Value Addition in Sweet Potato

भाकृअनुप-केन्द्रीय कन्द फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
श्रीकार्यम, तिरूवनन्तपुरम 695 017, केरल,भारत
ICAR-Central Tuber Crops Research Institute
(Indian Council of Agricultural Research)
SREEKARIYAM, THIRUVANANTHAPURAM 695 017, KERALA, INDIA

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March 2025

Correct citation

Chintha Pradeepika, Sajeev, M.S., Jyothi A.N., Krishnakumar T., Nedunchezhiyan, M. 2025.Value addition in sweet potato, Technical Bulletin No.TB-104/2025, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 24p.

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From the Director

Tuber crops are important sources of starch after cereals, besides being used as staple or supplementary food. Sweet potato (*Ipomoea batatas* L.) is one of the most nutritionally rich tuber crops that can be integrated in health-focused dietary support strategies to address global nutritional insecurity and related public health challenges. It is mainly grown as vegetable crops on home stead or semi commercial scale. The perishable nature of tubers and the difficulties in long distance transport, storage and marketing constitutes major problems for farmers. In order to overcome these problems, processing, value addition and product diversification of sweet potato tubers on the production catchment itself is recommended. Even though they are branded as poor man's crops in rural areas, have considerable unrealized potential for processing into high end products for food, feed and industrial uses. Agro-industrial transformation of these crops by linking improved production and processing technologies, marketing techniques and institutional innovation in processing technologies ensure food security, rural employment and adequate remuneration to the producers. ICAR-Central Tuber Crops Research Institute under Indian Council of Agricultural Research is a pioneer in the R&D activities of tropical tubers crops and developed an array of novel value added products from sweet potato suited to food sectors.

The ICAR-CTCRI is the only research organization in the world dedicated solely to basic, strategic and applied research on 15 tropical root and tuber crops for catering to the needs of marginal and tribal farmers as well as other stakeholders across the country. The Institute has made significant contributions through systematic research and extension programmes during the last six decades of service to the nation and empowering the farmers and other stakeholders. It is my privilege to present the technical bulletin titled 'value addition of sweet potato' which covers comprehensive knowledge on the innovative technologies available for the development of novel functional food products from sweet potato to achieve sustainable income.

I hope that this technical bulletin will be a valuable reference document for the researchers, development professionals, FPOs, SHGs and other stakeholders for the utilization and scientific adoption of improved practices, thereby maximizing productivity and sustainable income from sweet potato. I appreciate the Editors for their efforts in bringing out this publication covering all novel functional food products of sweet potatoes.

G. BYJU
Director

March 2025

Nutritional properties of sweet potato

Sweet potato (*Ipomoea batatas* L.) is one of the most nutritionally rich tuber crops that can be integrated in health-focused dietary support strategies to address global nutritional insecurity and related public health challenges. Hence sweet potatoes have gained popularity as a health food in recent years due to the presence of different bioactive components. Sweet potato tubers are considered as 3-in-1 food sources as they have qualities similar to cereals, fruits, and vegetables like carbohydrate, bioactive compounds, and vitamins. Table 1 shows the proximate composition of sweet potato tubers. They are high in carbohydrates, and uncooked tubers contain 6-14% (dry matter) sugars, primarily sucrose, glucose, fructose, and maltose. The dry matter ranges between 25.1-38.2%, with starch accounting for 50-80% of the total. Moreover sweet potato is becoming increasingly recognized as a health-promoting food due to its high content of non-starch polysaccharides, which play an important role in the prevention of diseases such as colon cancer, diabetes mellitus, cardiovascular disease, hypercholesterolemia, and obesity. The principal non-starch polysaccharides in sweet potatoes are cellulose, hemicellulose, and pectin, which serve as 'dietary fiber'. The tubers are high in micronutrients like potassium, calcium, phosphorus, and vitamin C.

Table 1. Proximate composition of sweet potato roots

Parameter	**Quantity (fresh wt.)**
Dry matter (%)	25.1-38.2
Moisture (%)	64.8-79.7
Total carbohydrates (%)	18.0-28.0
Crude protein (%)	0.7-2.7
Crude fibre (%)	3.0-4.0
Ash (%)	0.73-4.2
Lipids (%)	0.10-0.46
Mineral composition (mg/100g)*	
Calcium	17-45
Phosphorous	29-57
Potassium	250-450
Magnesium	18-20
Iron	0.6-1.0

*Source: Byju et al., 2022

Fig. 1: Different flesh colored sweet potatoes

Table. 2. Nutritive values of orange and purple-fleshed sweet potato tubers

Nutrients	Orange flesh variety: Bhu Sona	Purple flesh variety: Bhu Krishna
Starch (%)	20.03	24.15
Sugars (%)	2.20	1.20
Fibre (%)	2.29	2.89
Protein (%)	0.40	1.42
Bioactive compound (mg 100 g^{-1})	14.04 (β-carotene)	75.00 (anthocyanin)

