreated tannia corm flours were estimated. The constituents like moisture, starch, total sugars, carbohydrates, protein, fibre, total ash, acidity, calcium, iron, phosphorus, sodium, potassium, polyphenols, *in vitro* digestibility of starch, *in vitro* availability of calcium, iron, zinc and oxalate content of the samples were also analysed.

From the various pretreatments tried for the selection of flour, the most acceptable treatment was selected for developing instant soup mix.

Starch powder was prepared from tannia corm. The shelf life qualities of selected tannia corm flour and starch powder were estimated initially and at monthly intervals. The bulk density of corm flour and starch was found to be 0.63 g per cc and 0.54 per cc respectively. A decrease in water absorption index in corm flour and starch powder were observed after three months of storage.

Bacterial count in corm flour was found to be 0.4×10^5 cfu g^{-1} initially which increased to 2.2×10^5 cfu g^{-1} by the end of storage period. The fungal growth was not detected initially in flour but at the end of third month of storage, a fungal count of 1.2×10^3 cfu g^{-1} was observed. The fungal growth in tannia corm starch powder was found to be 0.6×10^3 cfu g^{-1} initially which increased to 1.4×10^3 cfu g^{-1} at the end of storage. Yeast growth was not detected in corm flour and starch powder initially but a yeast content of 1.2×10^3 cfu g^{-1} was found at the end of the storage period in the starch powder. There was no considerable change in sensory qualities in both flour and starch powder after three months of storage.

An instant soup mix was standardised using different proportions of selected tannia corm flour and corn flour. Treatment with 30 per cent tannia corm flour and 70 per cent corn flour (T_8) had the maximum mean score for overall acceptability (7.9). The selected instant soup mix were packed in metallised polyethylene covers (200 gauge) and kept for storage studies for three months. The instant soup mix was found to be shelf stable up to three months of storage.

Tannia corms contain good amount of starch, carbohydrate, protein and mineral constituents like sodium, phosphorus, calcium and potassium. Oxalate content and browning reactions were reduced by various pretreatments. The present study found that good quality flour and starch powder could be prepared from tannia corms. Tannia corm flour and starch powder were of good sensory qualities and can be used to prepare acceptable products like instant soup mix. The tannia corm flour and starch powder could be effectively utilised for the development of instant mixes and is very much suited for various food applications.

Appendices

APPENDIX I

1. Score card for the organoleptic evaluation of tannia and rice flour based products

Name:

Food product: Date:

Sl. No.	Parameters	Rice varities					
		1	2	3	4	5	6
1.	Appearance						
2.	Colour						
3.	Flavour						
4.	Texture						
5.	Taste						
6.	Overall acceptability						

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

2. Score card for assessing the organoleptic qualities of tannia corm soup mix

Name:

Date:

Sl no	Parameters	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	Appearance											
2	Colour											
3	Flavour											
4	Texture											
5	Taste											
6	Overall acceptability											

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

APPENDIX II

1. Cost of production of 100 g of instant soup mix using tannia corm flour

Sl. No	Item	Quality	Cost (Rupees)
1	Raw materials		
	Tannia corm flour	49 g	15.5
	Vegetable mix	12 g	10.5
	Pepper powder	1 g	1
	Salt	10.9 g	.2
	Sugar	4 g	3
	Citric acid	.1	.02
2	Other items		
	LPG	10 minutes	3
	Electricity charge	3 unit	1.5
	Labour cost	1 hr. and 30 minutes	10
		Total	41.7 -42

2. Cost of production of 100 g of instant custard powder using tannia corm starch powder

Sl. No	Item	Quality	Cost (Rupees)
1	Raw materials		
	Starch powder	35 g	55
	Milk powder	15 g	2.28
	Sugar	45 g	1.58
	Cashew nuts	5 g	2.6
	Salt	1 g	.01
2	Other items		
	LPG	5 minutes	.50
	Electricity charge	1 unit	.03
	Labour cost	30 minutes	3
		Total	65