Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas*) and Berries

BY

LAVANYA.R

(20PFN011)

THESIS SUBMITTED TO

AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN

COIMBATORE-641043

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN FOOD SCIENCE AND NUTRITION

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S. Thilakavathy 27/5/2022 | M. Sylvia 27/5/22
Signature of the Supervisor | Signature of the Head of the Department

DECLARATION

I hereby declare that the dissertation entitled **"Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas*) and Berries "** submitted to the Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, in partial fulfilment of the requirement for the award of the Degree of Master of Science in Food Science and Nutrition is a record of original research work done by me under the supervision and guidance of **Dr.(Mrs.) S.Thilakavathy, M.Sc.,M.Phil.,Ph.D,Assistant professor(SG),** Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore and that it has not formed the basis for the award of any Degree/ Diploma/ Associateship /Fellowship or similar title to any candidate of any other University and it represents entirely an independent work on the part of the Candidate.

S. Thilakavathy 27/05/2022 Lauf. R

Signature of the Supervisor **Signature of the candidate**

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Introduction

I. INTRODUCTION

Sweet potatoes are becoming a research focus in the recent years due to the unique nutritional and functional properties. Bioactive carbohydrates, proteins, lipids, carotenoids, anthocyanins, conjugated phenolic acids, and minerals represent versatile nutrients in different parts (tubers, leaves, stems, and stalk) of sweet potato.(Sunan Wang *et al.,* 2016)

Ipomoea batatas, commonly called as sweet potato, is grown as an annual plant by vegetative propagation using either storage roots or stem cuttings. The generic name Ipomoea comes from the Greek words "ips," which means bindweed, and "homoios," meaning similar.The stem is cylindrical and its length depends on the growth habit of the cultivar and the availability of water in the soil. The leaves are simple and spirally arranged alternatively on the stem. The color of the smooth skin of the root tuber ranges between yellow, orange, red, brown, purple, and beige. Its flesh ranges from beige to white, red, pink, violet, yellow, orange, and purple. (Mohanraj *et al*., 2015)

Sweet potato is ranked as the most important food crop after rice, wheat, potato, maize, and cassava (Shekhar *et al*., 2015).Yenumula & Thilakavathy 2017 stated that the cultivation of sweet potatoes dates back to 750 BC, making it one of the oldest foods known to man.

Sweet potato production was reported to be 112.8 milliontons (in 115 countries) in 2017, and China is the leading producer, followed by Nigeria and Tanzania, Indonesia, and Uganda. Sweet potato production and consumption in Africa, Asia (India), South American continents, and Caribbean islands are increased tremendously in recent times. Sweet potato is the most abundantly grown root crops in Africa. (Satheesh *et al*., 2019)

International Potato Center (2017) reported that sweet potato is the 3rd vital food crop in seven central and eastern African countries, 4th priority crop in six South African nations, and 8th in four West African countries. Sweet potato is a key conventional crop, growing traditionally in limited area for domestic consumption purpose. (Solomon *et al*., 2019)

Sweet potato is mostly harvested for its tubers. It is the sixth most important food crop in the world and it contains phytochemicals, which are important for human health . Other than their nutritional benefits such as a rich source of dietary fibre,antioxidants, vitamins, and minerals, sweet potato root tubers also contain no saturated fats or cholesterol. Several reports have indicated that the phytochemicals in sweet potato possess multifaceted actions, including anti-oxidant, antimutagenic,anti-inflammatory, antimicrobial and anti-carcinogenesis and thus are important for several health-promoting functions in humans. (Mukwevho *et al*., 2016)

The major contribution of sweet potato to human nutrition is supply of antioxidants in the form of provitamin A, and to lesser extent vitamin C. Furthermore sweet potato do supply Zn and Fe which relates to two other major nutrition deficiencies in humans. In sweet potato, a natural large variation in β-carotene content occurs, depending on the flesh color.(Adebola, P., et al., 2015) .The antioxidant activity of sweet potato vary greatly depending on the parts of the plant, such as roots, leaves etc., as well as on the varieties, flesh color intensities (e.g., purple, orange, yellow, white) and product sources (e.g., cooked, baked, fried, flour, emulsion). (Wang *et al*., 2016)

The sweet potato is reported to be superior sources of polyphenols, terpenoids, saponins, glycosides, alkaloids, steroids, and other functional bioactive components (Alam et al., 2016). The predominant bioactive components present in sweet potatoes are phenolic compounds like phenolic acids (e.g., caffeic acid, monocafeoyl quinic (chlorogenic acid), caffeoylquinic acid (CQA) derivatives (primarily mono-CQA, di-CQA and 3,4,5-triCQA), p-coumaric acid, sinapic acid, hydroxybenzoic acids, and p-anisic acids), flavonoids (e.g., quercetin, myricetin, luteolin, and apigenin, etc.), and anthocyanins (cyanidin-, peonidin- and pelargonidin-derivatives) (Luo *et al*., 2021)

Sweet Potatoes are used in different parts of the world for the treatment of several diseases, such as diabetes, hypertension, dysentery, constipation, fatigue, arthritis, rheumatoid diseases, hydrocephaly, meningitis, kidney ailments and inflammations. They also possess antimicrobial, analgesic, spasmolitic, spasmogenic, hypoglycemic, hypotensive, anticoagulant, anti-inflammatory, psychotomimetic, and anticancer activities. Sweet potato is potent in the fight against cancer. It is rich in beta-carotene, which is good in fighting free radicals. Fluid and electrolyte balance is maintained by sweet potatoes. Tuber flour of sweet potato was found to potentially prevent ethanol-induced gastric ulceration by suppressing edema formation and partially protecting gastric mucosa wrinkles and to heal wounds. Because of its proven anti-ulcerative activity, it could be considered when treating gastric ulcers. (Sivasankar *et al.,* 2016)

Global food and nutritional insecurities, public health challenges of diet-linked noncommunicable chronic diseases (NCDs), and rapid climate change-linked agricultural production challenges are interconnected and require urgent attention. Therefore, to address these complex and interconnected challenges, it is essential to advance robust and resilient strategies based on sustainable agricultural production practices, wider integration of nutritionally-balanced plantbased foods in the diet, improvement of human health-targeted nutritional qualities, post-harvest preservation qualities and food processing optimization. (Pradeepika . 2020)

Sweet potato flour is becoming increasingly important and food producers, marketers and consumers are drawing attention to it. Producing food products from sweet potato flour are very feasible in worldwide due to wide availability, natural color, high-energy, low-protein, good biological activity in the human diet and low cost, as a result, become a key ingredient for the production of new products in the current global habitation. Sweet potato flour, plays a pivotal role in the preparation of various food items, which can boost consumer nutritional and health status. (Girma *et al*., 2020)

The flour can be used as a starting material for production of juice, bread, candy, noodles, snacks, fufu (dough), alcohol, etc. The suitability of the flour for use as food or other purposes will however depend on its composition and functional properties. Functional properties are those properties that determine the behavior of nutrients in food during processing, storage and preparation because they affect the general quality of foods as well as their acceptability. The sweetpotato variety that was studied was observed to possess good functional properties together with considerable energy value and carotene contents. In addition, it was found to be a rich source of protein. (Eleazu & Ironua 2016)

Increased consumption of fruits and vegetables is recommended in dietary guidelines worldwide and the intake of fruits like berries which are rich in nutrients and phytochemicals can prevent various diseases and disorders.Berry fruits are popularly consumed not only in fresh and frozen forms but also as processed and derived products, including dried and canned fruits, yogurts, beverages, jams, and jellies.(Shivraj *et al*., 2016)

Berries invariably rank high due to their powerful antioxidant content. Considerable research has been directed at the potential health benefits of eating berries. As well as being a good source of vitamin C, dietary fiber, and minerals, berries contain high levels of natural polyphenol components that act as potent antioxidants. Berry extracts, rich in polyphenols, have a range of biological effects that can have beneficial outcomes on human health.(Battino, *et al*., 2019)

Black Grapes are a valuable source of numerous phytonutrients, including, resveratrol. Over 1600 compounds have been identified in grapes, including anthocyanins, catechins, ellagic acid, lutein, lycopene, quercetin, and other potent antioxidants. Recently, melatonin has been discovered as a component of the grape, and this substance act in a synergistic manner with other active constituents.(John 2018)

Green Grape is rich in polyphenols and other various kinds of phytochemicals. Green grape methanolic extract is a rich source of phenolic compound. Other two extracts i.e. ethanolic and aqueous extracts also have significant amount of phenolic content in them. This concludes that green grapes may be exploitable as a potential source of phenolic compounds for possible use as antioxidant. Health benefits of polyphenols are well known, especially in the prevention of diseases such as cancer, cardiovascular, inflammatory and neurodegenerative diseases. (Sharma *et al*., 2017)

Tomato is termed as "the most popular vegetable fruit". Tomatoes, which are actually a fruit and not a vegetable, are loaded with all kinds of health benefits for the body. There are known different varieties of tomato, round, oval, "cherry", but all have the same nutritional characteristics, being an important source of: - potassium, phosphorus, magnesium, iron, so necessary to the normal activity of nerves and muscles. Tomatoes contain all four major carotenoids: alpha- and beta-carotene, lutein, and lycopene. In particular, tomatoes contain awesome amounts of lycopene, thought to have the highest antioxidant activity of all the carotenoids. (Srivastava *et al*., 2015)

Amla is one of the precious gifts of nature to mankind. Fruit known in Sanskrit as- Amalaka, Telugu- Usirikai, Tamil- Nellikai. Amla is a rich source of vitamin C and requisite for the synthesis of collagen, which is liable for keeping the cells of the body together. It has the same amount of vitamin C present in two oranges. It increases the red blood cell count and helps to promote good health. Amla fruit possess antioxidant, hepatoprotective, hypocholesterolemic and anti inflammatory activities.(Vaithiyanathan *et al*., 2015)

Star gooseberry, is an extraordinary commonly used herb in Indian Ayurvedic systems. It is known by the common name “the King of Rasyana” (Mirunalini et al., 2013; Singh et al., 2012). Star Goosebeery fruit also known as “arainelli” in Tamil, is a good source ascorbic acid, niacin, thiamine, sodium, potassium and calcium. It is traditionally used to treat jaundice, asthma, bronchitis, rheumatism, constipation, gonorrhea and psoriasis over different parts of the globe. (Kavitha & Padmini 2017)

Fruit bars have a far greater nutritional value than the fresh fruits because all nutrients are concentrated and, therefore, would be a convenience food assortment to benefit from the health benefits of fruits. The consumers prefer fruit bars that are very tasty followed by proper textural features that could be obtained by establishing the equilibrium of ingredients, the proper choosing of manufacturing stages and the control of the product final moisture content. Fruit bar preparations may include a mixture of pulps, fresh or dried fruit, sugar, binders, and a variety of minor ingredients. Additionally to the conventional steps of manufacturing (pulping, homogenizing, heating, concentrating, and drying) there have been proposed the use of gelled fruit matrices, dried gels or sponges, and extruders as new trends for processing fruit bars. The dehydration methods that use vacuum exhibited not only higher retention of antioxidants but also better color, texture, and rehydration capacity. Antioxidant activity resulting from the presence of phenolic compounds in the bars is well established. Besides this, fruit bars are also important sources of carbohydrates and minerals. Given the wide range of bioactive factors in fresh fruits that are preserved in fruit bars, it is plausible that their uptake consumption have a positive effect in reducing the risk of many diseases.(Orrego 2014**)**

Because of the increased demand in consuming convenient nutritious product, an attempt was made to develop antioxidant rich fruit bars by incorporating sweet potato flour in berries rich in antioxidants like black grapes, star gooseberry, amla, strawberry and cherry were selected. Hence, the present study entitled "Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas*) and Berries" was conducted with the following objectives :

- To prepare antioxidant rich fruit berry bars by incorporating sweet potato flour
- To analyse the organoleptic characteristics of bars prepared out of sweet potato flour and different fruit berries
- To analyse the nutrients and phytochemicals present in the prepared sweet potato berry bars
- To study the antioxidants present in the bars prepared out of different fruit berries and sweet potato flour
- To analyse the texture characteristics and shelf life of the prepared sweet potato berry bars

Review of Literature

II. REVIEW OF LITERATURE

The Review of literature pertaining to the study entitled **" Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas*) and Berries"**,is presented under the following headings

A. Sweet Potato - A Super Food

B. Functional properties of Sweet Potato Flour

C. Therapeutic effect of Sweet Potato

  A. Antioxidant Properties of Sweet Potato
  B. Antidiabetic and cardio protective activities
  C. Antiulcerogenic,anti - obesity activities and anti-cancerous effects

D. Antioxidant Properties of Berries

E. Health Benefits of ingredients used in the Standard recipe preparation

F. Advances in Sweet Potato Utilization as Value added Product in Human Food Systems

I. Sweet Potato – A Super food

Sweet potato is a a root vegetable, used as a staple food, a snack food, a source for industrial starch extraction and fermentation, and for various processed products. Sweet potato is high in nutritional value, with the exception of protein and niacin. It provides over 90% of nutrients per calorie required for most people. Roots are a valuable source of carbohydrates, vitamins (providing 100% of the recommended daily allowance [RDA] for vitamin A and 49% of the RDA for vitamin C), and minerals (providing 10% of the RDA for iron and 15% of the RDA for potassium).(Sivashankar *et al*., 2015)

Sweet potatoes contain enough RAE to meet over 90% of vitamin A needs. For those who are involved in strenuous jobs, sweet potato is a good source of carbohydrates and it is rich in vitamins and minerals. (Parle & Monika 2015)

Monika et al., 2015 stated that sweet potatoes can alleviate muscle cramps due to their high potassium content which are often related to potassium deficiency. Sweet potatoes contain magnesium, a crucial mineral, which promotes relaxation, calmness and nerve health.

II. Functional Properties of Sweet Potato Flour

Flour is the main ingredient in the production of many foods and is a staple in many countries diets. The economic and political issue of the countries is influenced by the availability and adequate supply of flour. The renovation of sweet potato into flour can play a vital role in addressing the question of losses and used for the production of a variety of foodstuffs. It can be produced after the tubers are cleaned, peeled, sliced, dried and milled into a fine powder. Flours can be stored for a long time and used for the production of diverse foods. (Girma, A *et al*., 2020)

The functional properties of sweet potato flours play an essential role in the manufacturing of food products. Such properties decide the production and use of sweet potato flours as a food ingredients for different foods, and also regulate the processing and storage of these items. For example, functional properties such as water absorption, oil absorption, and protein solubility affect the product's texture and appearance.(Chinma *et al*., 2017)

Swelling power, inter-associative forces within the amorphous and crystalline realms, and the presence of other components are among the factors marking the flour's solubility. Sweet potato flours from various varieties ranged from 8.61 to 9.57% with no significant difference due to variety are reported by(Kusumayanti *et al*.2015).

The steamed flour has the highest water absorption capacity. This indicates that this flour will retain large quantities of water during the preparation of food items such as gruels and thus become voluminous with low energy and nutrient density.(Abraham *et al* 2017)

Cooking and drying increased the digestibility of flours compared to acetylation and enzyme modification.(Avula, R. Y 2018).This could be concluded from the fact that flour obtained from the cooking and drying are digested easily. Although, there is not sufficient data regarding the digestibility of sweet potato flour, it is expected that flour obtained from drying and preheating treatments are digested easily. The fewer digestibility flours may function like dietary fiber and have therapeutic benefits such as blood glucose control in diabetes, or to aid in weight control.(Singh *et al* .,2017)

II. Therapeutic Properties of Sweet Potato

A. Antioxidant Properties of Sweet Potato

The antioxidant activity of sweet potato vary greatly depending on the parts of the plant, such as roots, leaves etc., as well as on the varieties, flesh color intensities (e.g., purple, orange, yellow, white) and product sources (e.g., cooked, baked, fried, flour, emulsion). The antioxidant capacities of the obtained crude extracts or fragments of sweet potatoes are affected not only by extraction methods (conventional and modern techniques) but also by variables (liquid to solid ratio, temperature, time, pH, particle size, choice of solvent) (Wang *et al*., 2016).

The number and structure of caffeoyl compounds found in sweet potatoes has also been linked to antioxidant activity (Sun, Mu, et al., 2018). The antioxidant activities of quinic acids combined with di-caffeoyl were much greater than quinic acids combined with mono-caffeoyl or cis-dicaffeoyl quinic acid, which also had a much higher antioxidant ability than trans-dicaffeoyl quinic acid (Zhao *et al*., 2018).

The bioactive triterpenes found in Sweet potato are: boehmeryl acetates, which act as ovipositional stimulants for the sweet potato weevil; Cylas formicarius elegantulus ; friedelin,showed good activity against S. aureus, compared with ampicillin and amoxicillin, and good antifungal activity against Pseudallescheria boydii. b-amyrin acetate showed pronounced antinociceptive properties in the writhing test and formalin test in mice.(Sivasankar, Subha., *et al*., 2017) .Kim *et al*. (2019) reported that the sweet potato roots were potent scavenger of free radicals as well as reducing agent.

B. Antidiabetic, cardio protective effect of sweet potato

Type 2 diabetes mellitus (T2DM) is a metabolic condition demonstrated by hyperglycemia (high blood glucose levels) and glucose sensitivity, leading to improper secretion of insulin or the action of insulin to improve glucose uptake. The combination of various factors, such as obesity, stress, sedentary lifestyle, and genetic factors related to insulin secretion or resistance, can contribute to the development of T2DM (Alam *et al*., 2020)

Sweet potato have shown promise as low-cost anti-diabetic agents and thus can be effectively utilized as a potential agent for managing T2DM. They accomplish this via the action of phytochemicals such as flavonoids, phenolic acids, anthocyanins, saponins, alkaloids, glycosides, terpenes, etc (Luo *et al*., 2021; Zhang *et al*., 2016).

The administration of aqueous sweet potato root extracts, containing tannin, saponin, flavonoids, terpenoids, alkaloids, anthraquinones, reducing sugar and cardiac glycosides, has resulted in a decrease in serum creatine and lactate dehydrogenase activity. The findings obtained indicate a possible cardioprotective effect of sweet potato aqueous root extracts (Shafe *et al*., 2016). Sweet potato trypsin inhibitors, also known as sporamin, are the major proteins present in root and it was found to reduce LDL oxidation in vitro (Lu *et al.*, 2020).

C. Antiulcerogenic, anti - obesity and anti-cancerous properties

Ulcer is characterized by the shedding of inflamed tissue from the skin or mucous membrane. Methanol extract of sweet potato roots showed gastroprotective activity against aspirin-induced ulcer in Wistar rats in a dose dependent manner. The flour of sweet potato roots potentially prevented ethanolinduced gastric ulceration by suppressing edema formation and partly protecting gastric mucosa wrinkles . In another in vivo study, ethanolic extract of sweet potato roots shows antacid-like action against a pylorus ligation and cold restraint stress induced ulcer in animal models. (Sathish *et al*., 2012).Phenolic acids, flavonoids, anthocyanin compounds, terpenoids, carotenoids, organosulfurs, and phytosterols are some natural dietary phytochemicals present in sweet potato have shown promise as anti-obesity agents (Sams *et al*., 2020; Singh *et al*., 2020). These phytochemicals have the ability to modulate inflammatory, oxidative, and cell proliferative processes, both of which are implicated in the onset of a number of metabolic disorders, like obesity (Singh *et al*., 2020).According to the WHO (2021), cancer is the second most common cause of death worldwide, accounting for nearly 10 million deaths per year. Cancer is responsible for nearly 1 in every 6 deaths worldwide and kills nearly 70% of people in low- and middle-income countries. The use of complementary and alternative medicine for cancer treatment has been growing alongside conventional medical treatments. Natural products and herbal medicine have been used for treatment of various diseases and have exhibited anticancer activities (Khan *et al*., 2020).In human colon cancer cell HT-29, sweet potato protein hydrolysates, treated by 6 proteases, exhibited certain antiproliferation effect with IC50 values ranging from 119.72 to 422.05 μg/mL (Zhang and Mu, 2018)

IV. Antioxidant Properties of Berries

A. Black Grapes

Catechin oligomers, proanthocyanidin dimers and trimers, along with other monomeric wine phenolics were extracted and then purified from grapes and grape seeds and tested for their inhibition of LDL oxidation. Among the various phenolic antioxidants present in red wine, (+)-catechin, (−)-epicatechin, proanthocyanidins, anthocyanins, resveratrol, quercetin and its glycoside (rutinoside) rutin are the most potent, since they have been found to protect human LDL against oxidation more efficiently than α-tocopherol on a molar basis.(Lachman *et al*.,2018)

B. Green Grapes

Total flavonols in green grape extract ranged between 1.6 to 10.4 mg/L, which significantly differ among grape genotypes (Breksa *et al*., 2015)

Resveratrol is involved in inducible as well as constitutive defense mechanisms of plants and produced as stress metabolite in response to various biotic e.g., pathogenic attach,injury and abiotic stresses e.g., UV-irradiation, O_3, growth hormone and heavy metals(Hassan and Bae, 2017).