*Source: Pradeepika et al., 2023

The great variety of sweet potato genotypes, mostly because of their varied flesh colors (white, yellow, orange, and purple), make sweet potato as a promising and effective integration in several ethnic as well as modern functional food designs. Furthermore, sweet potatoes are recognized as superfood in terms of presence of nutraceuticals components, which showed antidiabetic, antioxidant, anticancer, anti-hypertensive, anti-ulcer properties along with beneficial role against cardiovascular diseases and immune system (Vhintha et al., 2023). The nutritional profile, especially functional bioactives associated with health benefits of sweet potatoes vary widely between different flesh color and among cultivars/varieties. The orange-fleshed sweet potatoes for example are rich source of β-carotene (0.013-14mg/100g on fresh weight basis) and ideal targets for managing vitamin A deficiency and chronic oxidative stress. Therefore, orange sweet potatoes have been a key dietary target in WHO's nutrition mission to fight malnutrition and blindness in several African and Asian countries, where under nutrition and imbalanced nutrition-linked public health challenges co-exist (WHO, 2020). The anthocyanins found in sweet potatoes are excellent antioxidants that perform a variety of physiological tasks, including scavenging free radicals and lowering blood sugar levels. The antioxidant activity of purple-fleshed sweet potatoes is also influenced by phenolic acids and vitamins like ascorbic acid

(Vitamin C) and α-tocopherol (Vitamin E).With an IC50 value of 18.58 µg/ml, the anthocyanins from the tubers of the Bhu Krishna variety have potential antioxidant action against DPPH radicals, while the anthocyanins extracted from the purple leaves of the accession S-1467 have an IC50 value of 17.47 µg/ml. The unique composition and profile of starch in sweet potatoes, such as good amounts of amylose content is beneficial for postprandial blood glucose control and to improve insulin responses, which are critical for prevention and management of early stages of type 2 diabetes (Zakir et al. 2008). Furthermore, the presence of polysaccharides (PSWP, PSAP-1 and PSAP-2) consisting of monosaccharide units arabinose, galactose, glucose, and rhamnose from sweet potato consumption have hepato-protective properties (Sun et al. 2018). Therefore, sweet potatoes have been candidate for developing different functional foods all around the world. This document details the numerous functional foods that ICAR-CTCRI has created using different colored sweet potatoes.

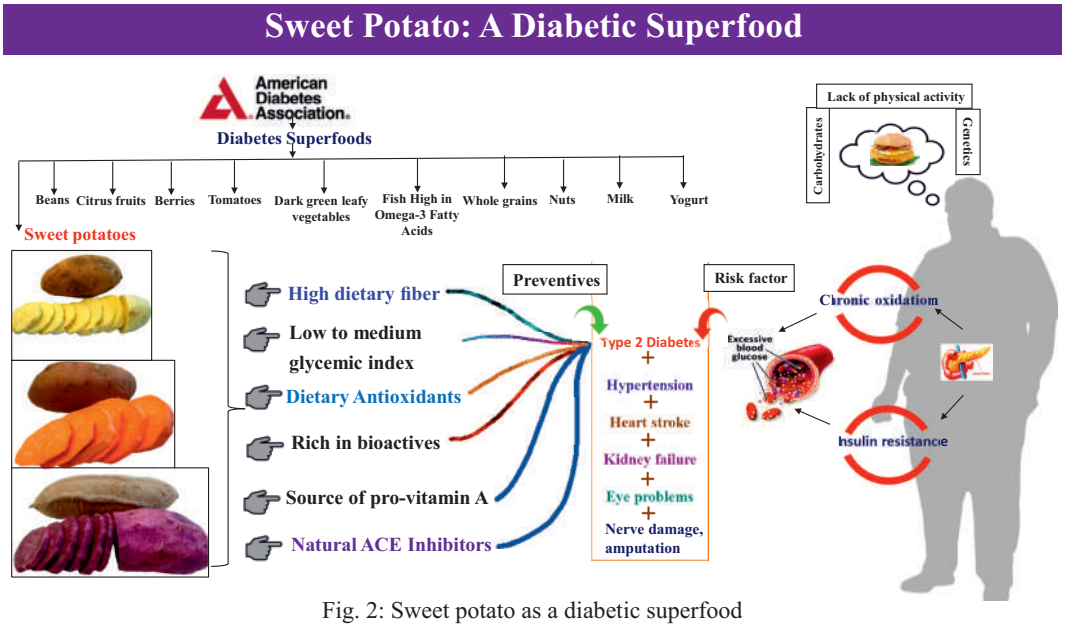

Fig. 2: Sweet potato as a diabetic superfood

Value Addition in sweet potato

Value added food products

A number of value-added food products, including as vacuum-fried chips, bakery goods, functional pasta and noodles, jam, ready-to-use food mixes, frozen desserts and different fermented foods have been designed and developed using sweet potatoes by ICAR-CTCRI. Composite flours, which are made by combining sweet potato flour with wheat flour, millet flours and protein sources, can be used to create a variety of these food products.

