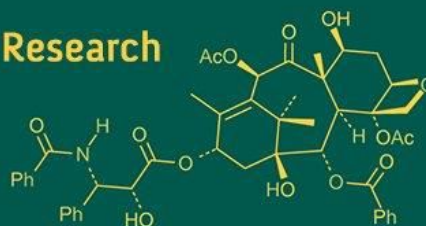
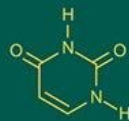
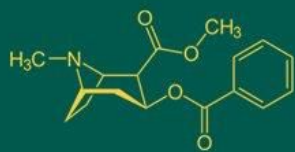


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Physico-chemical properties of some seasonal vegetables

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Abstract

Consumption of vegetables is associated with numerous health benefits as they enrich the diet with vital minerals and vitamins, besides providing other nutritionally important components including fibre. Prevalence of the fast foods and eating-outs have somehow affected the pattern of vegetable consumption. Realizing the importance of vegetables in the diet and for pushing forward the case of its increased consumption the United Nation General Assembly has declared 2021 as the “International Year of Fruits and Vegetables”.

Among the seasonal vegetables cucurbitaceous crops viz bitter gourd spine gourd, and sweet potato have high medicinal and nutritional value.

The summary of measured and calculated geometrical characteristics of bitter gourd, spine gourd and sweet potato in Table1. The average values of major, median and minor diameters of bitter gourd, spine gourd and sweet potato were 16.54, 3.35, 2.83cm, 3.34, 2.18, 1.87 cm, 8.42, 3.02 and 2.77 cm respectively (Table1). The average Geometric mean, Sphericity and Surface area of bitter gourd, spine gourd and sweet potato were 5.383 mm, 165.58, 90.87 cm² 2.410 mm, 270.43, 14.34 cm² 4.121 mm, 212.09 and 53.31 cm² respectively (Table1). The shape of bitter gourd spine gourd and sweet potato compared with the standard chart (Mohsenin, 1986) [20] and can be consider as spindle-shaped, oval and circular. The average weight, length, diameter and volume were determined. The required fruits were taken randomly for examination of physical parameters (Kusat *et al.*, 2021) [18].

Biochemical properties of bitter gourd, spine gourd and sweet potato were determined. The biochemical properties are proximate and chemical analysis of bitter gourd, spine gourd and sweet potato. In a study of bitter gourd the average nutritional value per 100g edible vegetable was found to contain 90.2 per cent moisture, 4.2g carbohydrate, 1.46g protein, 0.26g fat, 2.34g fibre and 1.36g total sugars (Table 2). In spine gourd the average nutritional value per 100g edible vegetable was found to contain 86.5 per cent moisture, 4.4g carbohydrate, 2.1g protein, 0.3g fat, 2.8g fiber and 0.89g total sugars (Table 2). In sweet potato the average nutritional value per 100g edible vegetable was found to contain 67.2 per cent moisture, 20.4g carbohydrate, 1.47g protein, 0.11g fat, 1.67g fiber and 1.12g total sugars (Table 2).

Keywords: Vegetable consumption, cucurbitaceous crops, physical properties, biochemical composition, nutritional value

Introduction

Vegetables have contributed largely towards food and nutritional security of the people, particularly the poor. India is the second largest producer of vegetables in the world after China. In the world production of vegetables was 209.39 million metric tons and Area was 11.23 million hectares (2023-24). Many vegetables are seasonal and available for in shorten days in the year, but they have a great demand throughout the year. Among the seasonal vegetables spine gourd, bitter gourd and sweet potato are the vegetables for common people to meet their daily nutritional requirement.

Bitter gourd (*Momordica charantia*) is a member of the cucurbit family. It is considered to be native to China or India and Pakistan. It is cultivated widely in many tropical and subtropical regions of the world and is frequently used in India and orient as a foodstuff and a medicinal plant (Habicht *et al.*, 2011) [13].

Spine gourd (*Momor dicadioca*) is the member of cucurbitaceae family having a high nutritional as well medicinal value. This vegetable bearing plant has its origin in the Indian subcontinent, it is a perennial climber with tuberous root and almost 4 m long vine bearing

simple tendrils. It is commonly known as, Kantoli, Kantola, Teasle Gourd, Kakrol, Spine gourd, Ban karola, or small bitter-gourd (Trivedi and Roy, 1972; Rai, 2012) ^[21, 31].