Although resveratrol found in almost 70 plant species (berries, grapes, peanuts and pines) however, it is found in very limited range of edible materials mainly skin of grapes, juice and wine produced from these grapes. Green Grape skin proved to be rich sources of anthocyanins, hydroxycinnamic acids, fl avan-3-ols (class of reduced fl avonoids with 2-phenyl-3,4-dihydro-2H-chromen3-ol skeleton) and flavonol glycosides, whereas fl avan-3-ols are mainly present in seeds and could exert antibacterial activities.(Chong *et al*., 2019)

C. Tomato

Tomatoes, which are actually a fruit and not a vegetable, are loaded with all kinds of health benefits for the body. Lycopene is a vital anti-oxidant that helps in the fight against cancerous cell formation as well as other kinds of health complications and diseases. Free radicals in the body can be flushed out with high levels of Lycopene, and the tomato is so amply loaded with this vital anti-oxidant that it actually derives its rich redness from the nutrient. (Paswan *et al*.,2012)

Vitamin E can be found in nature under several isoforms, the most important among them is -tocopherol and its biological action is mainly due to its antioxidant properties. There are three tocopherol isoforms in tomato fruits but that more than 90 % is constituted by –tocopherol. In addition to the carotenoids and ascorbic acid, the main antioxidants in tomatoes are the phenolic compounds .When they are absorbed into the body, they induce protective action against oxidant agents. (Santamaria 2016)

D. Amla

Ethyl acetate extract of Amla has been reported to reduce the elevated levels of urea nitrogen and serum creatinine in aged rats. Oral administration of this extract significantly reduced the thiobarbituric acid-reactive substance levels of serum, renal homogenate and mitochondria in aged rats, suggesting that amla would ameliorate the oxidative stress under aging. (Pandey, Govind., *et al* 2017)

Amla extracts orally administered to the diabetic rats slightly improved body weight gain and also significantly increased various oxidative stress indices of the serum of the diabetic rats. Moreover the decreased levels of albumin in the diabetic rats were significantly improved with this drug. It also significantly improved the serum adiponectin levels. Thus, amla can be used for relieving the oxidative stress and improving glucose metabolism in diabetes.Amla contains tannoid principles comprising of emblicanin A, emblicanin B, punigluconin and pedunculagin, which have been reported to posses antioxidant activity in vitro and in vivo . Ellagic acid, as a powerful antioxidant present in Amla, has the ability to inhibit mutations in genes and repairs the chromosomal abnormalities. (Rao *et al*.,2015)

D. Star Gooseberry

Methanolic extract of fruit and leaves was reported to possess antimicrobial activity. In vitro screening of petroleum ether extract of fruits showed cytotoxic, antibacterial and antioxidant activity. Different parts of Star gooseberry have been reported for several biological activities, fruits and leaves of the plant showed promising hepatoprotective activity. Phyllanthosols A and B were isolated from roots, which were proposed as promising antitumor activity (Habib 2011). Star gooseberry is reach in different secondary metabolite like alkaloids, tannins, flavonoids, lignans, phenolics and terpenes.Several species of phyllanthus have shown antinociceptive activity in mice. (Siripong 2019)

V. Health Benefits of ingredients Used in the Standard recipe preparation

A. Black Grapes

(i) Anti cancer properties

Cui *et al*., (2016) found that resveratrol lowered the expressions of cyclins D1 and D2. Cdk 2, 4 and 6; and multiplication cell nuclear antigen, but can be amplified the p21WAF1/CIP1. It also suppressed the anti-apoptotic proteins e.g., tumor promotion markers, survivin, ornithine decarboxylase and cyclo oxygenase.Resveratrol (5000 ppm) administration in mice speed up wound tightening and curing and grapes exhibited the healing of wounds through regulating oxidant-induced modifications in keratinocytes. (Hannah *et al*., 2014).

B. Green Grapes

(i) Inhibition of Platelet Aggregation

The inhibitory effect of grape phenolics on platelet aggregation is one of the accepted mechanisms in cardioprotection. The inhibition of platelet aggregation by grapes was demonstrated in animal and human studies. (Bagchi *et al*., 2020).Quercetin, the predominant grape flavonoid, suppresses platelet aggregation in vitro and lowers thromboxane synthesis in vivo (Yang *et al*.,2013)

(ii) Antiproliferative Activity

Grapes provide a rich source of phenolics such as RSV, which inhibit cellular events related to initiation, promotion, and progression of carcinogenesis both in vitro and in vivo, like breast cancer, prostate ,liver cancer,colorectal and intestinal cancers, skin cancer, lung cancer, blood cancer and thyroid cancer. The inhibitory effects of 14 wine grape varieties on Caco-2 human colon cancer cells, HepG2 human liver cancer cells, and MCF-7 human breast cancer cells in vitro were examined (Yang *et al*., 2019).

C. Tomato

(i) Anti cancer properties

The health benefits of tomatoes are becoming more and more documented recently. Cancers such as prostate cancer, cervical cancer, colon cancer, rectal cancer, and cancers of the stomach, mouth, pharynx, and esophagus have all been proven to be staved off by high levels of Lycopene in tomato. Researchers introduced Lycopene into pre-existing cancer cell cultures and the Lycopene prevented the continued growth of these cultures. This is pretty powerful evidence that the health benefits of eating a tomato are really quite phenomenal. (Sampath *et al*.,2012)

(ii) Cardio – protective Properties

Agarwal *et al*. (2020) reported that lower blood lycopene levels are associated with increased risk for death from coronary artery disease. Lycopene may have a cholesterol synthesis-inhibiting effect and may enhance LDL degradation leading to prevention of cardiovascular diseases in humans.

(iii) Antiaggregatory effect

The phytonutrients present in tomato helps in preventing excessive clumping of platelet cells. This ability is referred as an "Antiaggregatory effect".(Rajesh *et al*.,2012)

(iv) Bone health

The connection of tomato intake to bone health involves the rich supply of antioxidant in tomatoes, since antioxidant protection is important for bone health. Tomatoes have a fair amount of vitamin K and calcium, which helps to strengthen and possibly repair the bones and bone tissue in minor ways. (Ganesan *et al.*,2012)

D. Amla

Some of the toxins may be stored in liver by regular uptake of pain killers, antibiotics, medication and alcohol consumption. Amla prevents the body from these toxins by strengthening the liver thereby amla act as good detoxifier helps to purify the blood. The fresh juice of amla acts as a diuretic which normalize acidic urine. It is helpful in burning urinary infection(Krishnaveni *et al.*, 2012).It assists in balancing nitrogen levels and increasing protein levels very well, which helps in increasing your weight. Amla contains minerals including chromium, zinc, and copper, which helps in maintaining proper functioning of the metabolic activities of the body. (Mirunalini, S. et al., 2012).Amla has anti-inflammatory property. Its use has been found beneficial in reducing inflammation in arthritis and other rheumatic conditions (Bakhru 2014).Table I presents the Antioxidant properties of Amla

Table I

S.no.	**Properties**	**Components**	**Reference**
1	Anticancer	Aqueous/methan olic fruit extract and polyphenols of Emblica officinalis.	Baliga and Dsouza, 2011;
2	Hepatoprotective	Vitamin C, Gallic acid, Flavonoids, Tannins and Phyllanthin	Sharma et al., 2019
3	Cardioprotective	Emblicanin A, B, Ascorbic acid, Polyphenols, Ellagic acid	Pandey and Govind, 2011
4	Anti inflammatory	Methanolic extract of fruit	Golechha et al., 2014
5	Antimicrobial	Ethanolic extract	Thaweboon and Thaweboon, 2011
6	Metabolic syndrome	Polyphenol	Kim et al., 2010

E. Star Gooseberry

Fawzi *et al.*, 2019 stated that the people of the Mascarene Island use the plant for hepatitis and dysentery. Methanol extracts of the leaves and fruits have been reported to show antimicrobial and hepatoprotective activity. Methanol fruit extracts have also been reported to exhibit cytotoxic and antioxidant potential.

Star Gooseberry are also considered as essential active ingredients in Unani and Ayurvedic systems of medicine due to their rich sources of phytochemicals that benefit human health (Huang *et al*., 2017).Traditionally, fruits and leaves are used to treat ulcer, cough, scurvy, and asthma, and also used as an astringent and laxative. The extracts obtained from various parts of the Star Gooseberry plant have cytotoxic, antihyperlipidemic, and hypotensive effects; they can also be used to treat cystic fibrosis. (Chongsa *et al*., 2014)

Jaggery

Jaggery is a natural traditional sweetener made by concentrating the extracted sugarcane juice containing all the minerals and vitamins present in sugarcane juice, it is known as healthiest sugar in the world. India is the largest producer and consumer of jaggery. In Ayurvedic way of medicine, it is used as medicine, blood purifier and base material for syrupsMagnesium present in jaggery strengthens our nervous system, helps to relax our muscles, gives relief from fatigue and takes care of our blood vessels. It also along with selenium acts as an antioxidant property scavenge free radicals from our body .The potassium and low amount of sodium present in it maintain the acid balance in the body cells and also combat acids and acetone and control our blood pressure..It has moderate amount of calcium, phosphorous and zinc so it helps to optimum health of a person along with all its benefits, purifies the blood and prevents rheumatic afflictions and bile disorders and thus helps to cure jaundice. (Kumar 2017)

VI. Advances in Sweet Potato Flour Utilization in Human diets

Sweet potato flour can also be used directly or as a raw material for processing into other products. A variety of products such as doughnuts, biscuits, muffins, cookies, fried sweet potato cakes, extruded sweet potato chips, ice creams, porridge, brownies, pies, breakfast foods, and weaning foods have been made from SPF (Fuglie & Hermann, 2014).The flour prepared using blanching as pretreatments which have high swelling power can be partly incorporated with wheat flour for bread making. The less digestibility of acetylated flours makes them suitable for specific and targeted food products such as for diabetics and obese people who may have a lower digestibility ability. Preheating treatments such as blanching, steaming could be used as a method for modifying and preserving functional properties to suit various applications of sweet potato flour in the food industry. (Daniel Mamo *et al*., 2020).

Table II presents the data on processed products of Sweet potato

Table II

Processed Products of Sweet Potato (Avula 2015)

COUNTRY	PRODUCTS
China	Dried / fried chips, Fructose syrups,Monosodium glutamate, Amino acids
Japan	Noodles,Glucose and Fructose syrups, Candy, fried chips,
India	Flour
Philippines	Snack foods, Dried cubes
Taiwan	Noodles, Candy, Bread and Baked goods
USA	Canned roots, Puree / Paste, Flakes, β-amylase

The sweet potato combines a number of advantages from nutritional to socioeconomic to environmental, which makes it a potentially good candidate for reducing the increasing food insecurity, VAD, and the under- and overnutrition that is occurring globally, especially in developing countries. Repositioning sweet potato production and its potential for value-added products will contribute substantially to utilizing its benefits and many uses. (Bovell-Benjamin, A.2007)

Methodology

III. METHODOLOGY

The methodology pertaining to the study on **" Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas*) and Berries"** comprised of the following phases:

PHASE I : Selection and Collection of Oriental and Hannah Varieties of Sweet potatoes

A. Selection of Oriental and Hannah Varieties of Sweet potatoes
B. Collection of Oriental and Hannah Varieties of Sweet potatoes
C. Cleaning, Slicing ,Drying and Powdering of Sweet potatoes

PHASE II: Preliminary analysis of Phytochemicals and Nutrients present in the Oriental and Hannah Varieties of Sweet potatoes

A. Analysing the Phytochemical compounds present in Oriental and Hannah varieties of Sweet potatoes
B. Analysing the Nutrients present in Oriental and Hannah varieties of Sweet potatoes

PHASE III : Formulation, standardization and evaluation of berry bars incorporating Oriental and Hannah varieties of Sweet potato flour

A. Selection and Collection of ingredients for development of berry bars incorporating Sweet potato flour
B. Preparation of berry bars incorporating Sweet potato flour
   (a) Sweet potato black grapes bar
   (b) Sweet potato green grapes bar
   (c) Sweet potato tomato bar
   (d) Sweet potato amla bar
   (e) Sweet potato star gooseberry bar
C. Standardization, organoleptic evaluation and acceptability trials of prepared sweet potato berry bars.
D. Evaluation of Physio-chemical properties of standardized berry bars

Evaluation of Colour, Texture, TSS-Total Soluble Solids, Acidity and pH of standardized sweet potato berry bars

PHASE IV : Analysing the nutrient Content, antioxidant profile, microbial assay and conducting shelf life study of most acceptable sweet potato berry bars

A. Analysis of nutrients present in the most acceptable sweet potato berry bars
B. Analysis of antioxidants and conducting the shelf life study of most acceptable berry bars
C. Microbial analysis of most acceptable berry bars

PHASE I : Selection and Collection of Oriental and Hannah varieties of Sweet potatoes

The research study and the protocols used in the research was presented to the Institutional Ethical Committee and Ethical Clearance was obtained and it is presented in Appendix I. The approval number given by the ethical committee is AUW/IHEC/FSN-21-22/XPD-11.

A. Selection and Colletion of Oriental and Hannah varieties of Sweet potatoes

Oriental and Hannah varieties of sweet potatoes were selected based on the local availability, latest literature on the nutritional value, phytochemical composition and health beneficial properties. Sweet potatoes have a broad range of colors, high-quality nutritional composition including bioactive substances (anthocyanins and β-carotene), vitamins, minerals, dietary fiber and starch. The high nutritional value and the presence of good levels of polyphenols, antioxidants in sweet potato varieties grabs the attention of food industries to produce value-added products. (Hernandez *et al* 2020)

The dietary intakes of sweet potatoes are strongly recommended for their undeniable health-promoting properties. They also offer potential application in food industries for novel value-added food products. (Alam , M.K. 2021).Oriental and Hannah varieties of Sweet potatoes were collected from the local market of Gopalapuram, Udumalpet.

B. Cleaning, Slicing, Drying and Powdering of Sweet potatoes

The collected Sweet potato varieties were thoroughly washed with running water as well as distilled water in order to remove all the dirt and debris. The washed Sweet potato were then peeled with the help of peeler. Slices of 2-3mm were prepared from the peeled sweet potatoes using a slicer.

The slices are steamed for about 3-5 minutes to increase the bioavailability of nutrients and to prevent enzymatic darkening.

Mu, Tai-Hua. et al., (2019). conducted a study and concluded that, steaming was found to retain carotenoids, TPC and VC, and enhance the antioxidant activity of Sweet potato.

The steamed slices are cooled, spread on a cloth and then shade dried until free of moisture. The dried slices are pulverized in a pulverizer and made into a flour. Figure 1 represents the flowchart for the preparation of oriental and hannah sweet potato flour.

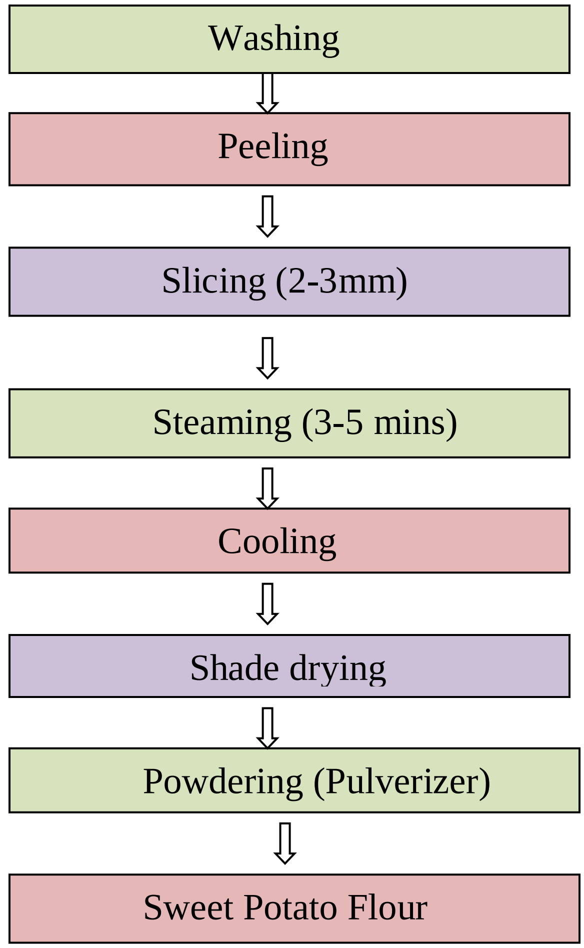


Figure 1. Flowchart for the Preparation of Oriental and Hannah sweet potato flour

PHASE II :Preliminary analysis of Phytochemicals and Nutrients present in the Oriental and Hannah Varieties of Sweet potatoes

A. Analysing the Phytochemical compounds present in Oriental and Hannah varieties of Sweet potatoes

Phytochemicals are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans as medicinal ingredients and nutrients. phytochemicals have been reported and are classified on the basis of their protective functions, and physical and chemical characteristics, amongst these about 350 phytochemicals have been studied in detail.(Koche *et al*.,2016)

Phytochemicals analysed for the oriental and hannah sweet potato flour include tannins, steroids, terepenoids, cardio-glycosides, chalcones, flavonoids, saponins, phenol and alkaloids.

(i) Extraction of Sweet potato Flour

For the ethanolic extracts , finely ground powdered samples of sweet potato(3g) was extracted with 30 ml acidified methanol (1% conc. HCl in ethanol) using a three steps approach as follows: A 10 ml solvent was added to each flour sample in a conical flask and completely covered with aluminum foil. The samples were stirred for 2 hrs using magnetic stirrer, centrifuged in a 50 ml plastic centrifuged tube at 1900 rpm for 10minutes at room temperature and decanted. The supernatant and the residue was re-extracted in 10 ml of the solvent for 15minutes, centrifuged and the process was repeated thrice. The supernatant was combined and stored in a glass bottle covered with aluminum foil and kept at 4°C in refrigerator until further analysis.

The extract was used for the analysis of tannins, steroids, terepenoids, cardio-glycosides,chalcones,flavonoids,saponins,phenol and alkaloids.

(a) Test for Tannis (Braymer's Test)

To 1ml of test sample, 3 m of distilled water and 3 drops of 10% Ferric chloride solution is added. Appearance of blue – green colour confirmed the presence of tannin.

(b) Test for Steroids (Acetic anhydride Test)

2ml of acetic anhydride was added to 2ml of test sample followed by careful addition of 2ml Sulphuric acid. The color changed from violet to blue or green indicated the presence of steroids.

(c) Test for Terpenoids (Cholroform Test)

5ml of test sample was mixed with 2ml of chloroform and 3ml concentrated $H_2 SO_4$ was carefully added to form a layer. A reddish -brown coloration at the interface was formed to show positive result for the presence of terpenoids.

(d) Test for Cardic Glycosides (Keller- Killani Test)

5ml of each extracts was treated with 2ml of glacial acetic acid containing one drop of ferric chloride solution. This was treated with 1ml of concentrated sulphuric acid. A browning of the interface indicated a deoxysugar characteristic of cardio-glycosides which confirms a positive presence of cardio-glycosides.Violet green rings appearing below the browning in the acetic acid layer indicated the presence of glycoside.

(e) Test for Chalcones (Ammonia Test)

2 ml of ammonia solution was added to 5 ml of test sample and formation of a reddish color confirmed the presence of chalcones.

(f) Test for Flavonoids

3ml of aluminium chloride solution was added to 5ml of test sample, a yellow coloration was observed indicating the presence of flavonoids after addition of concentrated H_2SO_4. A yellow coloration disappeared on standing. The yellow coloration which disappeared on standing indicated a positive test for flavonoids.

(g) Test for Saponins

One gram of each extract was boiled with 5 ml of distilled water and filtered. To the filtrate, about 3 ml of distilled water was further added and shaken vigorously for about 5minutes. Frothing which persisted on warming was taken as an evidence for the presence of saponins.

(h) Test for Phenol (Lead acetate Test)

5ml of the test sample was dissolved in 5ml of distilled water. To the diluted sample 3 ml of 10% lead acetate solution was added. A white precipitate was observed indicating the presence of phenol.

(i) Test for Alkaloids (Picric Test)

To 3ml of test sample 1 ml of picric acid solution was added. Appearance of yellow colour indicated the presence of alkaloids.

B. Analysing the Nutrients present in Oriental and Hannah varieties of Sweet potatoes

Nutrient Analysis

Nutrient analysis refers to the process of determining the nutritional content of foods and food products.There are a variety of certified methods used for performing nutritional analysis. By utilizing scientific methods and equipment the food sample is analyzed for the different components that compose the nutritional information needed. The laboratory analysis measures the actual levels of nutrients in the prepared food, thus providing a high level of accuracy of the analysis. The analysis accounts for the changes in nutritional value that occur due to the cooking and processing of the food. Analysis of moisture content, ash content, energy content , carbohydrates, protein, fat, dietary fibre, beta-carotene, calcium, iron, ascorbic acid.

(i) Moisture Content

Moisture content was measured using evaporation scale ‘Moisture balance MOC-120H’ from Shimadzu (Shimadzu Corporation, Japan) at 120°C until the difference in sample weight was less than 0.05 percent from previous weight measurement.