Vacuum fried chips from biofortified sweet potatoes

Ingredients:

- Orange and purple fleshed sweet potato tubers
- Vegetable oil

Vacuum frying:

Vacuum frying is a promising food processing technology that preserves nutrients, colour, texture and flavor in ready-to-eat snacks. It involves simultaneous mass and heat transfer at very low temperatures and frying periods to give higher-quality products. During the frying process, many kinds of physical, chemical, and structural changes occur due to moisture evaporation, oil obstruction, gelatinization of starch, denaturation of protein structure, and solubilization of pectin cells. The vacuum frying process is usually performed at below atmospheric pressure. It also results in less oil degradation and less oxidation of volatile substances such as colour, flavour and vitamins. Oil absorption by the products is also reduced when compared to other frying methods. Another advantage of vacuum frying is that it reduces the development of acrylamide formation during the frying of starch-rich products such as sweet potato chips. However, to achieve a better texture in vacuum frying, the product should be pre-treated before frying. Sweet potato is a popular tropical tuber grown for food purposes all over the world. Biofortified sweet potato (orange and purple flesh) cultivars are recognized as healthy foods due to their abundance of health-promoting compounds, essential minerals and dietary fiber. In this context, ICAR-CTCRI has developed two biofortified cultivars; Bhu Sona (orange flesh) and Bhu Krishna (purple flesh). The vacuum frying technique can be used to produce sweet potato chips with good retention of colour and health-promoting compounds from biofortified sweet potatoes, providing a diverse human health-focused diet, particularly to address diet-linked non-communicable chronic disease issues.

Vacuum frying system:

A vacuum frying system consists of three components, viz., a) a vacuum frying chamber b) a refrigerated condenser and c) a vacuum pump (Fig. 2). The vacuum frying chamber is an airtight vessel provided with an oil heater and a frying basket. The frying basket is raised and

lowered into the heated oil by a lift rod. The lift rod is usually connected to a spinner motor that is used for centrifuging the product after frying to get rid of surface oil. The refrigerated condenser is provided to trap the evolved steam during frying by condensing it on a cold

Vacuum frying process:

The vacuum frying process required the heating of oil to the required temperature. Then the sample to be processed has to be placed in the basket inside the frying chamber but suspended above the hot oil. The pressure inside the vacuum frying chamber has to be reduced to the required pressure. The sample then lowered into the hot oil for the required duration and then the basket to be raised above the oil and then centrifuged within the chamber for the required speed and time. The fried product can also be taken out of the chamber and centrifuged using a separate machine or stood in the frying chamber to drain the surface oil. The product is then placed on absorbent paper, cooled and packed in an aluminum laminate bag with or without nitrogen flushing.

Fig.2 : Vacuum frying system

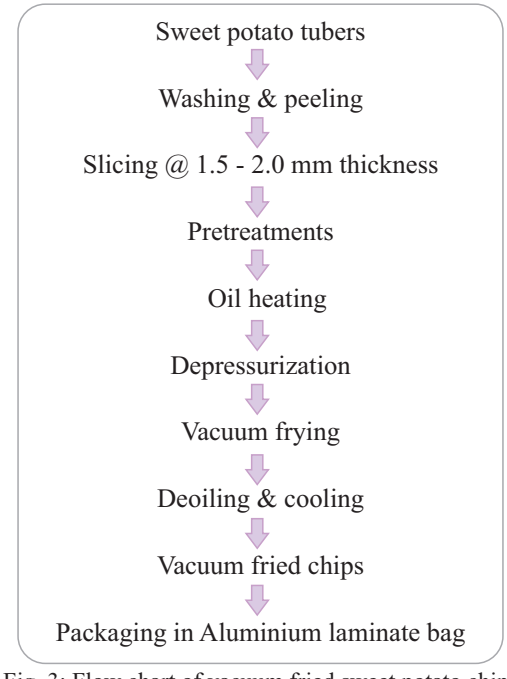

Fig. 3: Flow chart of vacuum fried sweet potato chips

Orange fleshed sweet potato chips

The optimal conditions for vacuum frying orange fleshed sweet potato chips were found to be at 110°C with a vacuum pressure of 16.12 kPa for 7 min to produce healthy chips. When compared to deep fat fried chips, vacuum fried orange fleshed sweet potato chips had good retention of β-carotene content (6.80 mg/100g) and a 50.36% lower oil content. Similarly, the moisture and oil content of optimized samples were 9.53% and 12.44%, respectively, which were lower than the 15.43% and 22.76% measured for deep fat fried chips (Fig. 4).