Sweet potatoes (*Ipomoea batatas*) are dicotyledonous plants belonging to the family Convolvulaceae. Their edible root is covered with a thin, smooth skin whose colour may range from red, purple, or brown to white even. The colour of its flesh may be white, yellow, orange or purple (Camire *et al.* 2009) ^[9]. It is a nutritious vegetable that is rich in vitamin A precursor, calories, and fibre and contains a small amount of protein. Sweet potatoes contain about 70% of carbohydrates on a dry basis, mostly starch, that could potentially be utilized for their functional properties like controlling the rate of heating during cooking (Hoover, 2001) ^[15]. Sweet potatoes made up roughly 20% of the total world production of root and tuber crops (FAO, 1999).

Material and methods

Fresh bitter gourd, spine gourd and sweet potatoes were sourced from Rampachodavaram Market, Alluri Sitharama Raju district, Andhra Pradesh. Bitter gourd and sweet potatoes were then analyzed for the physical properties such as Geometric mean (mm), Sphericity (mm), Surface area (cm³), Volume (cm³), Bulk density (g/cm³) and True density (g/cm³).

Length, Width and Thickness. Measure the length (L), width (W) and thickness (T) of the bitter gourd slices using a scale (30cm).



Sweet Potato



Bitter Gourd slice



Bitter Gourd



Spine Gourd slices



Spine Gourd



Sweet potato slices

1. Geometric mean (mm)

The average mass of fifty vegetables which picked randomly were determined by using the electronic balance (Shemadzu AP 124 X) reading to 0.01g. the three axial diameters i.e. major (L), medium (W) and minor (T) were determined using a scale (30cm) with least count 0.1 cm. geometric mean (D_g), of bitter gourd, spine gourd and sweet potato were calculated by using the following formula (Mohsenin, 1986) [20].

$$D_g = (LWT)^{1/3}$$

2. Sphercity

Sphercity of bitter gourd, spine gourd and sweet potato were calculated by using following formula (Mohsenin, 1986) [20].

$$\text{Sphercity} = \frac{(LWT)^{1/3}}{L}$$

- L=length
- W=width
- T= Thickness

3. Surface area (cm²)

Surface Area of bitter gourd, spine gourd and sweet potato were found by analogy with a sphere of the same geometric mean diameter using the following relationship (Garnayak *et al.*, 2008) [11].

$$\text{Surface area, (cm}^2\text{), } S = \pi(D_g)^2$$

4. Volume (cm³)

Volume of spine gourd, bitter gourd and sweet potato were calculated by using following formula.

$$\text{volume} = \frac{4\pi r^3}{3}$$

r= radius

5. Bulk Density (g/cm³)

The Bulk density was determined by using mass per volume relation (AOAC,1984) [2]. Bulk material of bitter gourd, spine gourd and sweet potato were poured from pre-determined height in to container of size 8.5 x 9.5 x 9.5 cm and excess vegetables above container were scrapped off. The density was calculated by knowing the mass and volume of the samples.

$$\text{Bulk density} = \frac{\text{Mass of sample (g)}}{\text{Volume (cm}^3\text{)}}$$

6. True density (g/ cm³)

The true density or solid density was defined as the ratio between the mass and its true volume. The volume of toluene displaced was found by immersing a weighted quantity of vegetable in toluene (Sacilik *et al.*, 2003) [21].

$$\text{True density} = \frac{\text{Mass of sample (g)}}{\text{Total Volume (cm}^3\text{)}}$$

Proximate Analysis

3.1.7 Moisture content (%)

Approximately 5 g of bitter gourd spine gourd and sweet potato sample was used for the estimation of moisture content. Moisture content was measured by standard oven drying method by keeping 5 g of sample in a moisture box as per AOAC method (1997). The moisture content was determined as a loss in moisture using the following equation.

$$\text{MC (\% w. b)} = \frac{W_1 - W_3}{W_2 - W_1} \times 100$$

$$\text{MC (\% d. b)} = \frac{W_2 - W_3}{W_3 - W_1} \times 100$$

Where,

- W_1 = Weight of moisture box,
- W_2 = Weight of moisture box along with sample before drying, g
- W_3 = Weight of moisture box along with sample after drying in oven, g

3.1.8 Protein estimation (%)

The protein content of the bitter gourd, spine gourd and sweet potato were estimated using Lowry's method given by Sadasivam and Manickam (1992) [25]. A sample of 500 mg was extracted using 5 to 10 ml of buffer (Tris buffer, GR-trishydroxymethyl amino methane) and centrifuged. An aliquot of 0.1ml from the supernatant was taken in a test tube, 5 ml of alkaline copper solution was mixed well and allowed to stand for 10 minutes. Folin-Ciocalteu reagent of 0.5 ml was added and incubated at room temperature in the dark for 30 minutes and the developed blue colour was read at 660 nm (OD). A standard graph was prepared using bovine serum albumin (FractionV) solution by applying serial dilutions. From the standard graph, the amount of total protein present in the chocolates was estimated and expressed in milligrams per gram of sample.