(ii) Ash Content

Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a food sample. Determining the ash content of a food is part of proximate analysis for nutritional evaluation and it is an important quality attribute for some food ingredients. Also, ashing is the first step in the preparation of a sample for specific elemental analysis. This laboratory exercise uses the dry ashing technique with a muffle furnace to determine the ash content of a variety of food products.(Baraem.P.Ismail 2017)

$$\text{Ash Content (g/100g sample)} = \frac{\text{Weight of Ash}}{\text{Weight of Sample}}$$

(iii) Macronutrients

a. Energy Content

The calorie content was determined using a bomb calorimeter (LECO, USA). The sample was placed in the crucible in the combustion chamber for the combustion process. Once the sample is ignited, a thermometer which is partially submerged in the water records the temperature changes that occur. The heat of combustion (cal/g), the change in temperature was recorded as the calories content of the sample. (Wan Mohamad Din et al., 2020)

b. Carbohydrates

The sample is treated with 80% alcohol to remove sugar and then starch is extractedwith perchloric acid. In hot acidic medium starch is hydrolysed, to glucose and dehydrated tohydroxyl methyl furfurol. This compound forms a green colour product with anthrone.

c. Protein

The protein content of foods has been determined on the basis of total nitrogen content. Kjeldahl method has been almost universally applied to determine nitrogen content.Samples are digested with sulphuric acid in a macro kjeldahl flask when nitrogen getsconverted to Ammonium Sulphate. Ammonia is liberated by the action of strong alkali in a macrokjedahl steam distillation apparatus.

d. Fat

Ether extraction of the crude fat in vegetable products is carried out in a continuous extractor that is an apparatus in which the ether, after dissolving a portion of the fat of the material and discharging into the extraction flask, is volatized, condensed and again allowed to act on the material. The steps in the process are repeated continuously and automatically until the extraction is complete. The soxhlet extraction used depends on the intermittent action of a glass syphon. The ether gradually condenses into the extraction tube containing the material until it rises to the top when it is discharged into the extraction flask.

e. Fibre

The term "crude fibre" ordinarily meant in agriculture and food analysis is the organic residue consisting largely of cellulose, that is left after other carbohydrates and proteins has been removed by successive treatment with boiling acids and alkalies. The crude fibre obtained in this way is not cellulose but contains distinct properties of hemicellulose, and nitrogenous substances. However, these are not sufficient to prevent the results from being reasonably accurate and comparable.

(iii) Micronutrients

a. Beta-carotene

Pigment extraction for β-carotene analysis

This was carried out according to the method of the Association of Official Analytical Chemists (AOAC, 1980). In to a conical flask containing 50ml of 95% ethanol,10g of the macerated sample was placed and maintained at a temperature of 70-80ºC in a water bath for 20minutes with periodic shaking. The supernatant was decanted, allowed to cool and its volume was measured by means of a measuring cylinder and recorded as initial volume. The ethanol concentration of the mixture was brought to 85% by adding 15ml of distilled water and it was further cooled in a container of ice water for about 5minutes. The mixture was transferred in to a separating funnel and 25ml of petroleum ether (pet-ether) was added and the cooled ethanol was poured over it. The funnel was swirled gently to obtain a homogenous mixture and it was later allowed to stand until two separate layers were obtained. The bottom layer was run off into a beaker while the top layer was collected in to a 250ml conical flask. The bottom layer was transferred in to the funnel and re-extracted with 10ml petroleum ether for 5-6 times until the extract became fairly yellow. The entire petroleum ether was collected in to 250ml conical flask and transferred in to separating funnel for re-extraction with 50ml of 80% ethanol. The final extract was measured and poured in to sample bottles for further analysis.

Measurement of absorbance

The absorbance of the extracts was measured using a spectrophotometer (model 22UV/VIS) at a wavelength of 436nm. A cuvette containing pet-ether (blank) was used to calibrate the spectrophotometer to zero point. Samples of each extract were placed in cuvettes and readings were taken when the figure in the display window became steady. The operation was repeated 5-6 times for each sample and average readings were recorded.

b.Calcium

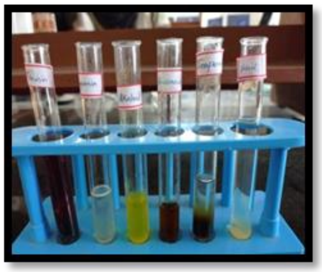
Calcium is determined by precipitating it as calcium oxalate and titrating the oxalate solution in dilute sulphuric acid against standard potassium permanganate.

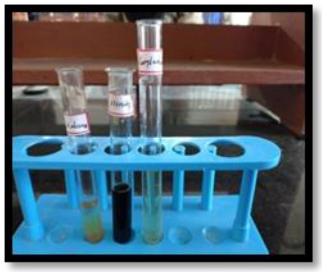
c. Iron

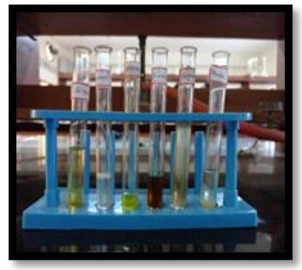
The food sample is oxidized with ignition or oxidation. Iron as ferric iron reacts with ammonium thiocyanate or with potassium thiocyanate to give ferric thiocyanate which is red in colour. The colour which is a measure of the concentration is measured colorimetrically.

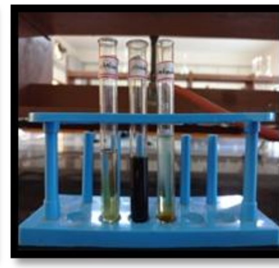
d. Vitamin C

Vitamin C is a good reducing agent and it reduces the dye 2,6 dichlorophenol-indophenol. In this reaction, the ascorbic acid itself is oxidisied to dehydro ascorbic acid. Inthe absence of interfering substances, the capacity of an extract of the sample to reduce a standard solution of the dye as determined by titration is directly proportional to the vitamin C content. Oxalic acid is not only used to reduce the pH of the extracting medium,thereby establishing vitamin C but also form complexes with metals.



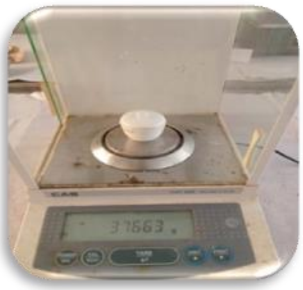






Phytochemical analysis of oriental sweet potato flour

Phytochemical analysis of hannah sweet potato flour



Determination of Moisture

Determination of Ash Content

Determination of Energy Value

Analysis of Fat

Estimation of Iron

Estimation of Vitamin C

Estimation of Calcium

Plate I Analysis of Phytochemicals and Nutrients

PHASE III : Formulation,standardization and evaluation of berry bars incorporating oriental and hannah varieties of Sweet potato flour

A. Selection and Collection of ingredients for development of berry bars incorporating Sweet potato flour

(i) Black Grapes

Grapes are a major fruit crop in the world. Grapes confer to health benefits due to their antioxidant activity. Black grapes are rich in antioxidants and essential nutrients. Reports indicate that Black grapes contain large amounts of phenolic compounds, which play an important role in human health, such as lowering of human low-density lipoprotein. (Thilak ,J.C., et al 2017).The berries were collected from the local market of Saibaba colony, Coimbatore.The collected berries were washed,seeds and stalks were removed and the pulp was extracted for further processing.

(ii) Green Grapes

Green Grapes are well known for being rich in phytochemicals and antioxidant property. They have drawn attention not only because of their important role in health but also for their benefits of deriving different products from them. Phenolic compounds are present in the pulp, skin, and seeds of grapes. They are considered one of the most important quality parameters of grapes and their products since they add to their color and organoleptic characteristics such as flavor, bitterness, and astringency. Phenolic compounds are efficient antioxidants. (Sharma, M. & Bais, R.T 2020).The berries of Green Grapes were collected from the local shops in Saibaba colony, Coimbatore and were bought to lab and washed , the seeds and stalks were removed.

(iii) Tomato

Tomatoes, are berries loaded with nutrients and antioxidants. One of the most well known tomato eating benefit is its Lycopene content. Lycopene is a vital anti oxidant that helps in the fight against cancerous cell formation as well as other kinds of health complications and diseases.Tomato is also an excellent source of nutrients, including folate, vitamin C and various other carotenoids and phytochemicals, such as polyphenols. Tomatoes also contain significant quantities of potassium, as well as some vitamin A and vitamin E. (Senthilkumar et al.,2012). Tomatoes are collected from the local farms of Gopalapuram, Udumalpet. The collected tomatoes were washed and the seeds are removed carefully using a stainless steel knife and the pulp is extracted for further processing

(iv) Amla

Amla is highly nutritious and is one of the richest sources of vitamin-C, amino acids and minerals.It contains several phytochemical constituents like tannins, alkaloids and phenols. Almost all parts possess medicinal properties, particularly fruit, which has been used in Ayurveda as a powerful "Rasayana". Amla fruit is widely used in the Indian system of medicine as alone or in combination with other plants and is used to treat common cold and fever, as diuretic, laxative, liver tonic, refrigerant, stomachic, restorative, anti-pyretic, hair tonic; to prevent ulcer and dyspepsia.(Swetha, D.,& Krishna M.G. 2014).Amla berries were collected from the local region of Kallapuram, Udumalpet. The pulp of the fruit is removed from the pod carefully for further processing.

(v) Star Gooseberry

Star gooseberry are cultivated as backyard fruit species in southern parts of India. The berry eaten in fresh/processed form are considered as highly nutritious and therapeutic due to its high amount of Vitamin C, antioxidant and polyphenol content.. The berry may eaten fresh after sprinkled with salt, processed into pickle and sweetened dried fruits, cooked and served as a relish, or made into a thick syrup or sweet preserve. (Pushpakumara, *et al.*, 2019).The Star Gooseberries were collected from the local market of Thudiyalur, Coimbatore. The collected berries were washed , the seeds and the stalks are removed and the pulp was extracted for further processing.

(vi) Jaggery

Jaggery is sugarcane based natural sweetener made by the concentration of sugarcane juice without any use of chemicals. It contains the natural sources of minerals and vitamins inherently present in sugarcane juice and it is one of the most wholesome and healthy sugars in the world. The micro nutrients present in the jaggery possess antitoxic and anti-carcinogenic properties.The development of different value added products from jaggery becomes needs of the hour to prevent life style diseases. (Kumar, P., et al 2015)Jaggery is purchased from the local store of Saibaba colony, Coimbatore. The purchased jaggery is sliced to use in the process.

B. Preparation of berry bars incorporating Sweet potato flour

(a) Sweet potato black grapes bar
(b) Sweet potato green grapes bar
(c) Sweet potato tomato bar
(d) Sweet potato amla bar
(e) Sweet potato star gooseberry bar

C. Standardization, organoleptic evaluation and acceptability trials of prepared sweet potato berry bars

(a) Sweet potato black grapes bar

Table III presents the Composition of black grapes bar incorporated with oriental and hannah Varieties of sweet potato flour

Table III

Composition of black grapes bar incorporated with Oriental and Hannah Varieties of Sweet potato flour.

Ingredients	Standard (S)	Variation I	Variation II	Variation III
Black Grapes	50	60	50	40
Jaggery	50	50	50	50
Sweet Potato Flour	-	40	50	60

S - Standard berry bar

Variation I –40 % Sweet potato flour incorporated berry bar

Variation II– 50 % Sweet potato flour incorporated berry bar

Variation III – 60 % Sweet potato flour incorporated berry bar

Pulp of the purchased black grapes was separated from the seed and stalks. The extracted pulp was then grinded. The grinded blend was heated at 50°C for 5 mins. Sweet potato flour was added and stirred continuously. Sliced jaggery was added to the heating mixture and the mixture was concentrated to 50°Brix. The berry bar blend was spread on a tray coated with glycerine. The berry bar spread was allowed to dry for 10 hours at 65°C. The dried fruit slab is cooled and cut into rectangular shapes(2.5 × 4.0 cm2) and wrapped in butter paper.

(b) Sweet Potato Green Grapes bar

Table IV presents the Composition of green grapes bar incorporated with oriental and hannah Varieties of sweet potato flour

Table IV

Composition of green grapes bar incorporated with Oriental and Hannah Varieties of Sweet potato flour.

Ingredients	Standard (S)	Variation I	Variation II	Variation III
Green Grapes	50	60	50	40
Jaggery	50	50	50	50
Sweet Potato Flour	-	40	50	60

S - Standard berry bar

Variation I –40 % Sweet potato flour incorporated berry bar

Variation II– 50 % Sweet potato flour incorporated berry bar

Variation III – 60 % Sweet potato flour incorporated berry bar

Green grapes were collected ,washed and the stalks was removed from the pod. The separated flesh was cut into pieces and grinded with the help of the mixer. The blend was heated at 50°C for 5 mins. Sweet potato flour is added and stirred continuously. Sliced jaggery was added to the heating mixture and the mixture was concentrated to 50°Brix. The berry bar blend was spread on a tray coated with glycerine. The berry bar spread was allowed to dry for 10 hours at 65°C. The dried fruit slab was cooled and cut into rectangular shapes (2.5 × 4.0 cm2) using a stainless steel knife and wrapped in butter paper.

(c) Sweet Potato Tomato bar

Table V presents the Composition of tomato bar incorporated with oriental and hannah Varieties of sweet potato flour

Table V

Composition of tomato bar incorporated with Oriental and Hannah Varieties of Sweet potato flour.

Ingredients	Standard (S)	Variation I	Variation II	Variation III
Tomato	50	60	50	40
Jaggery	50	50	50	50
Sweet Potato Flour	-	40	50	60

S - Standard berry bar

Variation I –40 % Sweet potato flour incorporated berry bar

Variation II– 50 % Sweet potato flour incorporated berry bar

Variation III – 60 % Sweet potato flour incorporated berry bar

Ripe tomato of uniform shape and size, firm texture and maturity (red in colour) were picked from the farm. The collected tomatoes were washed , the seeds were removed and the pulp is extracted. The pulp was then thermally processed with a addition of 0.5g of Nacl to retain the colour and quality.Studies have confirmed that the body absorbs better the lycopene from tomatoes when they are thermally treated.(Paswan, S.,et al 2012).The processed pulp was then cooled and blended. The blend was heated at 50°C for 5 mins. Sweet potato flour is added and stirred continuously. Sliced jaggery was added to the heating mixture and the mixture was concentrated to 50°Brix. The berry bar blend was spread on a tray coated with glycerine. The berry bar spread was allowed to dry for 10 hours at 65°C. The dried fruit slab was cooled and cut into rectangular shapes (2.5×4.0 cm^2) using a stainless steel knife and wrapped in butter paper.

(d) Sweet potato Amla bar

Table VI presents the Composition of amla bar incorporated with oriental and hannah Varieties of sweet potato flour

Table VI

Composition of amla bar incorporated with Oriental and Hannah Varieties of Sweet potato flour.

Ingredients	Standard (S)	Variation I	Variation II	Variation III
Amla	50	60	50	40
Jaggery	50	50	50	50
Sweet Potato Flour	-	40	50	60

S - Standard berry bar
Variation I –40 % Sweet potato flour incorporated berry bar
Variation II– 50 % Sweet potato flour incorporated berry bar
Variation III – 60 % Sweet potato flour incorporated berry bar

Fresh, mature amla berries were selected, washed and the stalks,seeds were removed. The pulp is cooked for 5 mins to remove the scum. The boiled mass is cooled and blended with the help of the mixer. The blend is heated at 50°C for 5 mins. Sweet potato flour is added and stirred continuously. Sliced jaggery is added to the heating mixture and the mixture is concentrated to 50°Brix. The berry bar blend was spread on a tray coated with glycerine. The berry bar spread was allowed to dry for 10 hours at 65°C. The dried fruit slab was cooled and cut into rectangular shapes (2.5×4.0 cm2) using a stainless steel knife and wrapped in butter paper.

(e) Sweet potato Star Gooseberry bar

Table VII presents the Composition of star gooseberry bar incorporated with oriental and hannah Varieties of sweet potato flour

Table VII

Composition of star gooseberry bar incorporated with Oriental and Hannah Varieties of Sweet potato flour.

Ingredients	Standard (S)	Variation I	Variation II	Variation III
Star Gooseberry	50	60	50	40
Jaggery	50	50	50	50
Sweet Potato Flour	-	40	50	60

S - Standard berry bar

Variation I –40 % Sweet potato flour incorporated berry bar

Variation II– 50 % Sweet potato flour incorporated berry bar

Variation III – 60 % Sweet potato flour incorporated berry bar

Fresh, mature star gooseberries were selected, washed and the stalks,seeds were removed. The pulp is cooked for 5 mins to remove the scum. The boiled mass was cooled and blended with the help of the mixer. The blend was heated at 50°C for 5 mins. Sweet potato flour was added and stirred continuously. Sliced jaggery was added to the heating mixture and the mixture is concentrated to 50°Brix. The berry bar blend was spread on a tray coated with glycerine. The berry bar spread was allowed to dry for 10 hours at 65°C. The dried fruit slab was cooled and cut into rectangular shapes (2.5×4.0 cm^2) using a stainless steel knife and wrapped in butter paper.

Evaluation of Sensory Characteristics

Sensory attributes such as appearance, flavour,color, taste, texture, and overall acceptability of the product as berry bars was evaluated as recommended by 9 Hedonic rating test. A semi-trained panel consisting of 30 members was selected to evaluate the sample through properly planned experiments. The evaluation was conducted in the Food Sensory Laboratory at Avinashilingam Institute for Home Science and Higher Education for Women.Coimbatore-43.

Color attribute was judged by visual observation. It also includes size, shape, uniformity, maturity, and absence of defects. Texture is the property of food, which is associated with the sense of feel or touch experienced by finger or the mouth. Texture attribute is best indicated by sensation caused by contact with hard and soft parts of the mouth. Samples were served to the panelists and they were asked to rate the acceptability of the product through sensory methods. Different attributes viz., color, odor, taste, texture, and overall acceptability were rated on the basis of the 9 points of the hedonic scale ranging from 1 (extremely dislike/ most undesirable) to 9 (extremely like/most desirable).It is given here, 9 - like extremely, 8 - like very much, 7 - like moderately, 6 - like slightly, 5 - neither like nor dislike, 4 - dislike slightly, 3 - dislike moderately, 2 - dislike very much, 1 - dislike extremely.The data obtained were statistically analyzed using One Way ANOVA to determine statistical differences between the sample

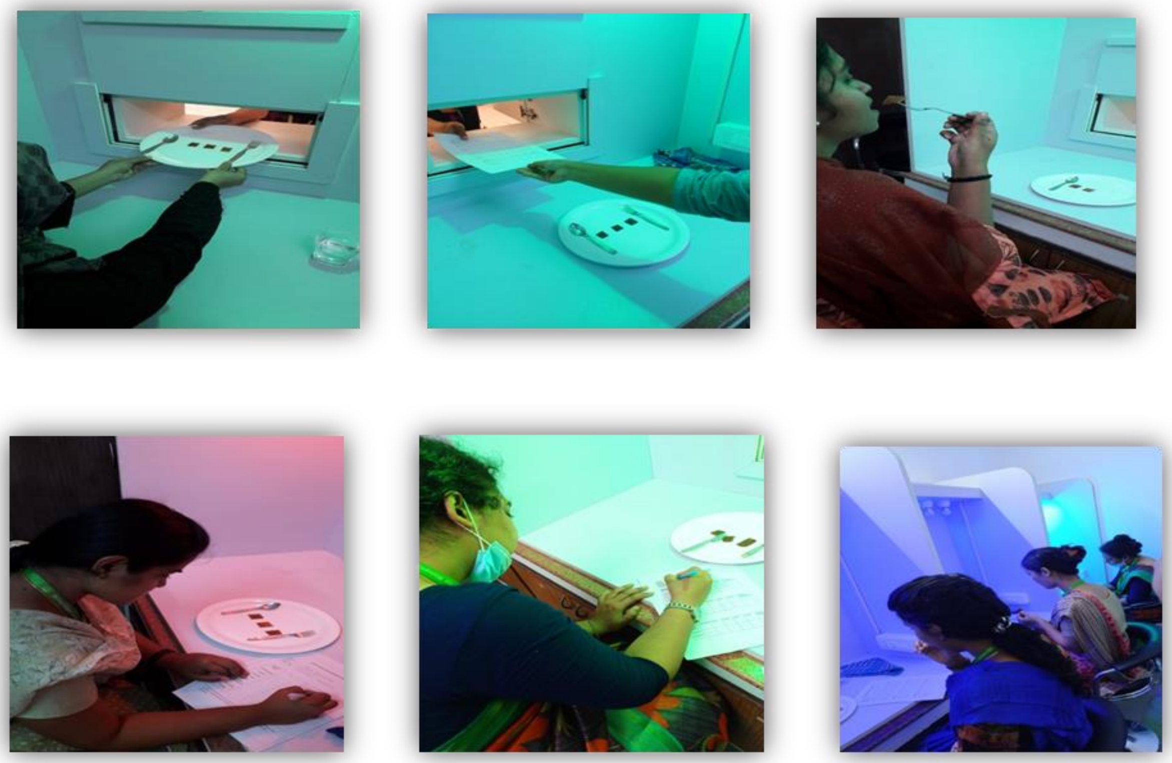


Plate II Organoleptic evaluation of sweet potato berry bars

D. Evaluation of Physio-chemical Properties of standardized Sweet potato berry bars

The physio-chemical properties like Colour, Texture, TSS, Acidity and pH were determined.

(a) Colour

Colour of the fruit bar samples was measured by Shimadzu Colour measuring system (UV-2100, Japan)

Plate III Colour Analysis of sweet potato berry bar

(b) Texture Analysis

Various textural properties of prepared bars such as hardness, adhesiveness,cohesiveness, springiness, gumminess, and chewiness values were calculated using texture profiles obtained from texture analyzer (Model: EZ-SX, Shimadzu Corporation, Japan). The texture analysis was carried out using a 5 mm diameter cylindrical steel probe and 50 kg load cell. The samples were compressed (4 mm) by the probe with a deformation speed of 1mm/s.

(c) TSS - Total Soluble Solids

A digital refractometer PAL-1, USA, calibrated with distilled water was used to determine Total Soluble Solids (TSS). Analysis was repeated thrice to get accurate results.

(d) Acidity (Ranganna, 2000)

Sample (10 g) was taken in a conical flask, water (40 ml) was added to it and mixed thoroughly. The mixture was opaque, then it was centrifuged for 5 min at 4000-6000 rpm. Then extract was titrated with 0.1 N sodium hydroxide using few drops of phenolphthalein solution as indicator. The titrate value was noted.