Purple fleshed sweet potato chips

The optimal vacuum frying conditions were found to be 105°C with a vacuum pressure of 14.79 kPa for 7.08 min to produce healthy purple sweet potato vacuum fried chips. When compared to deep fat fried chips, purple sweet potato vacuum fried chips retained 86% more anthocyanin and had 35.6% less oil (Fig. 4). Similarly, the moisture content, oil content, total colour difference (ΔE) and crispiness values for optimized vacuum fried samples were 7.30%, 12.30%, 10.46, and 0.71 N, respectively, which were lower than the values for deep fat fried chips samples of 13.78%, 19.10%, 27.10, and 3.43 N, respectively.

Nutrients	Orange flesh variety: Bhu Sona	
	Optimal value	Control (Deep fat fried)
Moisture (%)	9.53	15.43
Fat (%)	12.44	22.76
Total colour difference	18.85	25.04
Hardness (N)	1.58	4.37
Bioactive compound (mg 100 g^{-1})	6.80 (β-carotene)	4.28 (β-carotene)

Nutrients	Purple flesh variety: Bhu Krishna	
	Optimal value	Control (Deep fat fried)
Moisture (%)	7.30	13.78
Fat (%)	12.30	19.10
Total colour difference	10.46	27.10
Hardness (N)	0.71	3.43
Bioactive compound (mg 100 g^{-1})	57.44 (anthocyanin)	30.88 (anthocyanin)

Fig. 4: Orange fleshed vacuum fried sweet potato chips rich in carotenoids and purple fleshed vacuum fried sweet potato chips rich in anthocyanin

Vacuum frying has proven to be a viable technology for producing healthy and nutritious fried foods with lower fat content and higher nutritional qualities such as β-carotene (provitamin-A) and anthocyanins content which aids in the prevention of many diseases. Low-fat, nutrient-dense vacuum-fried chips made from orange and purple fleshed sweet potato tubers were developed. The benefit-cost ratio for producing orange fleshed vacuum fried sweet potato chips is 2.13; while the benefit-cost ratio for producing purple fleshed vacuum fried sweet potato chips is 2.29. The findings of this study demonstrated the potential of vacuum frying as a method for producing healthy chips with lower fat content and higher nutritional characteristics

Functional pasta and noodles

Sweet potato flour based functional pasta and spaghetti has been developed by enrichment with proteins, natural pigments, and dietary fiber. Process was optimized for producing sweet potato pasta enriched with protein from low cost sources such as green peas, Bengal gram flour and casein. The protein content in the pasta varied from 7.5 to 15.1%. Pasta is also prepared from sweet potato-pseudo millet based composite flour. The flours used are sweet potato flour (55%), millet flour (15%), refined wheat flour (30%) and starch (5%) along with quinoa and buckwheat flour. In addition, antioxidant rich functional pasta are developed from sweet potato using antioxidants such as betanin and β-carotene rich beetroot and orange sweet potato.

Fig. 5: Sweet potato based composite flour pasta with low cost protein sources (a) Green peas (b) Bengal gram and (c) Caseine


Fig. 6: Pasta from sweet potato-pseudo millet based composite flour


Fig. 7: Betanin and β-carotene enriched pasta

Antioxidant rich functional noodles are developed from sweet potato using antioxidants such as β-carotene, anthocyanin, betanin or curcumin either alone or in combination.




Fig. 8: Betanin and anthocyanin enriched noodles

Functional spaghetti enriched with commercial dietary fibers such as NUTRIOSE and guar gum are rich in dietary fiber have high level of residual undigested starch, which makes them idealfoods for diabetic and obese people.


Fig. 9: Dietary fiber enriched spaghetti and noodles

High protein starch noodles have also been prepared from sweet potato by fortification with different proteins which include whey protein concentrate, bengal gram, green gram and black gram flours. The protein content in the products is in the range of 12 to 17%. Furthermore addition of the flour of legumes with sweet potato decreases the starch content in the pasta, the values ranged from 54.80% for 30% red gram incorporated pasta to 62.90% for 10% rajma based pasta, whereas pasta from maida alone had a starch content of 64.04%. It was observed that as the legume content increases, the protein content also increased in the pasta and maximum protein content was noticed for 30% lentil flour mixed with sweet potato.

Fig. 10: Whey protein and bengal gram fortified noodles

Gluten free noodles from orange and purple sweet potato flour

- Gluten free flour blends comprising about 40% sweet potato flour (orange or purple fleshed), 22.5% amaranth flour, 22.5% foxtail millet flour, 10% cassava starch powder and 5% oil.
- Carotenoids and anthocyanin content is 3.98mg/100g and 180.57 mg/100g respectively.
- Antioxidant activity (%), total phenols (mg GAE/100g sample) and total flavonoides (mg QE/100g sample) for orange fleshed GF noodles as 64.03, 8.74, 90.20 and for purple fleshed GF noodles as 67.02, 11.77 and 103.65.