(e) pH

The pH values of the samples were determined using a digital pH meter (Elico LI 610 – pH meter).

PHASE IV : Analysing the nutrient Content, antioxidant profile, microbial assay and conducting shelf life study of the most acceptable sweet potato berry bars

A. Analysis of nutrients present in the most acceptable sweet potato berry bars

Two varieties of sweet potato flour (Oriental and Hannah) were analysed for all the nutrients. After the analysis, the Oriental sweet potato flour had high nutrient content and hence Oriental sweet potato berry bars were analysed for nutrients in laboratory.The nutrients such as moisture, ash, energy,carbohydrates, proytein, fat,fire,beta-carotene, calcium, iron, vitamin c were analysed in Oriental sweet potato berry bars following the standard procedure discussed in the PHASE II.

B. Analysis of antioxidants and conducting the shelf life study of most acceptable berry bars

(i) Antioxidant Assay

2, 2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay

Samples were diluted to 10 mg/mL with pure ethanol and then centrifuged at 6900 for 20min to 6900 for 20 mins to eliminate residues. 100 mL of each sample was mixed with 150 mL of DPPH radical solution in a 96-well microplate and absorbance was measured at room temperature every 5 min for 2 h at 500 nm, using an HTS 7000 Bio Assay Reader (Perkin Elmer, Norwalk, CT). All samples were run in triplicates.

The percent scavenging capacity was calculated using the following equation:

$$\text{Scavenging effect (\%)} = \frac{[Abs_{control} (Abs_{sample}\ Abs_{sample\ background})]}{Abs_{control}} * 100.34$$

(ii) Shelf life Analysis

Shelf life is an important feature of all foods, including raw materials, ingredients and processed foods. In general terms, Shelf life can be defined as the finite length of time after production and packaging during which the food product retain a required level of quality under well-defined conditions.(Nicoli, M.C. 2012).Shelf life of the prepared berry bars were studied for 28 days at room temperature. The parameters considered for the analysis of shelf life were Weight, Moisture, Colour and the Overall accepatability of the prepared berry bars.

C. Microbial Assay (Pour Plate Method) of most acceptable berry bars

A set of Petridishes was inoculated with 1 ml aliquots from appropriate dilutions of the food. (e.g. inoculate Id of sample from a tube containing 10: dilution to a plate marked as 10-7). Approx. 15-20 ml of molten SPC agar, cooled to 4S0C, is then added to each of the Petridishes. Petridishes are covered with their lids. Moved the plate gently five times clockwise and five times anticlockwise on the table to ensure proper mixing of agar and sample. After the agar has solidified, the plates are incubated at the required temperature for a period depending upon the incubation conditions. After incubation, plates containing between 30-300 colonies are selected for counting the colonies on them and an average of colonies on three Petridishes for that particular dilution is calculated. The number of viable cells per gram (or per cm2) of food can then be readily calculated.

Figure IV Microbial Analysis of oriental sweet potato berry bar

PHASE I →

Selection and Collection of Oriental and Hanna Varieties of Sweet potatoes

A. Selection and Collection Oriental and Hanna Varieties of Sweet potatoes
B. Cleaning, Slicing ,Drying and Powdering of Sweet potatoes

↓

PHASE II →

Preliminary analysis of Phytochemicals and Nutrients present in the Oriental and Hanna Varieties of Sweet potatoes

A. Analysis of phytochemicals – Tannins,Steroids,Terpenoids,cardio-glycosides, Chalcones, Flavanoids,Saponins,Phenol,Alkaloids
B. Analysis of Carbohydrate, Protein, Fat, Moisture, Ash, Fibre, Calcium, Iron, Vitamin C, Beta-carotene

↓

PHASE III →

Formulation, Standardisation and evaluation berry bars incorporating oriental and Hanna varieties of Sweet potato flour

A. Selection and Collection of ingredients for development of berry bars incorporating Sweet potato flour
B. Preparation of berry bars incorporating Sweet potato flour
C. Standardization, organoleptic evaluation and acceptability trials of prepared sweet potato berry bars
D. Evaluation of physio-chemical properties of standardized sweet potato berry bars
Colour, Texture, TSS – Total Soluble Solids, Acidity, pH

Peeling and pulping
↓
Mixing of pulp &sweet potato flour
↓
Heating to 80°C for 10 mins
↓
Addition of jaggery & concentrating to 50°Brix
↓
Spreading the blend on a tray coated with glycerine
↓
Shade drying
↓
Cooling,cutting the blend into rectangular shapes & wrapping it in butter paper

↓

Sweetpotato blackgrapes bar	Sweetpotato greengrapes bar	Sweetpotato tomato bar	Sweetpotato amla bar	Sweetpotato Stargooseberry bar

PHASE IV →

Analysing the nutrient Content, antioxidant profile, microbial assay and conducting shelf life study of most acceptable sweet potato berry bars

A. Analysis of Carbohydrate, Protein, Fat, Moisture, Ash, Fibre, Calcium, Iron, Vitamin C and Beta-carotene of most acceptable sweet potato berry bars
B. Analysis of antioxidants and conducting the shelf life study of most acceptable sweet potato berry bars
C. Microbial Analysis of most acceptable sweet potato berry bars

Figure 2 .Research Design

Result and Discussion

IV RESULT AND DISCUSSION

The results and discussion of the study **"Formulation of Antioxidant Rich Bars using Sweet potato (*Ipomoea batatas*) and Berries"** is presented under the following headings.

PHASE I- Selection and Collection of Oriental and Hannah Varieties of Sweet potatoes

A. Slicing, drying and powdering of selected Oriental and Hannah varieties of sweet potato

PHASE II - Preliminary analysis of Phytochemicals and Nutrients present in the Oriental and Hannah Varieties of Sweet potatoes

A. Analysing the Phytochemical compounds present in the Oriental and Hannah Varieties of sweet potatoes
B. Analysing the Nutrients present in the Oriental and Hannah varieties of sweet potatoes

PHASE III- Formulation, standardization and evaluation of berry bars incorporating Oriental and Hannah varieties of Sweet potato flour

A. Preparation of berry bars incorporating sweet potato flour
B. Standardization, Organoleptic Evaluation and acceptability trails of prepared sweet potato berry bars
C. Evaluation of Physio-chemical properties of standardized sweet potato berry bars
   f. Colour
   g. Texture
   h. TSS – Total Soluble Solids
   i. Acidity
   j. pH

PHASE IV - Analysing the nutrient Content, antioxidant profile, microbial assay and conducting shelf life study of the most acceptable sweet potato berry bars

A. Analysis of nutrients present in the most acceptable sweet potato berry bars
B. Analysis of antioxidants and conducting the shelf life study of the most acceptable berry bars
C. Microbial analysis of most acceptable berry bars

PHASE I- Selection and Collection of Oriental and Hannah Varieties of Sweet potatoes

A. Slicing, drying and powdering of selected oriental and hannah varieties of sweet potato

Oriental and hannah varieties of sweet potato was selected based on the local availability and the amount of research previously done on them.

Hundred grams of the oriental and hannah variety sweet potatoes were taken,cleaned and it was sliced to2.5x4.0cm^2. The sliced sweet potatoes were shade dried until free of moisture. Sweet potato slices were considered dried when they were crisp and could be powdered in the mixer grinder. The weight of the sample before and after drying was noted.

The dried sweet potato slices was powdered in a mixer until the desired fineness was reached. To obtain fine powder it was sieved in a 1.5mm wire mesh. Then the powders were transferred into well cleaned and dried air-tight containers.

Table VIII presents the weight of oriental and hannah sweet potatoes before,during and after processing it into flour.

TABLE VIII

Weight of oriental and hannah sweet potato in fresh, sliced, dried, powdered and sieved flour

Type of Sweet potato	Fresh Weight	Sliced Weight	Dried Weight	Powdered Weight	Seived Weight
Oriental Sweet potato	100	69.5	46.5	33.7	32.4
Hannah Sweet potato	100	68.3	45.4	32.5	31.2

Hundred gram of fresh sample of the oriental and hannah sweet potato was taken, after cleaning and slicing 69.5 and 68.3g of oriental and hannah sweet potato was obtained respectively. The dried weight of sliced oriental and hannah sweet potato was 46.5 and 45.4g respectively. The weight of the powder obtained after drying from oriental and hannah sweet potato was 33.7 and 33.5g respectively before sieving to get a fine powder. The sieved weight of oriental and hannah sweet potato was 32.4 and 31.2g respectively.The weight of the powder obtained after all the processing procedure from 100 g of the oriental and hannah sweet potato was 30% of the original weight.

PHASE II - Preliminary analysis of Phytochemicals and Nutrients present in the Oriental and Hannah Varieties of Sweet potatoes

A. Analysing the Phytochemical compounds present in the oriental and hannah varieties of sweet potatoes

The qualitative analysis of phytochemical compounds in oriental and hannah sweet potato flour was analysed using the ethanolic extracts. For ethanolic extracts, oriental and hannah sweet potato flour was taken and 30 ml of ethanol was added and shaken vigorously for 5-10 minutes and left for 24 hours after which the extract is filtered using the Whatman fiter paper 4.

Table IX gives details on the phytochemical compounds present in oriental and hannah sweet potato flour

TABLE IX

Phytochemical profile of oriental and hannah sweet potato flour

Phytochemical	**Oriental sweet potato flour**	**Hannah sweet potato flour**
Tannins	++	_
Steriods	+	+
Terpenoids	++	++
Cardio-glycosides	-	-
Chalcones	++	++
Flavonoids	++	++
Saponins	+++	+++
Phenol	++	++
Alkaloids	+	+

(+++)- Highly present (++) – Moderately present (+) – Presence (-) – Absence

Braymer's test revealed that the tannin was moderately present in oriental sweet potato flour and absent in hannah sweet potato flour.

Acetic anhydride test was performed to identify the presence of steroids in oriental and hannah sweet potato flour. The appearance of blue colour indicated the presence of steroids in oriental and hannah sweet potato flour.

Cholroform test was used to determine terpenoids in the sample. Terepinoids is moderately present in oriental and hannah sweet potato flour.

Killer- Killani test indicated the absence of cardio-glycosides in oriental and hannah sweet potato flour.

Ammonia test was performed to identify the presence of chalcones in the samples. It indicated the presence of fair amount of chalcones in oriental and hanna sweet potato flour.

Flavonoids has been identified to be moderately present in the samples using Conc.Sulphuric acid test.

Saponin was present in oriental and hannah sweet potato flour ,where it forms more foam and it is highly present in it.

Lead acetate test confirmed the presence of phenols in oriental and hannah sweet potato flour.

Picric test was performed to identify the presence of alkaloids in the samples. It indicated the presence of fair amount of alkaloids in oriental and hanna sweet potato flour.

B. Analysing the Nutrients present in the oriental and hannah varieties of sweet potatoes

Nutrient analysis refers to the process of determining the nutritional content of foods and food products. The process can be performed through a variety of certified methods.Nutrient analysis is a vital part of analytical chemistry that provides information about the chemical composition, processing, quality control and contamination of food. It ensures compliance with trade and food laws. There are a variety of certified methods used for performing nutritional analysis. By utilizing scientific methods and equipment the food sample is analysed for the different components to give the nutritional information needed (DimitrovaMihaela, 2019).

The nutrients of oriental and hannah sweet potato flour was analysed using the AOAC (The Association of Official Analytical Chemists) methods (Horwitz .W 2010). The oriental and hannah sweet potato flour was ashed and diluted. The diluted ash sample was used for analysis of the nutrient content of the oriental and hannah sweet potato flour.

Table X presents the data on the nutrients present in 100 grams of oriental and hannah sweet potato flour.

Table X

Proximate composition of Oriental and Hannah sweet potato flour

Chemical constituents	Oriental Sweet Potato Flour Mean ±SD	Hannah Sweet Potato Flour Mean ±SD
Moisture (g/100g)	6.7±0.0	6.3±0.1
Ash(g/100g)	1.4±0.0	1.4±0.0
Energy(g/100g)	381.5±0.5	365.3±0.5
Carbohydrate(g/100g)	86.6±0.3	85.0±1.00
Protein(g/100g)	4.7±0.2	3.6±0.1
Fat(g/100g)	4.4±0.0	4.2±0.3
Dietary fibre (g/100g)	4.4±0.2	3.5±0.3
Calcium (mg/100g)	8.7±0.2	6.0±0.0
Iron (mg/100g)	8.8±0.4	7.2±0.1
Beta-carotene(mcg/100g)	350±0.01	60±0.01
Vitamin C(mg/100g)	2.70±0.26	2.15±0.10

Moisture content of Oriental sweet potato flour was higher with 6.70% when compared with Hannah sweet potato with 6.33%. Ash content of oriental sweet potato flour and hannah sweet potato four was similar with value of 1.4g. Energy content of oriental sweet potato flour was higher with 381.5 while hannah sweet potato flour with 365.3g.Analysis of macronutrients like carbohydrate revealed that oriental sweet potato flour was rich in carbohydrate with 86g and hannah sweet potato flour had 85.0g. Protein content of oriental sweet potato flour was higher with 5.6g while Hannah sweet potato flour had 3.6g. Analysis of fat revealed that oriental sweet potato flour was rich in fat with 4.4g while hannah sweet potato flour had 4.2g. Fibre content of oriental sweet potato flour was higher with 4.4g while Hannah sweet potato flour had 3.5g. With regard to micronutrients, the calcium content was 8.6mg in oriental sweet potato flour and calcium was low in hannah sweet potato flour with 6.0mg. With regard to iron oriental sweet potato flour had higher quantity of iron with 7.9mg and iron was low in Hannah sweet potato flour with 6.1mg. Vitamin-C content of oriental sweet potato flour was higher with 2.7mg while hannah sweet potato flour had low vitamin-C content with 2.1mg. Beta – carotene content of Oriental sweet potato flour was higher with 350mcg while Hannah sweet potato flour had low beta- carotene content of 60mcg. Vitamin C content of oriental sweet potato flour was higher with 2.70mg while hannah sweet potato flour had low vitamin c content of 2.15 mcg.From Table X, it was inferred that the nutrients present in the oriental sweet potato flour was higher when compared to hannah sweet potato flour. Therefore, the nutrient content of the oriental sweet potato flour incorporated berry bars were analysed in the laboratory. Figure 3 represents the comparsion between the nutrients present in oriental and hannah sweet potato flour.

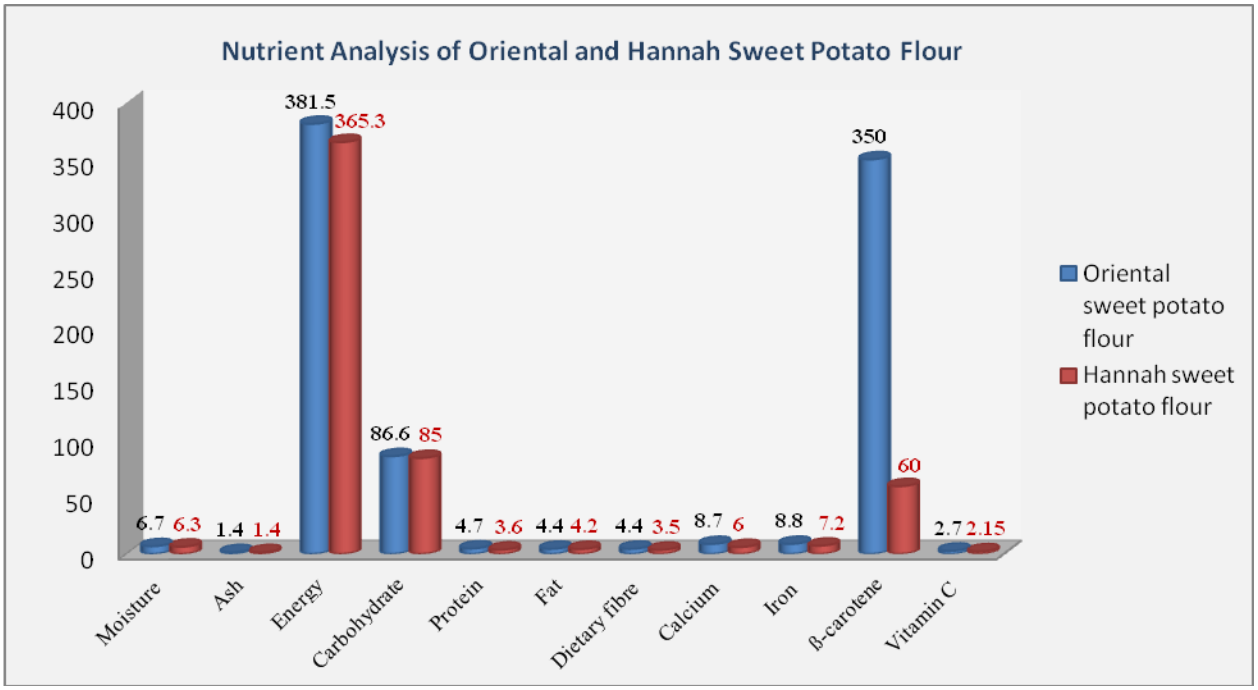


Figure 3. Nutrient Analysis of Oriental and Hannah Sweet potato flour

PHASE III - Formulation, standardization and evaluation of berry bars incorporating Oriental and Hannah varieties of Sweet potato flour

A. Preparation of berry bars incorporating sweet potato flour

Selected and collected ingredients such as black grapes, green grapes, tomato , amla and star gooseberry were used to prepare bars with the incorporation of oriental and hannah sweet potato flour.Table XI presents the data on the weight of sweet potato berry bars incorporated with oriental sweet potato flour

TABLE XI

Weight of sweet potato berry bars incorporated with oriental sweet potato flour

Varieties of sweet potato berry bars	Quantity of ingredients (g)							Weight of berry bar before drying	Weight of berry bars after drying	Weight of berry bars in percentage
	Black grapes pulp	Green grapes pulp	Tomato pulp	Amla pulp	Star gooseberry pulp	Sweet potato flour	Jaggery			
Standard	100						50	78.3	63.5	42.3
Sweet potato black grapes bar	40					60	50	86	75.4	50.2
Standard		100					50	84.5	78.2	52.1
Sweet potato green grapes bar		60				40	50	86.5	80.4	53.6
Standard			100				50	88.7	77.6	51.7
Sweet potato tomato bar			40			60	50	89.4	80.8	53.8
Standard				100			50	89.5	70.8	47.2
Sweet potato amla bar				60		40	50	93.2	81.8	54.5
Standard					100		50	90.4	87.5	58.3
Sweet potato star gooseberry bar					50	50	50	98.9	92.3	60.5

The weight of sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star-gooseberry bar obtained after processing and drying of 150 g of ingredients was 50.2, 53.6, 53.8 , 54.5, 60.5 percent respectively. The weight of oriental sweet potato berry bars after drying was about 50-60 % of the original weight of ingredients.

Table XII presents the data on the weight of sweet potato berry bars incorporated with hannah sweet potato flour

TABLE XII

Weight of sweet potato berry bars incorporated with hannah sweet potato flour

Varieties of sweet potato berry bars	Quantity of ingredients (g)							Weight of berry bar before drying	Weight of berry bars after drying	Weight of berry bars in percentage
	Black grapes pulp	Green grapes pulp	Tomato pulp	Amla pulp	Star gooseberry pulp	Sweet potato flour	Jaggery			
Standard	100						50	78.3	63.5	42.3
Sweet potato black grapes bar	40					60	50	86.5	77.4	51.6
Standard		100					50	84.5	78.2	52.1
Sweet potato black grapes bar		60				40	50	89.2	78.4	55.6
Standard			100				50	88.7	77.6	51.7
Sweet potato green grapes bar			40			60	50	89.4	78.8	52.5
Standard				100			50	89.5	70.8	47.2
Sweet potato amla bar				60		40	50	93.2	82.6	55.0
Standard					100		50	80.4	74.5	52.3
Sweet potato star gooseberry bar					50	50	50	83.5	76.3	54.3

The weight of sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar,sweet potato amla bar and sweet potato star-gooseberry bar obtained after processing and drying of 150 g of ingredients was 51.6, 55.6 , 52.5 , 55.0 , 54.3 percent respectively. The weight of hannah sweet potato berry bars after drying was about 50-55 % of the original weight of the ingredients.

B. Standardization, Organoleptic Evaluation and acceptability trails of prepared sweet potato berry bars

Sensory Evaluation was carried out to evaluate the product by panel of members towards the statisfactory- using of rating scale. Black grapes, Green grapes, Tomato, Amla and Star gooseberry bars were prepared with the incorporation of Oriental and Hannah varieties of Sweet potato flour . Standard and variations of bars were prepared and evaluated based on the 9 point hedonic rating scale for sensory attributes like Appearance, Colour, Flavour, Texture , Taste and Overall acceptability by 30 panel members for successive trails.

Oriental sweet potato black grapes bar

Table XIII presents the data of mean acceptability sensory scores for sweet potato black grapes bar

Table XII

Mean Acceptability Sensory Scores of Sweet potato Black grapes bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	9.00±0.000	8.79±0.559	8.68±0.712	8.96±0.185	2.961	<.001*
Colour	8.93±0.253	8.31±0.849	8.68±0.541	8.93±0.257	8.847	<.001*
Flavour	8.86±o.345	8.34±0.813	8.62±0.676	8.89±0.309	5.784	<.001*
Taste	8.93±0.253	8.41±o.824	8.55±0.631	8.96±0.815	7.585	<.001*
Texture	8.93±0.253	8.55±0.736	8.93±0.257	9.00±0.000	7.231	<.001*
Overall acceptability	9.000±0.000	7.72±0.648	8.41±0.682	9.00±0.000	48.926	<.001*

S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Black grapes Bar

V I - 40% incorporation level of Sweet potato flour in standard Black grapes Bar
V II - 50% incorporation level of Sweet potato flour in standard Black grapes Bar
VIII - 60% incorporation level of Sweet potato flour in standard Black grapes Bar

With regard to appearance standard scored the highest score of 9.0±0.0 followed by variation III, variation II and variation I with scores of 8.9±0.1, 8.7±0.5,8.6±0.7 respectively. With regard to colour, variation III and standard obtained the highest score of 8.9±0.2 followed by variation II and variation I with scores of 8.6±o.5, 8.3±0.8 respectively. Standard and variation III scored the highest scores of 8.8±0.3 for flavour followed by variation II and variation I with scores of 8.6±0.6,8.3±0.8 respectively. With regard to taste, variation III and standard scored the highest score of 8.9±0.8, 8.9±o.2 followed by variation II and variation I with scores of 8.5±0.6,8.4±0.8 respectively. For the mean acceptability scores of texture, variation III scored the highest score of 9.0±0.0 followed by Standard , variation II and variation I with scores of 8.9±0.2,8.9±0.2 and 8.5±0.7 respectively.With regard to overall acceptability sensory score for Sweet potato Black grapes bar, variation III and Standard scored the highest score of 9.0±0.0, followed by variation II and variation I with scores of 8.4±0.6 and 7.7±0.6 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level ($p<0.005$) between standard ,variation I,II and III. The difference is between the organoleptic characteristics such as appearance,colour,flavour,taste,texture and overall acceptability.

Oriental Sweet potato green grapes bar

Table XIV presents the data of mean acceptability sensory scores of sweet potato green grapes bars

Table XIV
Mean Acceptability Sensory Scores of Sweet potato Green grapes Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	9.00±0.000	8.96±0.812	8.83±0.379	8.23±0.858	16.768	<.001*
Colour	8.93±0.253	8.83±0.379	8.66±0.479	8.30±0.794	8.690	<.001*
Flavour	9.00±0.000	8.86±0.345	8.66±0.479	8.03±0.764	23.531	<.001*
Taste	8.96±0.812	8.90±o.305	8.60±0.498	8.30±o.702	12.944	<.001*
Texture	9.00±0.000	8.93±0.253	8.93±0.253	8.40±0.813	11.859	<.001*
Overall acceptability	9.00±0.000	9.00±0.000	8.53±0.507	7.66±0.47	97.305	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Green grapes Bar
V I - 40% incorporation level of Sweet potato flour in Standard Green grapes Bar
V II - 50% incorporation level of Sweet potato flour in Standard Green grapes Bar
V III - 60% incorporation level of Sweet potato flour in Standard Green grapes Bar

With regard to appearance Standard scored the highest score of 9.0±0.0 followed by variation I, variation II and variation III with scores of 8.9±0.8, 8.8±0.3, 8.2±0.8 respectively. With regard to colour, Standard and variation I obtained the highest score of 8.9±0.2 and 8.8±0.3 respectively followed by variation II and variation III with scores of 8.6±o.4, 8.3±0.7 respectively. Standard scored the highest scores of 9.0±0.0 for flavour followed by variation I, variation II and variation III with scores of

8.8±0.3,8.6±0.4 and 8.0±0.7 respectively. With regard to taste, standard and variation I scored the highest score of 8.9±0.8 and 8.9±0.3 followed by variation II and variation III with scores of 8.6±0.4, 8.3±0.7 respectively. For the mean acceptability scores of texture, Standard scored the highest score of 9.0±0.0 followed by variation I, variation II, variation I with scores of 8.9±0.2,8.9±0.2 and 8.4±0.8 respectively.

With regard to overall acceptability sensory score for Sweet potato Green grapes bar, variation I and Standard scored the highest score of 9.0±0.0, followed by variation II and variation III with scores of 8.5±0.5 and 7.6±0.4 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level (p<0.005) between standard ,variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Oriental Sweet potato tomato bar

Table XV presents the data of mean acceptability sensory scores of sweet potato tomato bar

Table XV

Mean Acceptability Sensory Scores of Sweet potato Tomato Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	8.93±0.253	8.56±0.773	9.00±0.000	9.00±0.000	5.292	<.001*
Colour	8.70±0.466	8.36±0.718	8.43±0.504	8.86±0.345	5.892	<.001*
Flavour	8.83±0.379	8.36±0.764	8.53±0.507	8.73±0.44	4.375	<.001*
Taste	8.90±0.305	8.46±0.681	8.40±0.498	8.83±0.379	8.098	<.001*
Texture	8.86±0.345	8.70±0.549	8.86±0.345	8.96±0.182	2.337	<.001*
Overall acceptability	8.90±0.305	8.26±0.639	8.26±0.449	9.00±0.00	26.792	<.001*

M±S.D – Mean ± Standard Deviation ; * - Significant at 5 % Level

S- Standard tomato bar
V I - 40% incorporation level of Sweet potato flour in Standard Tomato Bar
V II - 50% incorporation level of Sweet potato flour in Standard Tomato Bar
VIII - 60% incorporation level of Sweet potato flour in Standard Tomato Bar

With regard to appearance variation III and variation II scored the highest score of 9.0±0.0 followed by standard and variation I with scores of 8.9±0.2,8.9±0.2, 8.5±0.7 respectively. With regard to colour, Variation III obtained the highest score of 8.8±0.3 followed by Standard,variation II and variation I with scores of 8.7±o.4, 8.4±0.5 and 8.3±0.7 respectively. Standard scored the highest scores of 8.8±0.3 for flavour followed by variation III, variation II and variation I with scores of 8.7±0.4,8.5±0.5 and 8.3±0.7 respectively. With regard to taste, standard scored the highest score of 8.9±0.3followed by variation III and variation II and variation I with scores of 8.8±0.3,8.4±0.4 and 8.4±0.6 respectively. For the mean acceptability scores of texture, variation III scored the highest score of 8.9±0.8 followed by standard, variation II and variation I with scores of 8.8±0.3,8.8±0.3 and 8.2±0.6 respectively.

With regard to overall acceptability sensory score for Sweet potato Tomato bar, variation III scored the highest score of 9.0±0.0, followed by standard, variation II and variation I with scores of 8.9±0.3 , 8.2±0.4 and 8.2±0.6 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level (p<0.005) between standard, variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Oriental sweet potato amla bar

Table XVI presents the data of mean acceptability sensory scores of sweet potato amla bar

Table XVI
Mean Acceptability Sensory Scores of Sweet potato Amla Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	8.93±0.253	9.00±0.000	8.60±0.674	8.73±0.449	5.603	<.001*
Colour	8.73±0.449	9.00±0.000	8.33±0.660	8.40±0.855	8.402	<.001*
Flavour	8.83±0.379	9.00±0.000	8.10±0.844	8.56±0.568	15.691	<.001*
Taste	8.90±0.305	9.00±0.000	8.33±0.606	8.66±0.479	15.232	<.001*
Texture	8.86±0.345	9.00±0.000	8.46±0.819	8.70±0.466	6.294	<.001*
Overall acceptability	8.90±0.305	9.00±0.000	7.96±0.746	8.56±0.762	30.210	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Amla Bar

V I - 40% incorporation level of Sweet potato flour in Standard amla bar

V II - 50% incorporation level of Sweet potato flour in Standard amla bar

VIII - 60% incorporation level of Sweet potato flour in Standard amla bar

With regard to appearance variation I scored the highest score of 9.0±0.0 followed by Standard ,variation III and variation II with scores of 8.7±0.4, 8.6±0.6 respectively. With regard to colour, variation I obtained the highest score of 9.0±0.0 followed by standard,variation III and variation II with scores of 8.7±o.4, 8.3±0.6 and 8.4±0.8 respectively. Variation I scored the highest scores of 9.0±0.0 for flavour followed by variation III, standard and variation II with scores of 8.3±0.3,8.5±0.5 and 8.1±0.8 respectively. With regard to taste, variation I scored the highest score of 9.0 ±0.0 followed by standard, variation III and variation II with scores of 8.9±0.3,8.6±0.4 and 8.3±0.6 respectively. For the mean acceptability scores of texture, variation I scored the highest score of 9.0±0.0 followed by standard, variation III and variation II with scores of 8.6±0.3,8.7±0.4 and 8.4±0.8 respectively. With regard to overall acceptability sensory score for sweet potato amla bar, variation I scored the highest score of 9.0±0.0, followed by standard, variation III and variation II with scores of 8.9±0.3 , 8.5±0.7 and 7.9±0.7 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level ($p<0.005$) between standard, variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Oriental Sweet potato star gooseberry bar

Table XVII presents the data of mean acceptability sensory scores of sweet potato star gooseberry bar

Table XVII
Mean Acceptability Sensory Scores of Sweet potato Star gooseberry Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	8.93±0.253	7.73±0.907	9.00±0.000	8.53±0.507	35.522	<.001*
Colour	8.96±0.182	8.23±0.504	9.00±0.000	7.66±0.844	49.16	<.001*
Flavour	8.86±0.345	7.73±0.784	8.93±0.748	8.50±0.572	36.483	<.001*
Taste	8.96±0.182	8.46±0.507	8.97±0.748	8.00±0.830	1.442	<.001*
Texture	8.86±0.345	8.33±0.546	8.96±0.182	8.43±0.568	15.203	<.001*
Overall acceptability	8.90±0.456	8.93±0.72	9.00±0.000	8.73±0.500	33.479	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Star gooseberry Bar
V I - 40% incorporation level of Sweet potato flour in Standard Star gooseberry Bar
V II - 50% incorporation level of Sweet potato flour in Standard Star gooseberry Bar
VIII - 60% incorporation level of Sweet potato flour in Standard Star gooseberry Bar

With regard to appearance Variation II scored the highest score of 9.0±0.0 followed by standard ,variation III and variation I with scores of 8.9±0.2, 8.5±0.5 and 7.7±0.9 respectively. With regard to colour, variation II obtained the highest score of 9.0±0.0 followed by standard,variation I and variation III with scores of 8.9±0.1, 8.2±0.5 and 7.6±0.8 respectively. Variation II scored the highest scores of 8.9±0.7 for flavour followed by standard, variation III and variation I with scores of 8.8±0.3,8.5±0.5 and 7.7±0.7 respectively.With regard to taste, variation II scored the highest score of 8.9 ±0.7 followed by standard , variation I and variation III with scores of 8.9±0.1,8.4±0.5 and 8.0±0.0 respectively. The mean acceptability scores of texture, variation II scored the highest score of 8.9±0.1 followed by standard, variation III and variation I with scores of 8.8±0.3,8.4±0.5 and 8.9±0.1 respectively.With regard to overall acceptability sensory score for sweet potato star gooseberry bar, variation II scored the highest score of 9.0±0.0, followed by variation I, standard and variation III with scores of 8.9±0.7 , 8.9±0.4 and 8.7±0.5 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level (p<0.005) between standard, variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Hannah sweet potato black grapes bar

Table XVIII presents the data of mean acceptability sensory scores of sweet potato black grapes bar

Table XVIII

Mean Acceptability Sensory Scores of Sweet potato black grapes Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	8.83±0.379	8.033±0.764	8.23±0.817	8.90±0.305	15.037	<.001*
Colour	8.90±0.305	8.16±0.592	8.20±0.714	8.46±0.860	8.132	<.001*
Flavour	8.86±0.345	8.45±o.696	8.86±0.345	8.00±0.643	21.460	<.001*
Taste	8.83±0.379	8.23±0.618	8.23±0.777	8.73±0.583	7.968	<.001*
Texture	8.83±0.379	8.36±0.490	8.10±0.803	8.86±0.345	14.505	<.001*
Overall acceptability	9.00±0.000	8.10±0.547	8.33±o.660	9.00±0.000	34.791	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Black grapes Bar
V I - 40% incorporation level of Sweet potato flour in standard Black grapes Bar
V II - 50% incorporation level of Sweet potato flour in standard Black grapes Bar
VIII - 60% incorporation level of Sweet potato flour in standard Black grapes Bar

With regard to appearance, variation III scored the highest score of 8.9±0.3 followed by Standard, variation I and variation II with scores of 8.8±0.3, 8.0±0.7,8.2±0.8 respectively. With regard to colour, Standard obtained the highest score of 8.9±0.3 followed by variation III, variation II and variation I with scores of 8.4±0.8, 8.2±0.7 and 8.0 ±0.3 respectively. Standard and variation II scored the highest scores of 8.8±0.3 for flavour followed by variation I and variation III with scores of 8.4±0.6,8.0±0.6 respectively. With regard to taste, standard scored the highest score of 8.8±0.3, followed by variation III, variation II and variation I with scores of 8.7±0.5,8.2±0.7 and 8.23±0.6 respectively. For texture the mean acceptability scores, variation III scored the highest score of 8.6±0.3 followed by standard, variation I, variation II with scores of 8.8±0.3, 8.3±0.4 ,8.1±0.8 respectively.

With regard to overall acceptability sensory score for sweet potato black grapes bar, variation III and Standard scored the highest score of 9.0±0.0, followed by variation II and variation I with scores of 8.3±0.6 and 8.1±0.5 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level ($p<0.005$) between standard, variation I, II and III. The difference is between the organoleptic characteristics such as appearance,colour,flavour,taste,texture and overall acceptability.

Hannah sweet potato green grapes bar

Table XIX presents the data of mean acceptability sensory scores of sweet potato green grapes bar

Table XIX
Mean Acceptability Sensory Scores of Sweet potato Green grapes Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	9.00±0.000	7.50±0.504	8.33±0.802	9.00±0.000	62.221	<.001*
Colour	9.00±0.000	7.06±0.639	8.43±0.626	9.00±0.000	124.640	<.001*
Flavour	8.90±0.305	7.50±0.861	8.30±0.534	8.70±o.466	34.381	<.001*
Taste	8.83±0.379	8.33±0.792	8.33±0.546	7.43±0.810	37.171	<.001*
Texture	8.86±0.345	7.40±0.932	8.50±0.629	8.76±0.430	34.675	<.001*
Overall acceptability	8.70±0.305	7.40±1.031	8.36±0.556	8.80±0.406	34.232	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Green grapes Bar
V I - 40% incorporation level of Sweet potato flour in Standard green grapes Bar
V II - 50% incorporation level of Sweet potato flour in Standard green grapes Bar
VIII - 60% incorporation level of Sweet potato flour in Standard green grapes Bar

With regard to appearance Standard and variation III scored the highest score of 9.0±0.0 followed by variation II and variation I with scores of 8.3±0.8, 7.5±0.5 respectively. With regard to colour, standard and variation III obtained the highest score of 9.0±0.0 followed by variation II and variation I with scores of 8.4±0.6, 7.6±0.6 respectively. Standard scored the highest scores of 8.9±0.3 for flavour followed by variation III, variation II and variation I with scores of 8.7±0.4, 8.3±0.5 and 7.5±0.8 respectively. With regard to taste, standard scored the highest score of 8.8±0.3 followed by variation I , variation II and variation III with scores of 8.3±0.7,8.3±0.5, 7.4±0.8 respectively. The mean acceptability scores of texture, standard scored the highest score of 8.8±0.3 followed by variation III, variation II, variation I with scores of 8.7±0.4, 8.5±0.6 and 7.4±0.9 respectively.With regard to overall acceptability sensory score for sweet potato green grapes bar, variation III scored the highest score of 8.8±0.4, followed by standard, variation II and variation I with scores of 8.7±0.3, 8.3±0.5 and 7.4±1.0 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level ($p<0.005$) between standard ,variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Hannah sweet potato tomato bar

Table XX presents the data of mean acceptability sensory scores of sweet potato tomato bar

Table XX

Mean Acceptability Sensory Scores of Sweet potato Tomato Bar

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	9.00±0.000	7.50±0.504	8.33±0.802	9.00±0.000	62.221	<.001*
Colour	9.00±0.000	7.06±0.639	8.43±0.626	9.00±0.000	124.640	<.001*
Flavour	8.90±0.305	7.50±0.861	8.30±0.543	8.70±0.449	34.381	<.001*
Taste	8.83±0.379	7.43±0.817	8.33±0.546	8.76±0.430	37.177	<.001*
Texture	8.86±0.345	7.40±0.932	8.50±0.629	8.73±0.449	34.675	<.001*
Overall acceptability	8.90±0.305	7.40±0.031	8.36±0.556	9.00±0.000	34.232	<.001*

S- Standard tomato Bar
V I - 40% incorporation level of Sweet potato flour in Standard Tomato Bar
V II - 50% incorporation level of Sweet potato flour in Standard Tomato Bar
VIII - 60% incorporation level of Sweet potato flour in Standard Tomato Bar

With regard to appearance Variation III and Standard scored the highest score of 9.0±0.0 followed by variation II and variation I with scores of 8.3±0.8, 7.5±0.5 respectively. With regard to colour, variation III and standard obtained the highest score of 9.0±0.0 followed by variation II and variation I with scores of 8.4±0.6 and 7.6±0.7 respectively. Standard scored the highest scores of 8.9±0.3 for flavour followed by variation III, variation II and variation I with scores of 8.7±0.4,8.3±0.5 and 7.5±0.8 respectively. With regard to taste, standard scored the highest score of 8.8±0.3 followed by variation III and variation II and variation I with scores of 8.7±0.4, 8.3±0.5 and 7.4±0.8 respectively. For the mean acceptability scores of texture, standard scored the highest score of 8.8±0.3 followed by variation III, variation II and variation I with scores of 8.7±0.4,8.5±0.6 and 7.4±0.9 respectively. With regard to overall acceptability score for sweet potato tomato bar, variation III scored the highest score of 9.0±0.0, followed by standard, variation II and variation I with scores of 8.9±0.3 , 8.3±0.5 and 7.4±0.0 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level (p<0.005) between standard ,variation I,II and III. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste,texture and overall acceptability.

Hannah Sweet potato amla bar

Table XXI presents the data of mean acceptability sensory scores of sweet potato star gooseberry bar

Table XXI
Mean Acceptability Sensory Scores of Sweet potato amla bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	9.00±0.000	8.90±0.305	8.43±0.678	8.76±0.504	9.062	<.001*
Colour	9.00±0.000	8.90±0.305	8.50±0.629	8.33±0.802	10.706	<.001*
Flavour	8.90±0.305	8.93±0.253	8.36±0.490	8.33±0.546	18.504	<.001*
Taste	9.00±0.000	8.93±0.253	8.40±0.498	8.13±0.681	27.170	<.001*
Texture	8.96±0.182	8.90±0.305	8.56±0.568	8.63±0.556	6.093	<.001*
Overall acceptability	8.96±0.182	9.00±0.000	8.50±0.508	8.46±0.571	16.243	<.001*

M±S.D – Mean ± Standard Deviation ; * - Significant at 5 % Level

S- Standard Amla Bar
V I - 40% incorporation level of Sweet potato flour in Standard Amla bar
V II - 50% incorporation level of Sweet potato flour in Standard Amla bar
VIII - 60% incorporation level of Sweet potato flour in Standard Amla bar

With regard to appearance standard scored the highest score of 9.0±0.0 followed by variation I, variation III and variation II with scores of 8.9±0.3, 8.7±0.5 and 8.4±0.6 respectively. With regard to colour, standard obtained the highest score of 9.0±0.0 followed by variation I , variation II and variation III with scores of 8.9±0.3, 8.5±0.8 and 8.3±0.8 respectively. Variation I scored the highest scores of 8.9±0.2 for flavour followed by standard,variation II and variation III with scores of 8.9±0.3,8.3±0.4 and 8.3±0.5 respectively. With regard to taste, standard scored the highest score of 9.0 ±0.0 followed by variation I, variation II and variation III with scores of 8.9±0.2,8.4±0.4 and 8.1±0.6 respectively. For the mean acceptability scores of texture, standard scored the highest score of 8.9±0.1 followed by variation I,variation III and variation II with scores of 8.9±0.3,8.6±0.5, 8.5±0.5 respectively.

With regard to overall acceptability sensory score for Sweet potato Amla bar,variation I scored the highest score of 9.0±0.0, followed by standard, variation II and variation III with scores of 8.9±0.3 , 8.5±0.7 and 7.9±0.7 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level (p<0.005) between standard, variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

Hannah sweet potato star gooseberry bar

Table XXII presents the data of mean acceptability sensory scores of sweet potato star gooseberry bar

Table XXII

Mean Acceptability Sensory Scores of Sweet potato Star gooseberry Bar

Sensory Characteristics	Standard M±S.D	Variation I M±S.D	Variation II M±S.D	Variation III M±S.D	One Way ANOVA	
					F value	P value
Appearance	8.92±0.000	7.739±0.909	8.93±0.253	8.53±0.507	35.522	<.001*
Colour	8.80±0.000	7.93±0.639	8.86±0.345	8.10±0.607	38.456	<.001*
Flavour	8.93±0.253	8.50±0.572	8.83±0.379	8.50±0.379	37.388	<.001*
Taste	8.90±0.000	8.20±0.664	8.96±0.182	8.16±0.698	23.289	<.001*
Texture	8.72±0.182	8.20±0.761	8.90±0.305	8.46±0.507	19.219	<.001*
Overall acceptability	9.00±0.000	7.96±0.964	9.00±0.000	8.36±0.490	37.536	<.001*

M±S.D – Mean ± Standard Deviation; * - Significant at 5 % Level

S- Standard Star gooseberry Bar
V I - 40% incorporation level of Sweet potato flour in Standard Star gooseberry Bar
V II - 50% incorporation level of Sweet potato flour in Standard Star gooseberry Bar
VIII - 60% incorporation level of Sweet potato flour in Standard Star gooseberry Bar

With regard to appearance variation II scored the highest score of 8.9±0.2 followed by standard, variation III and variation I with scores of 8.9±0.0, 8.53±0.5 and 7.7±0.9 respectively. With regard to colour, variation II obtained the highest score of 8.8±0.3 followed by standard, variation III and variation I with scores of 8.8±0.0, 8.1±0.0 and 7.9±0.6 respectively. Standard scored the highest scores of 8.9±0.2 for flavour followed by variation II ,variation I and variation III with scores of 8.8±0.3,8.5±0.3 and 8.5±0.3 respectively. With regard to taste, variation II scored the highest score of 8.9 ±0.8 followed by standard, variation I and variation III with scores of 8.9±0.0,8.6±0.6 and 8.2±0.1 respectively. For the mean acceptability scores of texture, variation II scored the highest score of 8.9±0.3 followed by standard, variation III and variation I with scores of 8.7±0.1,8.4±0.5 and 8.2±0.6 respectively.