Fig. 11: Gluten free noodles from orange and purple sweet potato flour

Sweet potato nutribar

Ingredients:

- Sweet potato flour
- Bengal gram
- Defatted soy flour
- Sweeteners (honey and jaggery)
- Oats
- Puffed rice
- Dhal
- Nuts

Fig. 12: Nutribar

Product description:

The nutribars are considered as a snack having good sensory and nutritional characteristics because it contains high amounts of carbohydrates, proteins, lipids and minerals. Consumers

demand for healthy snacks, has motivated the food manufacturers to develop food bars that provide nutrition and convenience. The nutritious bars have gained importance and popularity in the market. Nutribars are small rectangular bars of weight 25-50 g, which takes all aspects into consideration, combining the best part of cereal with fruit and added vitamins, minerals and calcium and they can therefore prove to be a perfect health conscious food choice. Another positive aspect of nutribars is the fact that they do not require preparation or making ready to eat. Therefore, sweet potato based functional bars enriched with enzymatically modified resistant starch were developed. The level of resistant starch was 5 – 15%. It contained moisture 5.48 - 6.52%, ash 2.17 - 2.35%, crude protein 5.37 - 6.80%, crude fat 21.68 - 28.75%, crude fiber 1.29 - 2.45%, carbohydrates 54.80 - 62.84% and energy 467.56 - 505.15 kcal $100g^{-1}$.

Sweet potato based ready-to-use food-mixes

Roots and millet nutri- meal (ready to eat)

Ingredients:

- Sweet potato flour- (Bhu sona or Bhu-Krishna)
- Cassava flour
- Arrowroot starch
- Jawar
- Little Millet
- Foxtail millet
- Ragi (Finger millet)
- Chickpea
- Flax seed
- Green gram(germinated)
- Groundnut
- Flattened Rice flakes
- Almond
- Sugar or Jaggery Powder

A. Four types prepared using two varieties of sweet potato flour combination with sugar or jaggery with Elaichi flavour.

Type -1 : Bhu-Krishna flour with sugar keeping other ingredients as listed above

Type -2: Bhu-Krishna flour with jaggery keeping other ingredients as listed above

Type -3: Bhu-sona flour with sugar keeping other ingredients as listed above

Type -4: Bhu-sona flour with jaggery keeping other ingredients as listed above

B. Four types prepared using two varieties of Sweet potato flour combination with Sugar or jaggery with vanilla flavour.

Type -1 : Bhu-Krishna flour with sugar keeping other ingredients as listed above

Type -2 : Bhu-Krishna flour with jaggery keeping other ingredients as listed above

Type -3 : Bhu-sona flour with sugar keeping other ingredients as listed above

Type -4 : Bhu-sona flour with jaggery keeping other ingredients as listed above

Product description:

A nutritious blend of cereals, pulses, millets, tuber crops, and dry fruits makes up an instant nutritious meal. This nutri-meal preserves the nutritious quality of each ingredient, resulting in a safe, nutritious, and gluten-free finished product. It is highly recommended and ideal for a balanced diet for all age groups

Fig. 13: Sweet potato and millet nutri- meal

Ready to use laddu mix

Ingredients:

- Sweet potato flour
- Bengal gram flour
- Sugar
- Cardamom powder

Fig. 14: sweet potato based Ready to use laddu mix

Product description:

The ready to use laddu mix from different combinations of sweet potato flour, Bengal gram flour, sugar and cardamom powder was developed. The moisture content in the laddu mix ranged from 3.48-3.92%, protein 10.75-11.52%, fat 2.38-2.86%, total ash 2.58-3.53%, fibre 2.7-3.3% and carbohydrates 75.12 to 76.50%.

Weaning food mixes from sweet potato

Ingredients:

- Sweet potato flour
- Arrowroot flour
- Chuda powder
- Malted ragi flour
- Rice flour
- Sugar
- Skim milk powder
- Starch
- **Product description:**

Ready to use weaning food mixes from different combinations of sweet potato (var. Kishan) flour, arrowroot flour, chuda powder, malted ragi flour, rice flour, sugar, skim milk powder and starch were formulated and prepared. The nutritional compositions of weaning food mixes contains moisture content 6.4 - 7.2%, crude protein 12.4 - 13.6%, crude fat 5.8 - 6.2%, total ash 3.2 - 3.4%, crude fibre 6.3 - 6.9%, calcium 139 – 147 mg 100 g-1 and iron 9 – 11 mg 100 g^{-1}

Sweet potato flour based paratha mix

Ingredients:

- Sweet potato flour
- Millet flour
- Multigrain flour
- Dried spices

Product description: A ready-to-use paratha mix was prepared from sweet potato flour 50%, millet flour-15%, multigrain flour-30% and dried spices-5%.