With regard to overall acceptability sensory score for sweet potato star gooseberry bar, variation II and standard scored the highest score of 9.0±0.0, followed by variation III and variation I with scores of 8.3±0.4 and 7.9±0.9 respectively.

By performing the one-way ANOVA test, it was shown that there is significant difference at 5 percent level ($p<0.005$) between standard, variation I,II andIII. The difference is between the organoleptic characteristics such as appearance, colour, flavour, taste, texture and overall acceptability.

In a study conducted by Dhilipkumar M (2020) on sensory evaluation of sweet potato jam blended with cucumber, the sensory attributes such as appearance, colour, flavour, taste and texture was analyzed and highly accepted.

C. Evaluation of Physio-chemical properties of standardized sweet potato berry bars

Colour, Texture, TSS-Total Soluble Solids, Acidity, pH

a. Colour

b. The colour is the important quality attribute of fruit bar which attracts the consumer. It is essential for food processor to minimize the colour losses during processing and storage. Colour analysis was performed in triplicate values.

Colour analysis of sweet potato berry bars are depicted in TABLE XXIII

TABLE XXIII

Colour analysis of berry bars incorporated with oriental and hannah sweet potato flour

Berry bars incorporated with oriental sweet potato flour	**Colour analysis**		
	L* M±S.D	**a* M±S.D**	**b* M±S.D**
Sweet potato black grapes bar	26.71±0.105	1.42±0.580	2.76±0.574
Sweet potato green grapes bar	39.62±0.100	4.40±0.005	18.42±0.365
Sweet potato tomato bar	34.72±0.005	14.87±0.346	7.90±0.115
Sweet potato amla bar	32.33±0.001	16.76±0.005	8.59±0.050
Sweet potato star gooseberry bar	31.72±0.016	16.87±0.006	9.32±0.025

Berry bars incorporated with hannah sweet potato flour	L* M±S.D	a* M±S.D	b* M±S.D
Sweet potato black grapes bar	26.71±0.100	1.12±0.005	2.45±0.005
Sweet potato green grapes bar	39.76±0.208	4.60±0.340	17.62±0.100
Sweet potato tomato bar	32.72±0.001	17.87±0.005	8.57±0.990
Sweet potato amla bar	30.52±0.007	17.87±0.005	7.34±0.440
Sweet potato star gooseberry bar	31.54±0.015	16.76±0.005	8.57±0.005

Note L*-lightness from black to white, a*- Green to red , b* -Blue to yellow

The L value for colour represents the black-white axis. All the oriental and Hannah sweet flour incorporated berry bars had positive value and were lighter in colour with higher ‘L’ values. The ‘a’ value for colour represents the red-green axis. The entire oriental and Hannah sweet flour incorporated berry bars had the positive a* value and were therefore slightly red. The ‘b’ values measure the blue-yellow axis. All the berry bars had the positive b* value, and therefore were slightly yellow.The oriental sweet potato black grapes bar is lighter, redder and more yellow in colour than hannah sweet potato bar. The oriental sweet potato green grapes bar is less light, less red and more yellow in colour than hannah sweet potato berry bar. The oriental tomato bar is more lighter, less red and more yellow in colour than hannah sweet potato tomato bar.The oriental sweet potato amla bar is more lighter,less red and more yellow in colour than hannah sweet potato amla bar. The oriental sweet potato star-gooseberry is lighter, redder and more yellow in colour than hannah sweet potato star-gooseberry bar.

c. Texture

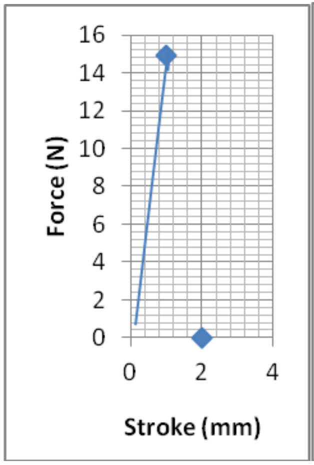
Texture is another most important property which determines the overall quality and consumer acceptability of a food product. Two texture parameters that is hardness (the force required to disintegrate sample when compressed) and adhesiveness (the force required to overcome the attractive forces between the surface of the product and the probe) is studied in oriental sweet potato berry bars and hannah sweet potato berry bars.The textural analysis of sweet potato berry bars as shown in TABLE XXIV

TABLE XXIV

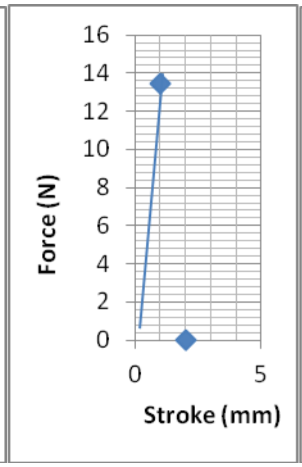
Texture analysis of berry bars incorporated with oriental and hannah sweet potato flour

Berry bars incorporated with oriental sweet potato flour	**Test mode**	**Speed**	**Test type**	**Shape**	**Hardness**	**Adhesiveness**
Sweet potato black grapes bar	Texture	1mm/sec	Compression	Plate	14.9144	0.01097
Sweet potato green grapes bar	Texture	1mm/sec	Compression	Plate	13.4602	0.01097
Sweet potato tomato bar	Texture	1mm/sec	Compression	Plate	3.9169	0.01065
Sweet potato amla bar	Texture	1mm/sec	Compression	Plate	10.9975	0.01086
Sweet potato star gooseberry bar	Texture	1mm/sec	Compression	Plate	12.4356	0.00018
Berry bars incorporated with hannah sweet potato flour	**Test mode**	**Speed**	**Test type**	**Shape**	**Hardness**	**Adhesiveness**
Sweet potato black grapes bar	Texture	1mm/sec	Compression	Plate	14.9244	0.01097
Sweet potato green grapes bar	Texture	1mm/sec	Compression	Plate	13.3782	0.04574
Sweet potato tomato bar	Texture	1mm/sec	Compression	Plate	9.9467	0.02345
Sweet potato amla bar	Texture	1mm/sec	Compression	Plate	10.9875	0.08764
Sweet potato star gooseberry bar	Texture	1mm/sec	Compression	Plate	12.4906	0.08368

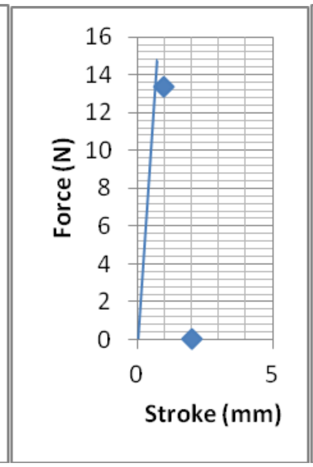
In comparsion between the oriental and hannah sweet potato berry bars, the hardness and adhesiveness values are similar. The hardness and adhesiveness values of oriental sweet potato black grapes bar, oriental sweet potato green grapes bar, oriental sweet potato tomato bar, oriental sweet potato amla bar, oriental sweet potato star gooseberry bar are similar to the values of hannah sweet potato black grapes bar, hannah sweet potato green grapes bar, hannah sweet potato tomato bar, hannah sweet potato amla bar, hannah sweet potato star gooseberry bar respectively.



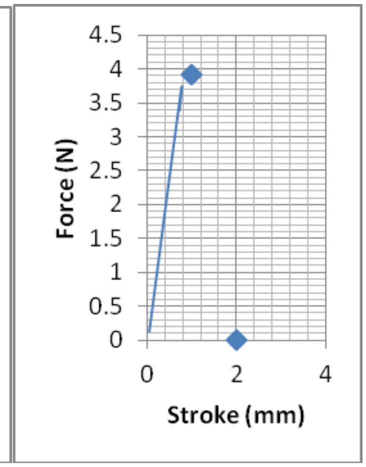
Oriental black grapes bar



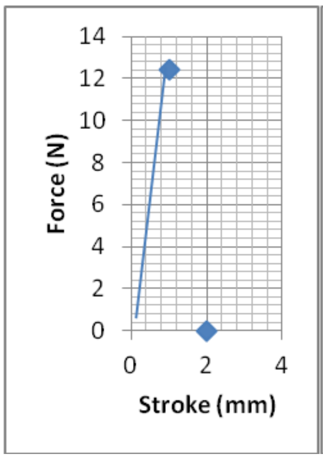
Oriental green grapes bar



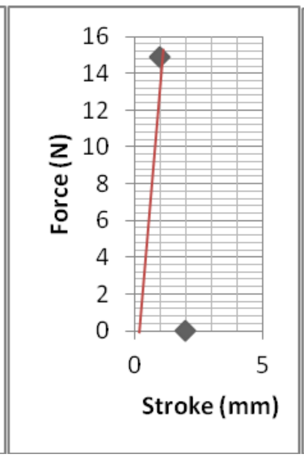
Oriental tomato bar



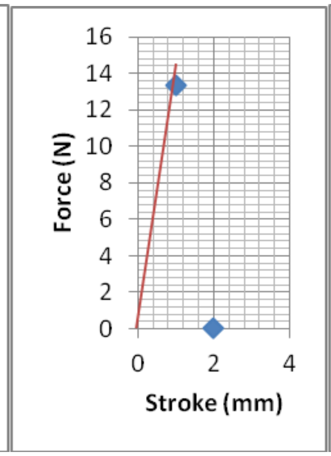
Oriental amla bar



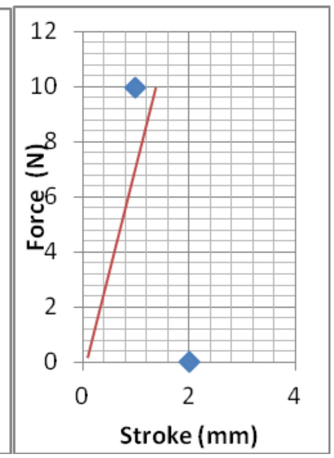
Oriental stargooseberry bar



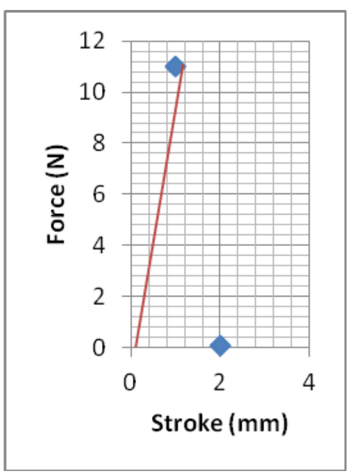
Hannah black grapes bar



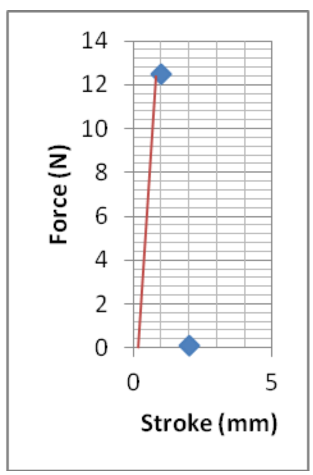
Hannah green grapes bar



Hannah tomato bar



Hannah amla bar



Hannah stargooseberry bar

Figure 3 . Texture Analysis of Oriental and Hannah sweet potato berry bars

c. TSS – Total Soluble Solids

TSS are an important quality parameter of a fruit bar. TSS states the amounts of soluble solids in liquids. TSS affects the taste of the fruit bar, because it can indicate the level of sweetness of the fruit bar.

The variations of TSS of sweet potato berry bars as shown in Table XXV

TABLE XXV

TSS of sweet potato berry bars

Products	**TSS M±S.D**
Berry bars incorporated with oriental sweet potato flour	
Sweet potato black grapes bar	22.56±0.057
Sweet potato green grapes bar	22.70±0.100
Sweet potato tomato bar	23.01±0.010
Sweet potato amla bar	32.26±0.251
Sweet potato star gooseberry bar	32.33±0.057
Berry bars incorporated with hannah sweet potato flour	
Sweet potato black grapes bar	25.23±1.582
Sweet potato green grapes bar	22.36±1.497
Sweet potato tomato bar	24.34±2.091
Sweet potato amla bar	32.93±1.365
Sweet potato star gooseberry bar	32.63±2.650

The TSS of the berry bars incorporated with oriental sweet potato flour ranges from 22.56 – 32.33 and TSS of the berry bars incorporated with hannah sweet potato flour ranges from 22.36 – 32.63.

d. Acidity

Titratable acidity is a measure of the amount of acid or acids present in the food product.

Table XXVI presents the acidity values of sweet potato berry bars.

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TABLE XXVI

Titratable acidity of sweet potato berry bars

Products	pH M±S.D
Berry bars incorporated with oriental sweet potato flour	
Sweet potato black grapes bar	0.79±0.016
Sweet potato green grapes bar	0.78±0.015
Sweet potato tomato bar	0.80±0.014
Sweet potato amla bar	0.90±0.003
Sweet potato star gooseberry bar	0.93±0.025
Berry bars incorporated with hannah sweet potato flour	
Sweet potato black grapes bar	0.80±0.024
Sweet potato green grapes bar	0.82±0.026
Sweet potato tomato bar	0.80±0.001
Sweet potato amla bar	0.99±0.025
Sweet potato star gooseberry bar	0.94±0.001

The acidity of the berry bars incorporated with oriental sweet potato flour ranged from 0.79 -0.93 %. The titratable acidity of the berry bars incorporated with hannah sweet potato flour ranged from 0.80 – 0.94%.

e. pH

The pH value of a food is a direct function of the free hydrogen ions present in the food. Acids present in foods release free hydrogen ions , the hydrogen ions give acid foods their distinctive sour flavour.The variations of pH of sweet potato berry bars as shown in Table XXVII

TABLE XXVII

pH values of sweet potato berry bars

Products	pH (M±S.D)
Berry bars incorporated with oriental sweet potato flour	
Sweet potato black grapes bar	4.43±0.493
Sweet potato green grapes bar	3.80±0.100
Sweet potato tomato bar	4.20±0.300
Sweet potato amla bar	3.30±0.360
Sweet potato star gooseberry bar	4.13±0.416
Berry bars incorporated with hannah sweet potato flour	
Sweet potato black grapes bar	4.10±0.100
Sweet potato green grapes bar	3.90±0.100
Sweet potato tomato bar	4.03±0.152
Sweet potato amla bar	2.96±0.251
Sweet potato star gooseberry bar	3.86±0.305

The pH of the berry bars incorporated with oriental sweet potato flour ranged from 3.30 – 4.43. The pH of the berry bars incorporated with hannah sweet potato flour ranged from 2.96 – 4.10. As a result, the oriental and hannah sweet potato berry bars are moderately acidic. In a study, conducted by Sohail.Muhammed (2013), pH of the sweet potato beverage was significantly ranged from 4.08-4.29.

PHASE IV - Analysing the nutrient Content, antioxidant profile, microbial assay and conducting shelf life study of the most acceptable sweet potato berry bars

A. Analysis of nutrients present in the most acceptable sweet potato berry bars

Oriental Sweet potato black grapes bar

Table XXVIII presents the data on nutrient analysis of sweet potato black grapes bar

TABLE XXVIII

Nutrient analysis of oriental sweet potato black grapes bar in comparison to standard berry bar

S.No	Nutrients	Standard M±S.D	Sweet potato black grapes bar M±S.D	P value
1	Moisture (%)	32.3±0.5	36.7±0.5	<.001*
2	Ash(g)	2.5±0.4	2.8±0.0	<.001*
3	Energy(Kcal)	177.7±98.6	200.0±0.5	<.001*
4	Carbohydrate(g)	50±0.3	160±0.3	<.001*
5	Protein (g)	0.3±0.04	3.9±0.0	<.001*
6	Fat(g)	0.1±0.0	5.9±0.0	<.001*
7	Dietary Fibre(g)	3.2±0.4	6.0±0.0	<.001*
8	Beta-carotene(mcg)	4.0±0.3	9.3±0.0	<.001*
9	Calcium(mg)	3.2±0.0	5.9±0.1	<.001*
10	Iron(mg)	0.0±0.0	3.5±0.4	<.001*
11	Vitamin C (mg)	3.4±0.0	4.8±0.7	<.001*

From the table it is inferred that the moisture content increased from 32.3% to 36.7% and ash content had increased from 2.5g to 2.8g in black grapes bar incorporated with Oriental sweet potato flour. When compared with the standard, energy value had increased from 177.7Kcal to 200 Kcal in the most acceptable variation. The carbohydrate and protein content had increased from 50 to 160g and 0.3 to 3.9 g respectively in the most acceptable variation. The fat and fibre content had increased from 0.1 to 5.9g and 3.2 to 6.0g in the most acceptable variation when compared with standard. The beta-carotene had increased from 4.0µg to 9.3µg. The calcium an iron content had increased from 3.9 to 5.9mg and 0.0 to 3.2g in the most acceptable variation. The vitamin C content had increased from 3.4mg in the standard product to 4.8g in the most acceptable variation. All the nutrients were enhanced in sweet potato black grapes bar when compared with the standard berry bar.

Oriental Sweet potato green grapes bar

Table XXIX presents the data on nutrient analysis of oriental sweet potato green grapes bar

TABLE XXIX

Nutrient analysis of oriental sweet potato green grapes bar in comparsion to standard berry bar

S.No	Nutrients	Standard M±S.D	Sweet potato green grapes bar M±S.D	P value
1	Moisture (%)	46.8±0.5	49.5±0.0	<.001*
2	Ash(g)	2.4±0.1	2.5±0.0	<.001*
3	Energy(Kcal)	29.5±0.5	69.3±0.7	<.001*
4	Carbohydrate(g)	160.2±0.0	225.2±1.0	<.001*
5	Protein (g)	0.5±0.1	0.7±0.2	<.001*
6	Fat(g)	0.1±0.0	1.9±0.0	<.001*
7	Dietary Fibre(g)	2.2±0.1	3.4±0.1	<.001*
8	Beta-carotene(mcg)	0.0±0.03	18±0.0	<.001*
9	Calcium(mg)	1.6±0.5	6.8±3.1	<.001*
10	Iron(mg)	1.3±0.5	2.7±0.9	<.001*
11	Vitamin C (mg)	2.13±0.6	4.23±0.5	<.001*

From the data on nutrient analysis it is revealed that the moisture content increased from 46.8% to 49.5% and ash content had increased from 2.4g to 2.5g in green grapes bar incorporated with Oriental sweet potato flour. When compared with the standard, energy value had increased from 29.5Kcal to 69.36 Kcal in the most acceptable variation. The carbohydrate and protein content had increased from 160.2 to 225.2g and 0.5 to 0.7g respectively in the most acceptable variation. The fat and fibre content had increased from 0.1 to 1.9g and 2.2 to 3.4 g in the most acceptable variation when compared to standard. In green grapes bar beta-carotene was absent as green grapes is a poor source of beta-carotene. But after incorporation with oriental sweet potato flour, the beta-carotene content increased to 18 µg. The calcium and iron content had increased from 1.6 to 6.8mg and 1.3 to 2.7mg in the most acceptable variation. The vitamin C content had increased from 2.13mg in the standard product to 4.23g in the most acceptable variation. All the nutrients were enhanced in sweet potato green grapes bar when compared with the standard berry bar.

Oriental sweet potato tomato bar

TABLE XXX presents the data on nutrient analysis of sweet potato tomato bar

TABLE XXX

Nutrient analysis of oriental sweet potato tomato bar in comparison to standard berry bar

S.No	Nutrients	Standard M±S.D	Sweet potato tomato bar M±S.D	P value
1	Moisture (%)	37.6±0.0	37.7±1.4	<.001*
2	Ash(g)	4.0±1.0	31.2±1.0	<.001*
3	Energy(Kcal)	51±1.5	80.0±0.0	<.001*
4	Carbohydrate(g)	100.4±0.1	228.7±0.9	<.001*
5	Protein (g)	0.3±0.1	3.2±0.6	<.001*
6	Fat(g)	0.09±0.1	2.6±0.2	<.001*
7	Dietary Fibre(g)	0.3±0.1	0.6±0.1	<.001*
8	Beta-carotene(mcg)	100.5±0.2	138.8±1.7	<.001*
9	Calcium(mg)	40.6±1.1	71.8±1.2	<.001*
10	Iron(mg)	19.5±0.4	20.2±1.3	<.001*
11	Vitamin C (mg)	8.2±0.0	11.8±0.9	<.001*

From the given data, it is inferred that the moisture content increased from 37.6% to 37.7% and ash content had increased from 4.0g to 31.2g in tomato bar incorporated with Oriental sweet potato flour. When compared with the standard, energy value had increased from 51Kcal to 80 Kcal in the most acceptable variation. The carbohydrate and protein content had increased from 100.4 to 228.7g and 0.3 to 3.2g in the most acceptable variation. The fat and fibre content had increased from 0.0g to 2.6g and 0.3 to 0.6 g in the most acceptable variation. The beta-carotene had increased from 100.5 µg to 138.8µg. The calcium and iron content had increased from 40.6 to 71.8mg and 19.5 to 20.2mg respectively in the most acceptable variation when compared to standard. The vitamin C content had increased from10.2mg in the standard product to 11.8g in the most acceptable variation. All the nutrients were enhanced in sweet potato tomato bar when compared with the standard berry bar.