Fig. 15: Ready to use sweet potato paratha mix, paratha dough and cooked paratha

Gummy confections

Ingredients:

- Sweet potato puree concentrate
- Gelatin/pectin
- Sorbitol
- Xylitol
- Glucose syrup
- Citric acid
- Sodium benzoate

Product description:

The feasibility of incorporating orange and purple sweet potato concentrate (OSPC and PSPC) as value-added food ingredients in convenient food products, using a model system of gummy candy, was investigated. Formulation for gelatin gummies includes gelatin which ranges between 10 to 16 % and for petin gummies pectin ranges from 0.5 to 2.5 % and OSPC and PSPC between 5 to 20%. The anthocyanin content was found to be higher in the gummies made with pectin than gelatin. The highest anthocyanin content was observed in pectin gummies (4.05 mg 100 g^{-1}), which had the highest PSPC. While gelatin gummies had the lowest amount of anthocyanin content (1.42 mg 100 g^{-1}). The beta carotene content was found to be higher in the gummies made with pectin than gelatin. The highest beta carotene content was observed in OSPC incorporated pectin gummy formulation (3.28 mg 100 g^{-1}) sample. While the gelatin gummies had the lowest amount of beta carotene content (0.29 to 0.74 mg 100 g^{-1}) sample. The beta carotene content shows an increasing trend as the percentage of puree increases.

Fig. 16: Beta carotene and anthocyanin enriched gelatin gummies

Fig. 17: Beta carotene and anthocyanin enriched Pectin gummies

Sweet potato based bakery food products

Anthocyanin rich cake from purple sweet potato

Fig. 18: Anthocyanin rich cake from purple sweet potato

Ingredients:

- Purple fleshed sweet potato flour
- Refined wheat flour
- Butter
- Sugar
- Baking powder

Product description:

The cake prepared with a combination of 70% sweet potato flour and 30% refined wheat flour was found to be the best. The crude protein content in the cake ranged from 6.32 to 6.93%, fat content from 16.24 to 16.50%, and ash content from 3.11 to 3.65%. The anthocyanin content was 39 to 41 mg 100 g-1 and the specific volume was 1.51 - 1.63 ml g-1. The overall acceptability of the cake as determined by sensory evaluation ranged from 7.51 to 8.90 on a 1-10 hedonic scale. Good source of anthocyanin (39 mg 100 g^{-1})

Beta carotene rich cake from purple sweet potato

Fig. 19: Beta carotene rich cake from orange sweet potato

Ingredients:

- Orange fleshed sweet potato flour
- Refined wheat flour
- Butter
- Sugar
- Baking powder

Product description:

The cake prepared with 80% sweet potato flour and 20% refined wheat flour was found to be the best in terms of sensory evaluation and physicochemical properties. The protein content in the cakes ranged from 5.73 to 6.21%, fat content from 16.22 to 16.62%, ash content 3.06 to 3.27% and β-carotene content from 6.3 to 6.7 mg 100g-1. The specific volume was 1.48 to 1.57 ml g-1 and the overall acceptability ranged from 7.54 to 8.52 on 1-10 hedonic scale. Excellent source of beta carotene i.e., 6.3 mg g^{-1} and it fulfils the RDA of children and adolescent.

Sweet potato gluten free cookies

Ingredients:

- Sweet potato flour
- whey protein concentrate
- Sorghum flour
- Fructo-oligosaccharides
- Maltodextrin
- Sucralose

Fig. 20: Sweet potato gluten free cookies

Product description: Protein and fiber enriched gluten free functional cookies from orange and purple fleshed sweet potato were developed using whey protein concentrate, fructo-oligosaccharide, maltodextrin and sucralose showed 8.02% protein, 10.33% fiber and 411kcal/100g. Also, they are rich in biofunctional components such as total phenols, total flavonoids, total carotenoids and anthocyanin content. Moreover, high content of minerals such as phosphorus (88 mg 100g-1), potassium (270.33 mg 100g-1) and iron (24.60 mg 100g-1) are reported with an added advantage for sweet potato flour based gluten-free cookies. It provides 2.53% protein, 7.44% crude fiber and 480.43 kcal

Sweet potato muffins

Ingredients:

- Orange fleshed sweet potato flour
- Wheat flour
- Whey protein concentrate
- Egg
- Milk powder
- Water
- Oil
- Butter
- Baking powder
- Salt
- Vanilla essence

Product description: Muffins are a quick bread that requires very little gluten, hence sweet potato flour works well for making them. Muffins developed from the sweet potato flour, whey protein concentrate and wheat flour showed the best physicochemical and functional characteristics with a protein content of 7.50% and fiber of 2.50%. In addition, beta carotene content of 1.20 mg 100 g^{-1}, total antioxidant activity of 25 % based on DPPH assay and total soluble phenolic content of 0.63 mg GAE 100 g^{-1} was observed in the developed product.

Fig. 21: Protein enriched sweet potato muffins

Protein-fiber rich orange fleshed sweet potato bread

Ingredients:

- Orange fleshed sweet potato four
- Wheat four
- Whey protein concentrate (WPC)
- Psyllium husk
- Sugar
- Yeast
- Calcium propionate
- Salt
- oil and water

Fig. 22: Protein-fiber rich orange fleshed sweet potato bread

Product description:

The bread made from orange fleshed sweet potato with 9% whey protein concentrate and 6% psyllium husk showed 17.72% protein and 8.02% fiber. The estimated glycemic index was found lower 52.58. The total carotenoid, total phenols, total favonoids and DPPH inhibition of OFSP bread was found as 3.78 (mg/100 g), 51.32 (mg GAE/100 g), 26.80 (mg QE/100 g) and 43.53% respectively.

Pearl millet incorporated sweet potato choco-filled cookies

Ingredients:

- Sweet potato flour
- Sorghum flour
- Wheat flour
- Butter
- Sugar
- Egg

Fig. 23: Pearl millet incorporated sweet potato choco-filled cookies

Product description: Choco-filled cookies combination containing sweet potato, sorghum and wheat flour showed protein content of 4.75 mg 100 g^{-1} dry weight (dw), starch of 39.59 mg 100 g^{-1}dw, fiber of 0.51 mg 100 g^{-1}dw, ash of 3.52 mg 100 g^{-1}dw. In addition, micronutrient analysis revealed the presence of good amounts of micronutrients such as calcium (0.99 to 3.40 mg l^{-1}), iron (1.05 to 1.67 mg l^{-1}), magnesium (0.27 to 0.34 mg l^{-1}), zinc (0.16 to 0.27 mg l^{-1}), and copper (0.04 to 0.09 mg l^{-1}).

Sweet potato-sorghum low-calorie cookies using natural sweeteners

Ingredients:

- Sweet potato flour
- Sorghum flour
- Wheat flour
- Butter
- Stevia
- Egg

Product description: Low-calorie cookies combination containing of sweet potato, sorghum and wheat flour showed excellent nutritional and sensory attributes. Natural sweetener (stevia) derived from *Stevia rebaudiana* was used for the development of sweet potato-sorghum low-calorie cookies. Total sugar content of low-calorie cookies found out to be 1.78% compared to 15.21% in control cookies with fiber content of 1.24%.

Sweet potato-millet cookies

Ingredients:

- Sweet potato Flour
- Arrowroot starch
- Ragi flour
- Little Millet flour
- Foxtail Millet flour
- Wheat flour
- Jiggery powder
- Butter
- Baking powder

Fig. 24: Sweet potato-millet cookies

Product description: Sweet potato and millet cookies are made with combinations of sweet potato and millet flours,wheat flour dry fruits, Amul butter and Jaggerry

Sweet potato nutri jam

Ingredients:

- Sweet Potato [Bhu Krishna (for anthocyanin rich jam), Bhu-Sona(for beta carotene rich jam)]
- Sugar
- Citric Acid
- Pectin (Food grade)
- Sodium Benzoate (Food Grade)

Product description: Anthocyanin and beta carotene rich nutri-jam prepared using the extract of purple fleshed sweet potato variety Bhu Krishna contains 28.4% moisture 67.51°Brix of TSS, 0.50% titratable acidity and 54.11 mg/100g anthocyanin content. The β-carotene rich nutri-jam has a moisture content of 27.3%, TSS of 67.53 °Brix, titratable acidity of 0.53% with a β-carotene content of 7.20 mg/100g. The nutri-jam has good storage stability at ambient and refrigerated temperatures up to 90 days.

Fig. 25: Beta carotene and anthocyanin rich nutri-jam

Nutri-sauce from orange fleshed sweet potato

Ingredients:

- Sweet potato pulp (BhuSona)
- Sugar
- Vinegar
- Chilli powder
- Salt

Fig. 26: Nutri-sauce from orange fleshed sweet potato

Product description: The final TSS (Total soluble solids) of prepared sauce is 25 ºBrix, pH 4.5, ash 3.14%, protein 1.92%, fat 1.52%, β-carotene content 5.75mg/100g and overall acceptability 8.72.