Oriental sweet potato amla bar

TABLE XXXI presents the data on nutrient analysis of oriental sweet potato amla bar

TABLE XXXI

Nutrient analysis of oriental sweet potato amla bar in comparison to standard berry bar

S.No	Nutrients	Standard M±S.D	Sweet potato amla bar M±S.D	P value
1	Moisture (%)	48.8±1.0	51.8±0.9	<.001*
2	Ash(g)	3.10±0.7	3.16±0.1	<.001*
3	Energy(Kcal)	350.4±0.5	740.8±0.60	<.001*
4	Carbohydrate(g)	146±0.2	363.0±1.0	<.001*
5	Protein (g)	0.2±0.5	0.3±0.1	<.001*
6	Fat(g)	0.1±0.0	1.6±0.5	<.001*
7	Dietary Fibre(g)	2.0±0.0	3.6±0.0	<.001*
8	Beta-carotene(mcg)	141.6±1.5	241.0±0.5	<.001*
9	Calcium(mg)	5.3±0.1	5.7±0.5	<.001*
10	Iron(mg)	3.1±0.1	6.6±1.5	<.001*
11	Vitamin C (mg)	10.9±0.1	12.0±0.06	<.001*

The data in the table, reveals that the moisture content increased from 48.8% to 51.8% and ash content had increased from 43.1g to 3.1g in tomato bar incorporated with Oriental sweet potato flour. When compared with the standard, energy value had increased from 350.4Kcal to 740.8 Kcal in the most acceptable variation. The carbohydrate and protein content had increased from 146.4 to 363.0g and 0.2 to 0.3 g respectively in the most acceptable variation when compared to standard. The fat and fibre content had increased from 0.1 to 1.6 g and 2.04 to 3.0 g respectively in the most acceptable variation. The beta-carotene had increased from 141.6 µg to 241.0µg. The calcium and iron content had increased from 5.3 to 5.7mg and 3.1 to 6.6mg respectively in the most acceptable variation. The vitamin C content had increased from 10.9mg in the standard product to 12.0g in the most acceptable variation. All the nutrients were enhanced in sweet potato amla bar when compared with the standard berry bar.

Oriental sweet potato star gooseberry bar

Table XXXII presents the data on nutrient analysis of oriental sweet potato star gooseberry bar

TABLE XXXII

Nutrient analysis of oriental sweet potato star gooseberry bar in comparison to standard berry bar

S.No	Nutrients	Standard M±S.D	Sweet potato star gooseberry bar M±S.D	P value
1	Moisture (%)	46.5±3.0	50.3±0.5	<.001*
2	Ash(g)	3.1±0.5	3.3±0.5	<.001*
3	Energy(Kcal)	109.2±0.6	152.7±0.5	<.001*
4	Carbohydrate(g)	75.3 ±0.2	222.6±1.1	<.001*
5	Protein (g)	0.2±0.0	0.3±0.0	<.001*
6	Fat(g)	0.1±0.0	2.1±0.1	<.001*
7	Dietary Fibre(g)	1.7±0.1	2.3±0.1	<.001*
8	Beta-carotene(mcg)	199.4±1.0	199.6±0.5	<.001*
9	Calcium(mg)	3.9±0.1	4.6±1.1	<.001*
10	Iron(mg)	5.43±1.00	7.5±0.2	<.001*
11	Vitamin C (mg)	10.9±0.2	12.8±0.9	<.001*

From the data on nutrient analysis it is revealed that the moisture content increased from 46.5% to 50.3% and ash content had increased from 3.1 to 3.3g in star gooseberry bar incorporated with Oriental sweet potato flour. When compared with the standard, energy value had increased from 109.2 Kcal to 152.7 Kcal in the most acceptable variation. The carbohydrate and protein content had increased from 75.3 to 222.1g and 0.2 to 0.3 g respectively in the most acceptable variation. The fat and fibre content had increased from 0.1 to 2.1 g and 1.7 to 2.3 g in the most acceptable variation.The beta-carotene had increased from 190.4 µg to 199.6µg. The calcium and iron content had increased from 3.9 to 4.6 mg and 5.4 to 7.5 mg respectively in the most acceptable variation when compared with standard. The vitamin C content had increased from 10.9mg in the standard product to 12.8g in the most acceptable variation. All the nutrients were enhanced in sweet potato star gooseberry bar when compared with the standard berry bar.

A. Analysis of antioxidant profile and conducting shelf-life study of most acceptable berry bars.

(i) Antioxidant Assay

Antioxidant assay of oriental sweet potato berry bars α,α-diphenyl-β-picrylhydrazyl (DPPH) free radical scavenging method offers the first approach for evaluating the anti-oxidant potential of a sample. This is the simplest method , wherein the prospective compound is mixed with DPPH solution and the absorbance is recorded after a defined period of time.

The percentage of inhibition values depends on the concentration of the sample

TABLE XXXIII presents the DPPH Assay of sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry bar

TABLE XXXIII

DPPH Assay of sweet potato berry bars

DPPH Assay of sweet potato black grapes bar	
Concentration (μl)	% Inhibition
50	84.5
150	80.3
250	81
350	77.3
500	76.2
DPPH Assay of sweet potato green grapes bar	
50	86.5
150	82.2
250	80.7
350	78.2
500	73.6
DPPH Assay of sweet potato tomato bar	
50	97.4
150	90.2
250	88.6
350	83.2
500	80.1
DPPH Assay of sweet potato amla bar	
50	83.7
150	82.2
250	80.1
350	78.2
500	76.5
DPPH assay of sweet potato star gooseberry bar	
50	88.6
150	87.2
250	83.1
350	78.1
500	77.2

An examination of TABLE XXXIII reveals that the total antioxidant activity of oriental sweet potato black grapes bar, oriental sweet potato green grapes bar, oriental sweet potato amla bar, oriental sweet potato star gooseberry bar, measured by DPPH method .

The antioxidant assay of sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar , sweet potato amla bar and sweet potato star gooseberry bar produced a positive correlation as indicated by the $R^2 = 0.876$, $R^2 = 0.9827$, $R^2 = 0.9482$, $R^2 = 0.9876$, $R^2 = 0.9275$, that clearly suggests the presences of antioxidant that scavenge the radical to a certain extent.

As a result of antioxidant assay of oriental sweet potato berry bars, sweet potato amla bar produced the highest positive correlation R^2 value of 0.987 followed by sweet potato green grapes bar, sweet potato tomato bar, sweet potato star gooseberry bar and sweet potato black grapes bar of R^2 values of 0.982,0.948,0.927,0.876 respectively as presented in figure 4.

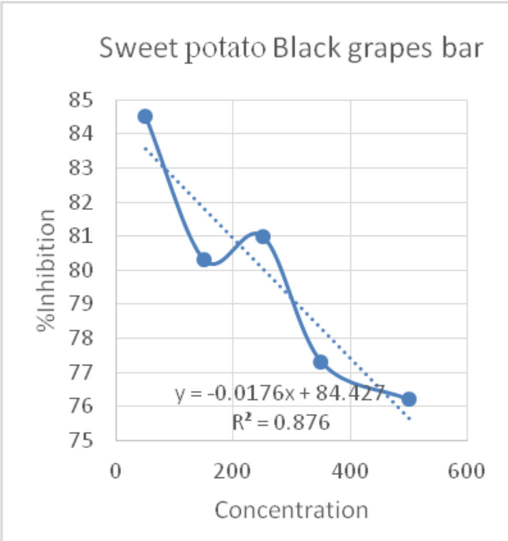

Fig 4.1.DPPH Assay of sweet potato black grapes bar

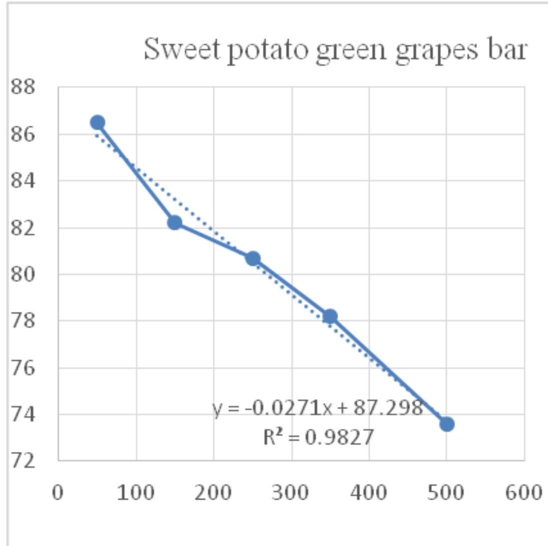

Fig 4.2.DPPH Assay of sweet potato green grapes bar

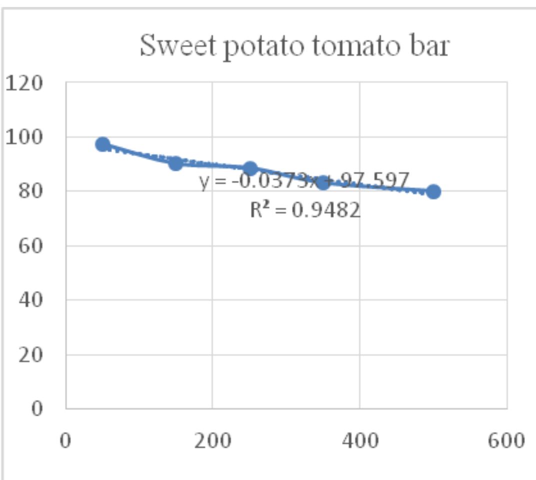

Fig 4.3.DPPH Assay of sweet potato tomto bar

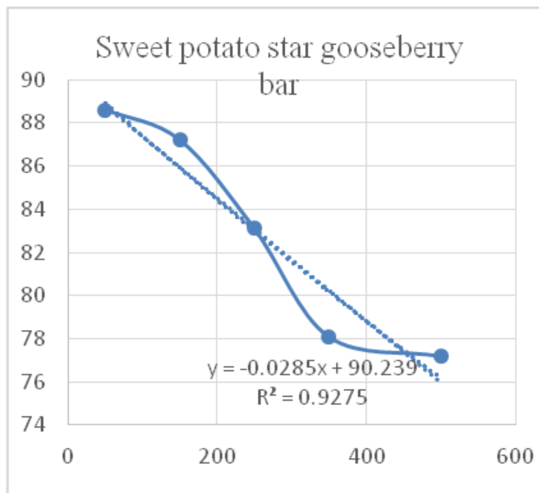

Fig 4.4.DPPH Assay of sweet potato star gooseberry bar

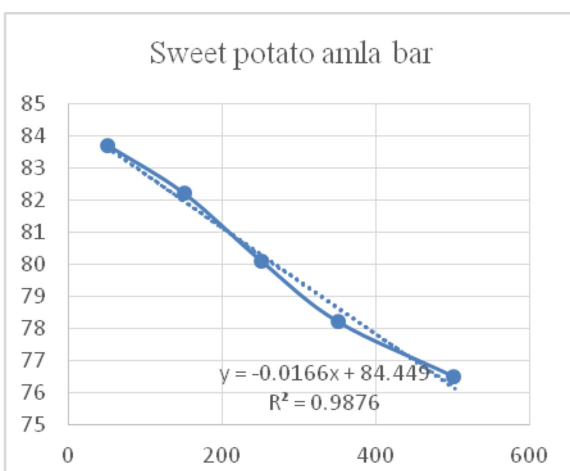

Fig 4.5.DPPH Assay of sweet potato amla bar

Figure 4 . DPPH Assay of oriental sweet potato berry bars

(ii) Shelf life study

Shelf life of the product was determined by Q10 values. Q10 is the factor by which the rate of reaction increased when the temperature was raised by 10 degrees.

Table XXXIV revealed the variations in moisture content during storage of 28 days

TABLE XXXIV

Shelf life study of oriental sweet potato berry bars

Product	Parameter	Temp (°C)	Number of days of storage				Rate of reaction	Q10	Prediction of shelf life
			0 day	14th day	21th day	28th day			
Sweet potato black grapes bar	Moisture %	T1 (40°C)	10.84	11.80	12.30	13.40	0.14	**1.13**	**4.05**
		T2 (30°C)	10.84	11.54	12.00	12.67	0.04		
Sweet potato green grapes bar	Moisture %	T1 (40°C)	12.63	12.93	13.56	14.35	0.24	**1.10**	**4.05**
		T2 (30°C)	12.63	12.78	12.93	14.21	0.05		
Sweet potato tomato bar	Moisture %	T1 (40°C)	27.26	27.44	27.89	28.93	0.32	**1.20**	**4.41**
		T2 (30°C)	27.26	27.35	27.76	28.80	0.02		
Sweet potato amla bar	Moisture %	T 1 (40°C)	22.81	22.90	23.45	24.05	0.22	**1.25**	**4.41**
		T2 (30°C)	22.81	22.84	22.94	23.78	0.03		
Sweet potato star gooseberry bar	Moisture %	T 1 (40°C)	20.93	21.43	22.78	25.34	0.43	**1.32**	**4.78**
		T2 (30°C)	20.93	21.32	21.45	21.78	0.03		

T1- 40°C, T2-30°C

For oriental sweet potato black grapes bar, the rate of reaction for moisture at 40°C was 0.14 and at 30°C was 0.04. Q10 value for change in the moisture percentage was found to be 1.13. For oriental sweet potato green grapes bar, the rate of reaction for moisture at 40°C was 0.24 and at 30°C was 0.05. Q10 value for change in the moisture percentage was found to be 1.10. For oriental sweet potato tomato bar, the rate of reaction for moisture at 40°C was 0.32 and at 30°C was 0.02. Q10 value for change in the moisture percentage was found to be 1.20. For oriental sweet potato amla bar, the rate of reaction for moisture at 40°C was 0.22 and at 30°C was 0.03. Q10 value for change in the moisture percentage was found to be 1.25. For oriental Sweet potato star gooseberry bar, the rate of reaction for moisture at 40°C was 0.43 and at 30°C was 0.03. Q10 value for change in the moisture percentage was found to be 1.32.

The Oriental sweet potato berry bars were wrapped in butter paper and stored in incubator (40°C) and ambient temperature (14-30°C).During the storage (0-28 days) moisture content was observed to be increased in all the sweet potato berry bars. In Oriental sweet potato flour incorporated with berry bars, in Sweet potato black grapes bar the moisture content increased from 10.8% to 13.4% and from 10.8% to 12.6% in bars stored in incubator and at ambient temperature respectively. In sweet potato green grapes bar, the moisture content increased from 12.6% to 14.3% and from 12.6% to 14.21% in bars stored in incubator and at ambient temperature respectively. In sweet potato tomato bar the moisture content increased from 27.2% to 28.9% and from 27.2% to 28.8% in bars stored in incubator and at ambient temperature respectively. In sweet potato amla bar the moisture content increased from 22.8% to 24.05% and from 22.8% to 23.7% in bars stored in incubator and at ambient temperature respectively. In sweet potato star gooseberry bar, the moisture content increased from 20.9% to 25.3% and from 20.9% to 21.7% in bars stored in incubator and at ambient temperature respectively.

In Oriental sweet potato flour incorporated berry bars during 28 days of storage, the moisture gain was 2.5% and 1.8%, 1.7% and 1.6%, 1.7% and 1.5%, 1.2% and 0.9%, 4.4% and 0.8% for sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry bar respectively which indicates moisture gain of samples at accelerated condition was significantly higher compared to samples stored at high temperature and high relative humidity the products absorb moisture.

It can be concluded that the oriental sweet potato berry bars which was packed in butter paper, sweet potato tomato bar and sweet potato amla bar has 4.41 months of predicted shelf life followed by sweet potato black grapes bar and sweet potato green grapes bar with a predicted shelf life of 4.05 months, and sweet potato star gooseberry bar with a shelf life of 4.78 months.\

(iii) Microbial Analysis of most acceptable sweet potato berry bars

Microbial analysis (the total plate count) is the enumeration of aerobic, mesophillic organisms that grow in aerobic conditions under moderate temperature. This count includes all pathogens and non-pathogens grown in food products. Total plate count is made using the plate count nutrient agar. The data related to microbial analysis of the oriental and hannah sweet potato berry bars are presented in table XXXV.

TABLE XXXV

Microbial analysis of oriental sweet potato berry bars

S.NO	Product	Microbial count (Total Plate count)			
		Day 0	**Day 14**	**Day 21**	**Day 28**
1	Sweet potato black grapes bar	0	$7.2x10^5$cfu/g	$11x10^5$cfu/g	$15.3x10^5$cfu/g
2	Sweet potato green grapes bar	0	$7.4x10^5$cfu/g	$10.2x10^5$cfu/g	$14.3x10^5$cfu/g
3	Sweet potato tomato bar	0	$8.3x10^5$cfu/g	$12x10^5$cfu/g	$16.2x10^5$cfu/g
4	Sweet potato amla grapes bar	0	$4.6x10^5$cfu/g	$7.3x10^5$cfu/g	$11.2x10^5$cfu/g
5	Sweet potato star gooseberry bar	0	$5.3x10^5$cfu/g	$9.2x10^5$cfu/g	$12.2x10^5$cfu/g

microbial analysis of the oriental and hannah sweet potato berry bars were evaluated at day 0, day 14, day 21 and day 28.

From the analysis it is evident that the total plate counts in day 0, experimental samples were 100 percent negative. Total plate count differs among the oriental sweet potato berry bars. The total plate count in day 14 was observed to be 7.2x105cfu/g, 7.4x105cfu/g, 8.3x105cfu/g, 4.6x105cfu/g, 5.3x105cfu/g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar, sweet potato star gooseberry respectively. The total plate count in day 21 was observed to be $11x10^5$cfu/g, $10.2x10^5$cfu/g, $12x10^5$cfu/g, $7.3x10^5$cfu/g, $9.2x10^5$cfu/g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar, sweet potato star gooseberry respectively. The maximum TPC was observed in sweet potato tomato bar with a value of 16.2x105 cfu/g followed by sweet potato black grapes bar, sweet potato green grapes bar, sweet potato star gooseberry bar and sweet potato amla bar with values of $15.3x10^5$cfu/g, $14.3x10^5$cfu/g, $12.2x10^5$cfu/g, $11.2x10^5$cfu/g respectively on the 28^{th} day. Low microbial growth was observed after 28 days of storage which makes the oriental sweet potato berry bars that has longer shelf life.

Summary and conclusion

V. Summary and Conclusion

Sweet potatoes are becoming a research focus in the recent years due to the unique nutritional and functional properties. Bioactive carbohydrates, proteins, lipids, carotenoids, anthocyanins, conjugated phenolic acids, and minerals represent versatile nutrients in different parts (tubers, leaves, stems, and stalk) of sweet potato. The major contribution of sweet potato to human nutrition is supply of antioxidants in the form of provitamin A, and to lesser extent vitamin C. Berries invariably rank high due to their powerful antioxidant content. Considerable research has been directed at the potential health benefits of eating berries. As well as being a good source of vitamin C, dietary fiber, and minerals, berries contain high levels of natural polyphenol components that act as potent antioxidants.

The present study entitled " Formulation of Antioxidant Rich bars using Sweet potato and Berries" represents the work on incorporation of antioxidant rich oriental and hannah sweet potato flour in berry bars that are rich in antioxidants which are not reduced by any factors such as heat or oxidation during processing. Therefore,the present study was undertaken to assess the phytochemical and nutrient profile of sweet potato flour. Formulation, standardization, organoleptic and quality evaluation of sweet potato berry bars was conducted. Based on the organoleptic and quality evaluation of sweet potato berry bars, the analysis of nutrients, antioxidant profile, microbial content and shelf life of the most acceptable variety of sweet potato berry bars was carried out.

The present study was conducted with the following objectives:

- To prepare antioxidant rich fruit berry bars by incorporating sweet potato flour
- To analyze the organoleptic characteristics of bars prepared out of sweet potato flour and different fruit berries
- To analyze the nutrients and phytochemicals present in the prepared sweet potato berry bars
- To study the antioxidants present in the bars prepared out of different fruit berries and sweet potato flour
- To analyze the texture characteristics and shelf life of the prepared sweet potato berry bars.

Oriental and hannah sweet potatoes were selected based on the local availability and the amount of previous research previously done on them. Fresh oriental and hannah sweet potatoes free from insecticides and injuries were procured from the local area. The procured oriental and hannah varieties were subjected to different processing steps like cleaning, slicing, drying and powdering.

The oriental and hannah sweet potatoes were collected from the local shops of Coimbatore, Tamilnadu. The sweet potatoes were later shade dried completely until free of moisture, then powdered and stored in air-tight containers. Ethanol extracts were used for the analysis of phytochemical compounds. The phytochemicals analyzed were tannins, steroids, terepenoids, cardio-glycosides, chalcones,flavonoids,saponins,phenol and alkaloids. The dried powdered samples were used for the analysis of macro-nutrients and ashed samples were used for the analysis of micronutrients. The nutrients analyzed include moisture, ash content, energy, carbohydrate, protein,fat,fibre, beta-carotene, iron, calcium and vitamin C using the AOAC (The Association of Official Analytical Chemists) method.