Sweet potato frozen desserts

Purple sweet potato frozen yogurt

Ingredients:

- Concentrated sweet potato puree (Bhu Krishna variety for anthocyanin rich puree)
- Starter (*Lactobacillus plantarum*)
- Fresh skim milk
- Fresh cream
- Milk powder
- Sucrose
- Carboxymethyl cellulose

Fig. 27: Anthocyanin rich purple sweet potato frozen yogurt

Product description: Frozen yogurt developed from purple fleshed sweet potato puree concentrate showed higher anthocyanin content of 30.45 mg100 g^{-1}, protein content of 6.56 %, and a fiber content of 0.69 % under refrigerated storage conditions. In addition, the viable beneficial microbial count was ranged between 5.45 to 7.22 log CFU/ml at tenth day of storage. Results suggested that *beneficial lactobacillus* (LAB) based frozen yogurt development was an effective post-harvest processing strategy for higher retention of anthocyanin content and its associated antioxidant and anti-hyperglycemic functionalities in sweet potato based functional foods. Additionally, such frozen yogurt with probiotic as well as prebiotic potential can be integrated into health-focused dietary solution strategies, especially to improve human gut health and to mitigate chronic oxidative stress-linked non-communicable disease challenges

Orange sweet potato frozen yogurt

Ingredients:

- Concentrated sweet potato puree (Bhu sona variety for beta carotene rich puree)
- Starter (*Lactobacillus plantarum*)
- Fresh skim milk
- Fresh cream
- Sucrose
- Carboxymethyl cellulose
- Vanilla flavor

Fig. 28: Beta carotene rich orange sweet potato frozen yogurt

Product description: Frozen yogurt developed from orange fleshed sweet potato puree concentrate showed higher beta carotene content of 12.41 mg100 g^{-1}, protein content of 4.62 %, and a fiber content of 0.47 % under refrigerated storage conditions. In addition, the viable beneficial microbial count was ranged between 4.52 to 5.87 log CFU/ml at tenth day of storage at 4°C. Results suggested that *beneficial lactobacillus* (LAB) based frozen yogurt development was an effective post-harvest processing strategy for higher retention of beta carotene content and its associated antioxidant and anti-hyperglycemic functionalities in sweet potato based functional foods.

Fermented food products

Sweet Potato Dahi

Ingredients:

- Sweet potato juice
- Fermented milk

Product description:

Fig. 29: Beta carotene rich sweet Potato Dahi

Sweet potato dahi was prepared by fermenting a mixture of milk and β-carotene rich sweet potato (variety Bhu-Sona) juice. Good amounts of beta carotene (6.40 mg $100g^{-1}$) was observed in the final product and which is above the recommended level suggested by U.S. Department of Agriculture (USDA) i.e., 3-6mg β-carotene/day. The consumer panel preferred the colour, flavor, texture and acceptability of the sweet potato dahi with 20 and 30% sweet potato juice that scored >3 (hedonic scale 1-5). Furthermore, dahi preserved with0.05% of potassium sorbate at 4°C showed highest shelf-life up to 37 days.

Lacto-pickle

Ingredients:

- Sweet potato tuner
- *Lactobacillus plantarum* (MTCC 1407) strain

Product description: Lacto-juice prepared by the lactic acid fermentation of β-carotene-rich sweet potato has high nutritive value, vitamins and minerals which are beneficial to human health. The lacto-juice has beneficial probiotics properties of lactic acid bacteria and enriched with phenolics and β-carotene, which is considered as an antioxidant and anticancer compound and the precursor of Vitamin A. There was no physiological and microbiological deterioration of lacto-juice for 30 days. The roots of orange flesh sweet potato variety, Bhu Sona have been pickled by lactic fermentation by brining the cut and blanched roots in 8-10% brine solution and subsequently inoculating with a strain of *Lactobacillus plantarum* (MTCC 1407) for 28 days. The lacto-pickle has a pH of 2.9-3.0, lactic acid concentration of 2.6-3.2g/kg and β-carotene content in the range of 169-176 mg/kg.

Fig. 30: Sweet potato lacto-pickles

Sweet potato wine

Ingredients:

- Sweet potato tuber
- *Lactobacillus plantarum* (MTCC 1407) strain
- **Product description:**

A red wine with high content of anthocyanins (55.09 mg/100g) has been produced from purple fleshed sweet potato tubers. The wine has the following proximate composition: total soluble sugar (TSS)- 2.25º Brix; starch-0.15 g/100 mL; total sugar- 1.35 g/100 mL; TA- 1.34 g tartaric acid/100 mL; phenol- 0.36 g as caffeic acid equivalent/100 mL; tannin- 0.64 mg/100 mL; lactic acid-1.14 mg/100 mL; ethanol- 9.33% (v/v); and pH- 3.61. The DPPH radical scavenging activity of the wine is 58.95% at a dose of 250 µg/mL.

Sweet Potato Superfoods: Harnessing Nature's Nutrient Powerhouse

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