Berry bars such as black grapes bar, green grapes bar, tomato bar, amla bar and star gooseberry bar were formulated with the incorporation of 40, 50 and 60g of oriental and hannah sweet potato flour. Standard and variations of the recipes were prepared and it was evaluated based on the nine point hedonic rating scale for sensory characteristics like appearance, colour, flavour, taste, texture and overall acceptability by 30 panel members for successive trials.

Physio-chemical evaluation was carried out for the oriental and hannah sweet potato berry bars. The physio-chemical characteristics evaluated were colour, texture, TSS (Total Soluble Solids), Titratable acidity and pH. Based on the organoleptic and physio-chemical evaluation of oriental and hannah sweet potato berry bars, analysis of nutrients, antioxidant profile, microbial content and shelf life study was carried out for the most acceptable variety of sweet potato berry bars.

Salient findings of the study :

- Hundred grams of oriental and hannah sweet potato were taken then it was dried and powdered. The powdered oriental and hannah sweet potato obtained from 100 g were $1/3^{rd}$ of the original weight.
- Oriental and Hannah sweet potato flour extracts indicated the presense of tannins, steroids,terpenoids,chalcones,flavonoids,saponins,phenols and alkaloids. Oriental and Hannah sweet potato flour extracts indicated the absence of cardio-glycosides.
- Moisture content of oriental and hannah sweet potato flour was 6.7% and 6.3% respectively. Ash content of oriental and hannah sweet potato flour was 1.4g and 1.3g respectively. Protein content of oriental and hannah sweet potato flour was 4.7g and 3.7g. Fat content of oriental and hannah sweet potato flour was 4.3g and 4.2g respectively. Fibre content of oriental and hannah sweet potato flour was 4.4g and 3.4g respectively..Calcium content of oriental and hannah sweet potato flour was 8.6g and 6.0 g respectively. Iron content of oriental and hannah sweet potato flour 7.9mg and 6.1mg respectively. Beta-carotene of oriental and hannah sweet potato flour was 350 mcg and 270mcg respectively. Vitamin C content of oriental and hannah sweet potato flour was 2.7 mg and 2.1mg.All the nutrients were higher in oriental sweet potato flour when compared to the hannah sweet potato flour.
- Berry bars were prepared incorporating oriental and hannah sweet potato flour. The weight of oriental sweet potato berry bars after drying was about 50-60 % of the original weight of ingredients. The weight of hannah sweet potato berry bars after drying was about 50-55 % of the original weight of ingredients.
- Organoleptic evaluation of oriental black grapes bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour,taste,texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of oriental green grapes bar revealed that incorporation of 40% of sweet potato flour was found to have

high overall acceptability in terms of appearance,colour,flavour, taste,texture and overall acceptability with statistically significant when compared standard with a p value of (0.05). Organoleptic evaluation of oriental tomato bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance, colour,flavour, taste, texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of oriental amla bar revealed that incorporation of 40% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste, texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of oriental star gooseberry bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05).

- Organoleptic evaluation of hannah black grapes bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of hannah green grapes bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture and overall acceptability with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of hannah tomato bar revealed that incorporation of 60% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of oriental amla bar revealed that incorporation of 40% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture with statistically significant when compared with standard with a p value of (0.05). Organoleptic evaluation of hannah star gooseberry bar, whwn compared revealed that incorporation of 50% of sweet potato flour was found to have high overall acceptability in terms of appearance,colour,flavour, taste,texture which is statistically significant when compared with standard with a p value o (0.05).
- Evaluation of physio-chemical properties were carried out for the oriental and hannah sweet potato berry bars. The physio-chemical properties evaluated were colour,texture,TSS,titratable acidity,pH.
- As a result of colour analysis, all the oriental and Hannah sweet potato flour incorporated berry bars had positive value and were lighter in colour with higher L values. All the oriental ad Hannah sweet flour incorporated berry bars had the positive a value and were therefore slightly red. The b values were positive, and therefore were slightly yellow.
- As a result of texture analysis, in comparsion between the oriental and hannah sweet potato berry bars, the hardness and adhesiveness values are similar. The hardness and adhesiveness values of oriental sweet potato black grapes bar, oriental sweet potato green grapes bar,

oriental sweet potato tomato bar, oriental sweet potato amla bar, oriental sweet potato star gooseberry bar are similar to the values of hannah sweet potato black grapes bar, hannah sweet potato green grapes bar, hannah sweet potato tomato bar, hannah sweet potato amla bar, hannah sweet potato star gooseberry bar respectively.

- The titratable acidity values for oriental and hannah sweet potato berry bars was noted which showed that the acidity of the berry bars incorporated with oriental sweet potato flour ranged from 0.79 -0.93 %. The titratable acidity of the berry bars incorporated with hannah sweet potato flour ranged from 0.80 – 0.94%.
- pH values of oriental and hannah sweet potato berry bars are noted. The pH of the berry bars incorporated with oriental sweet potato flour ranged from 3.30 – 4.43. The pH of the berry bars incorporated with hannah sweet potato flour ranged from 2.96 – 4.10. As a result, the oriental sweet potato bars were less acidic than hannah sweet potato berry bars.
- Based on the nutrient profile of flour, organoleptic evaluation and physio-chemical evaluation of sweet potato berry bars, it was shown that berry bars incorporated with oriental sweet potato bars came out to be highly acceptable when compared with berry bars incorporated with hannah sweet potato flour. Analysis of nutrient, antioxidants, microbial content and shelf life study was carried out for the most acceptable oriental sweet potato berry bars.
- Moisture content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard due to the addition of sweet potato flour. Moisture content was increased from 32.3 to 36.7%, 46.8 to 49.5%, 37.6to 37.7%,48.8 to 51.8%, 46 to 50.3 in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Ash content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 2.5 to 2.8g, 2.4 to 2.5g,4.0to 31.2g,3.10 to 3.16 g ,3.13 to 3.33 g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Energy value of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 177 to 200Kcal, 29 to 69.3 Kcal ,51.8 to 80 Kcal ,350.4 to 740.8 Kcal, 109.2 to 22.6Kcal in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Carbohydrate of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from50 to 160 g,160 to 225.4g, 100.4 to 228.7g,146 to 363g,75.3 to 222.6g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Protein of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 0.3 to 3.9g, 0.5 to 0.7 g , 0.3 to 3.9g, 02 to 0.3g, 0.2 to 0.3g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.

- Fat of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 0.1 to 5.9g,0.1 to 1.9g , 0.0 to 2.6g, 0.1 to 1.6g,0.1to 2.1g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Dietary fibre of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 3.2 to 6.5g, 2.2 to 3.4g,0.3 to 0.6g , 2.0 to 3.6g, 1.7 to 2.3g in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Beta-carotene content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 4.0 to 9.3mcg, 0.0 to 18mcg, 100.5 to 138.8mcg, 141.6 to 241.3mcg 199.4 to 199.6 mcg in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Calcium content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 3.2 to 5.8mg,1.6 to 6.8mg,40.6 to 71.8mg, 5.3 to 5.7 mg, 3.9 to 4.6 mg in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Iron content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 0.0 to 3.5mg, 1.3to 2.7mg, 19.5 to 20.2mg, 3.1 to 6.6mg, 7.5 to 54.3mg in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- Vitamin C content of oriental sweet potato berry bars increased significantly ($p<0.05$) when compared to standard from 3.4 to 4.8 mg,2.13 to 4.23 mg, 8.2 to 11.8 mg, 10.9 to 12.0 mg, 10.9 to 12.8mg to in sweet potato black grapes bar, sweet potato green grapes bar, sweet potato tomato bar, sweet potato amla bar and sweet potato star gooseberry respectively.
- As a result of antioxidant assay of oriental sweet potato berry bars, sweet potato amla bar produced the highest positive correlation R^2 value of 0.987 followed by sweet potato green grapes bar, sweet potato tomato bar, sweet potato star gooseberry bar and sweet potato black grapes bar of R^2 values 0.982,0.948,0.927,0.876 respectively.
- By conducting the microbial analysis,the maximum TPC was observed in sweet potato tomato bar with a value of 16.2x105 cfu/g followed by sweet potato black grapes bar, sweet potato green grapes bar, sweet potato star gooseberry bar and sweet potato amla bar with values of $15.3 x 10^5$cfu/g, $14.3 x 10^5$cfu/g, $12.2 x 10^5$cfu/g, $11.2 x 10^5$cfu/g respectively on the 28^{th} day. Low microbial growth was observed after 28 days of storage which makes the oriental sweet potato berry bars that has longer shelf life.
- From shelf life study, it can be concluded that the oriental sweet potato berry bars which was packed in butter paper, sweet potato tomato bar and sweet potato amla bar has 4.41 months of predicted shelf life followed by sweet potato black grapes bar and sweet potato green grapes bar with a predicted shelf life of 4.05 months, and sweet potato star gooseberry bar with a shelf life of 4.78 months.

Recommendations for further study

1. Functional properties of oriental and hannah sweet potato flour can be analysed
2. Mould, yeast count can be studied for oriental and hannah sweet potato berry bars.
3. Trace elements like zinc, magnesium and potassium content of oriental and hannah flour and oriental and hannah sweet potato flour incorporated berry bars can be analyzed.
4. Invivo and Invitro bioavailability of the oriental and hannah sweet potato flour berry bars can be studied.

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APPENDIX I

Ethical Clearance Certificate

INSTITUTIONAL HUMAN ETHICS COMMITTEE

Avinashilingam

Institute for Home Science and Higher Education for Women
(Deemed to be University under Category 'A' by MHRD, Estd. u/s 3 of UGC Act 1956) Re-accredited with 'A++' Grade by NAAC.Recognised by UGC Under Section 12 B
Coimbatore-641 043, Tamil Nadu, India

Chairman
Dr. SudhaRamalingam
Director-Research & Innovation,
Professor-Community Medicine,
PSG Institute of Medical Sciences & Research, Coimbatore

Member Secretary
Dr.S.Uma Mageshwari
Professor and Head,
Department of Food Service Management & Dietetics

Members
Mr.K.Arunmoli (Legal Expert)
Dr.Subhashini K. Sripathi
Dr.A.Saraswathy (Medical Officer)
Ms.D.Kavitha
Dr.A.R.SudamaniRamasamy
Dr.G.Victoria Naomi
Dr. Judith Justin
Dr.AnithaSubash

26th February 2022

To
Ms.Lavanya.R
Department of Food Science and Nutrition
Avinashilingam Institute for Home Science and Higher Education for Women
Coimbatore – 641 043

Dear Lavanya .R,

Ref: Your proposal No. IHEC/21-22/FSN-11 entitled "Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas)* and Berries" submitted for approval of IHEC on 23.11.2021.

The Institutional Human Ethics Committee of our University hereby grants approval to your research proposal No. IHEC/21-22/ FSN-11 entitled "Formulation of Antioxidant Rich Bars using Sweet Potato (*Ipomoea batatas)* and Berries" submitted by you. The Approval number for the same is AUW/IHEC/ FSN-21-22/XPD-11.

We wish you all the best in your research endeavours.

Regards,

Dr.S.Uma Mageshwari
Member Secretary

Institutional Human Ethics Committee

APPENDIX II
SCORE CARD FOR SENSORY EVALUATION

Name of the product:_________________________________ DATE:

Instructions:

Taste the samples and check how much you like or dislike each one. Use the appropriate scale to show your attitude by checking the point that best describes your feelings about the sample. Please give a reason for this attitude .Remember you are the only one who can tell what you like. An honest expression of your personal feelings will help us.

Quality aspects	**Standard**	**Variations**		
Appearance		**I**	**II**	**III**
Colour				
Flavour				
Taste				
Texture				
Overall acceptability				

9-POINT HEDONIC SCALE	
9	**Like extremely**
8	**Like very much**
7	**Like moderately**
L	**Like slightly**
5	**Neither Like nor Dislike**
4	**Dislike slightly**
3	**Dislike moderately**
2	**Dislike very much**
1	**Dislike extremely**

APPENDIX III
PROCEDURE OF NUTRIENT ANALYSIS

1.Determination of ash content:

Total ash content was determined using the standard protocols given by Manual Methods (AOAC). The clean crucible was kept in a muffle furnace at 400°C for half an hour, followed by cooling in a desiccator. Weight of the empty crucible was noted. Thereafter, 5 g of the sample was accurately weighed and placed in a tarred crucible, which was previously ignited, cooled, and weighed. The crucible with the sample was heated over bunsen burner till the sample got charred completely and later transferred to muffle furnace maintained at 650±10°C incinerated for 3 hours until free from carbon and it was cooled in a dessicator and weighed.

$$\text{Ash content (g/ 100g sample)} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

1.Estimation of Total Energy Content

The energy value of foods was determined by using bomb calorimeter. One gram of the sample was taken and made into pellets with the aid of a pellet press, which consists of a mold into which the sample is placed and a pestle which is then pushed into the mold, crushing the sample material into a compact pellet. The pellet is then placed in the sample holder of the crucible and a 10 cm length of fuse wire and a length of cotton thread is tied onto the filament, and its ends placed into the crucible so that it will act as a fuse. The calorimeter bucket was carefully filled with distilled water and the bomb was transferred into the bucket. Through the valves the air is removed and oxygen is filled at 20 atm. It was kept inside the calorimeter vessel which contain 2000 g of water. Electrodes are fixed and the calorimeter is closed. The thermocouple was put in place in the top of the calorimeter. In the digital bomb calorimeter, the start button and stirrer is pressed. The change in temperature of the bomb is displayed in calorimeter. The difference in initial and final temperature was noted and calculation was carried out.

2.Estimation of Carbohydrate: (AOAC,1990)

100 mg of the sample was weighed into a boiling tube. The sample was hydrolysed by keeping 0in a boiling water bath for three hours with 5 mL of 2.5 N HCl and it was cooled at room temperature. Neutralise it with solid sodium carbonate until the effervescence ceases. The volume was made upto 100 mL and centrifuged. The supernatant was collected and 0.5 and 1ml aliquots were taken for analysis. Prepare the standards by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard. '0' serves as blank. Make up the volume to 1 mL in all the tubes including the sample tubes by adding distilled water. Then add 4 mL of anthrone reagent. Heat for eight minutes in a boiling water bath. Cool rapidly and read the green to dark green colour at 630 nm.The analyses were performed in triplicates.

3.Estimation of Protein (AOAC, 1990)

Determination of protein content was carried out by micro kjeldhal method which consists of wet digestion (digestion flask), distillation (distillation chamber) and titration. The protein content was determined by weighing 0.2g of sample and transfer to a 250 ml Kjeldahl flask, care to see that no portion of the sample clings to the neck of the flask. To this 1 to 2 g of catalyst mixture (potassium sulphate 100 g and copper sulphate 20 g) and 10 ml of concentrated H_2SO_4 was added. Flask was placed on the stand in the digestion chamber and continue the process of digestion until the colour of the digest is pale green. The digestion mixture was cooled by adding 30 ml of water. After digestion, distillation was carried out by using 40% NaOH and 20% boric acid using methyl orange as an indicator and titrated against 0.1 N H_2SO_4.The protein content was calculated as follows:

$$\textbf{\%Nitrogen} = \frac{14.01 \text{ x ml titrate value of sample x N of } H_2SO_4 \text{ x } 100}{\text{Weight of the sample (g) x } 1000}$$

Protein content was obtained by converting nitrogen to protein by using conversion factor of 6.25
Protein (%) = 6.25 x Nitrogen (%)

4.Estimation of Fat content (AOAC, 1990)

Crude fat was estimated by continuous soxhlet extraction technique (Socs plus , SCS 6 , Pelican equipment , Chennai , India) using petroleum ether (40-60°C B.P.) as a solvent. Finely powdered sample was placed in fat extraction thimble and placed in a clean, dry pre-weighed beaker to which 80 ml petroleum ether was added. This beaker was then placed in the soxhlet apparatus for the extraction of fat for 2-3 hours. After extraction, the beaker was removed and kept in a hot air oven (100°C) to evaporate traces of solvent. It was then transferred to desiccator, cooled, and weighed. The difference between the weight of the beaker before and after gives the quantity of crude fat extracted from the unknown amount of the sample. The result was expressed as a percentage on a dry weight basis. The analysis were performed in triplicates.

5.Estimation of Crude Fibre (AOAC, 1990)

2g of the sample was weighed in a 500ml conical flask. 200ml of 0.255N sulphuric acid was added and heated gently on a hot plate and boiled for exactly 30 minutes. The mixture was filtered in another conical flask through a muslin cloth over a funnel. The residue on the clothwas washed with 200-300ml of hot water until it was free from acid. The material was transferred from the cloth to the same beaker. 200ml of 0.313N sodium hydroxide was added and was boiled exactly for 30 minutes. The mixture was filtered through the same cloth through a funnel. The residue was washed with 200-300ml of hot water until it was free from alkali. The residue was transferred to a crucible and dried overnight at 80-100°c and weighed. The crucible was heated in a muffle furnace at 600° c for 2-3 hours. Cooled and weighed again. The difference in the weight represents the weight of the fibre.

$$\text{Crude fibre (g/100g sample)} = \frac{\text{Weight of the crucible with contents before ashing} - \text{Weight of the crucible with contents after ashing}}{\text{Sample weight of the sample (g)}}$$

6.Estimation of Beta Carotene
Pigment extraction for β-carotene analysis

This was carried out according to the method of the Association of Official Analytical Chemists (AOAC, 1980). In to a conical flask containing 50ml of 95% ethanol,10g of the macerated sample was placed and maintained at a temperature of 70-80^{o}C in a water bath for 20minutes with periodic shaking. The supernatant was decanted, allowed to cool and its volume was measured by means of a measuring cylinder and recorded as initial volume. The ethanol concentration of the mixture was brought to 85% by adding 15ml of distilled water and it was further cooled in a container of ice water for about 5minutes. The mixture was transferred in to a separating funnel and 25ml of petroleum ether (pet-ether) was added and the cooled ethanol was poured over it. The funnel was swirled gently to obtain a homogenous mixture and it was later allowed to stand until two separate layers were obtained. The bottom layer was run off into a beaker while the top layer was collected in to a 250ml conical flask. The bottom layer was transferred in to the funnel and re-extracted with 10ml petroleum ether for 5-6 times until the extract became fairly yellow. The entire petroleum ether was collected in to 250ml conical flask and transferred in to separating funnel for re-extraction with 50ml of 80% ethanol. The final extract was measured and poured in to sample bottles for further analysis.

Measurement of absorbance

The absorbance of the extracts was measured using a spectrophotometer (model 22UV/VIS) at a wavelength of 436nm. A cuvette containing pet-ether (blank) was used to calibrate the spectrophotometer to zero point. Samples of each extract were placed in cuvettes and readings were taken when the figure in the display window became steady. The operation was repeated 5-6 times for each sample and average readings were recorded.

7.Estimation of Calcium (AOAC, 1990)

Calcium was determined by using the procedure given by Association of Official Agricultural Chemists (AOAC). 5g of ignited sample was dissolved in hydrochloric acid and made up to 100 ml. 10 ml of the ash solution was pipetted out in a conical flask and 90 ml of distilled water was added to it. A few drops of methyl red indicator were added. It was made strongly alkaline by adding ammonia and kept for boiling. The solution was heated to a boiling point and 20ml of saturated ammonium oxalate was added and this was done by adding 10ml each time to ensure complete precipitation directly. When it was hot, a few drops of acetic acid was added to render the medium acidic. The precipitate was allowed to stand overnight. The next morning, it was filtered through Whatman No. 40 filter paper and the precipitate was washed first with ammonical water and then with hot water several times until it was free from chloride. To test it 5 ml of the washing was collected, in a test tube, and a drop of silver nitrate solution was added. The filter paper was collected in a flask by making a hole in the filter paper. To this 2 ml of 2N sulphuric acid was added. The solution was heated to 70ºC and when still hot it was titrated against 0.01N $KMnO_4$ to a permanent pale pink colour. From the volume of potassium permanganate solution used up the milligrams of calcium present in 100g of the sample was calculated. The analyses were performed in triplicates.

8.Estimation of Iron

The iron content of the sample was analyzed using the protocol given by AOAC. When ashing has been completed 5 ml of concentrated HCL was added and made up to 100 ml with distilled water in a volumetric flask. The standard iron solution was taken (1-5 ml) corresponding to 10- 50 in a series of test tubes. 1 ml of 30 % sulphuric acid, 1 ml of potassium persulphate, and 1.5 ml of potassium thiocyanate were added to all the test tubes. This was made up to 10 ml with distilled water. A blank was prepared by adding the reagent except for the standard. It was allowed for 20 minutes for the color development and the intensity was at 530-540 nm filter in the colorimeter.The analyses were performed in triplicates.

9.Estimation of Vitamin C (AOAC, 1990)

5 g of the sample was weighed and soaked 4 % oxalic acid for 10 minutes, this was then ground in a mortar and transferred to centrifuge tube by adding more oxalic acid. The supernatant was transferred 100 ml standard flask repeat the extraction with oxalic acid 3-4 times. All the supernatant was collected in the same standard flask and this was finally made up to the mark with acid. The dye was taken in a micro burette and titrated against 5 ml of the extract in a beaker. The endpoint was the appearance of pink colour which persisted for 30 seconds; the titration was repeated to get a concordant value. The analyses were performed in triplicates.