3.1.9 Fat estimation (%)

Fat estimation was carried out on a Soxhlet apparatus (AOAC, 1997) [3]. Two grams of dried sample (bitter gourd spine gourd and sweet potato) was taken and grounded with mortar and pestle. The Soxhlet device was filled with a sample coated in filter paper and free of moisture. Moisture free samples were placed in a reflux condenser with petroleum ether (boiling point 80 - 100°C) as the solvent. The samples were run for 6 hours and the equipment flask was used to collect the fat. By placing the fat extract in the drying oven additional petroleum ether was evaporated.

$$\text{Fat (\%)} = \frac{W_2 - W_1}{W_s} \times 100$$

- W_1 = weight of flask (g)
- W_2 = Weight of flask with sample (g)
- W_s = Weight of sample (g)

3.1.10 Carbohydrates (%)

The carbohydrate content of the bitter gourd, spine gourd and sweet potato were estimated by using the anthrone method suggested by Sadasivam and Manickam (1992) [25]. One gram of

sample was hydrolysed with 5 ml of 2.5N HCl for 3 hours by boiling in a water bath and cooled to room temperature. The residue was neutralized with sodium carbonate until effervescence ceases. The volume was made up to 100 ml and centrifuged. An aliquot of 0.2ml from the supernatant was pipetted out and made up to 1ml and then 4ml of anthrone reagent was added. Heated for 8 minutes in a boiling water bath, cooled rapidly and the intensity of green to dark colour was read at 630 nm (OD). A standard graph was prepared using standard glucose by applying the serial dilutions. From the standard graph, the amount of carbohydrate present in the chocolate was estimated and expressed in milligrams per gram of sample.

3.1.11 Ash (%)

The total ash content (mineral matter) was determined by (AOAC, 2005) [5]. Initially crucibles were preheated in a muffle furnace as shown in Plate 3.10 at 550°C for 1 h. The crucibles were transferred from furnace to the desiccator and were cooled to room temperature. Two grams of sample was weighed in crucibles and placed into muffle furnace at 550°C temperature for 6 h. After that the crucibles were transferred to a desiccator and the samples were weighed immediately. The following formula was used in determining the ash content.

$$\text{Ash (\%)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where,

- W₁ = Weight of crucible, (g)
- W₂ = Weight of crucible + Sample, (g)
- W₃ = Weight of crucible + Ash, (g)

Chemical analysis

3.1.12 Titratable acidity (%)

The titratable acidity was measured using the procedure outlined by Ranganna (1997) [22]. The sample of five grams was crushed or grinded taken and in a beaker & 50ml distilled water was added. 10ml filtrate was taken in separate flask & 1-2 drops of phenolphthalein as indicator and titrate with 0.1 N NaOH till end point light pink colour.

Calculation

$$TA = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{volume made up (ml)} \times \text{eq wt. of acid (ml)}}{\text{Weight of sample (g)}} \times 100$$

3.1.13 P^H

P^H of fresh spine gourd, bitter gourd and sweet potato juice was determined by using a digital P^H meter in the Laboratory

3.1.14 Ascorbic acid (mg/g)

Ascorbic acid was estimated by titrimetric method using 2,6-dichlorophenol-indophenol dye (Ranganna, 1995) [21]. One gram of bitter gourd, spine gourd and sweet potato samples were taken and ground well and using 10 ml of 4% oxalic acid solution was pipetted out in to a conical flask and titrated against dye. The dye factor, i.e., mg of ascorbic acid per ml of the dye was calculated. The value of ascorbic acid was estimated by titrating the sample solution against the dye for the appearance of a persistent pale pink colour.

$$\begin{aligned} \text{Ascorbic acid content} &= \frac{\text{Titrate value} \times \text{dye factor} \times \text{volume made}}{\text{Volume taken} \times \text{weight of sample}} \times 100 \\ &= \frac{0.5 \times V_2 \times 50}{V_1 \times 5 \text{ml} \times \text{weight of sample}} \times 100 \end{aligned}$$

- V₁ = volume of dye occupied by the working standard
- V₂ = volume of dye occupied by samples

3.1.15 Total sugars (%)

The total sugar estimated by using Lane and Eynon method (1923) [19] with modifications suggested by Ranganna (1997) [22]. One gram of bitter gourd, spine gourd & sweet potato samples were taken and ground well and then transferred to 250 ml volumetric flask, 100 ml of distilled water added. Two ml of lead acetate solution (45%) was added to the flask to precipitate colloidal matter and kept for 30 min. Potassium oxalate (22%) of 2 ml was added in this solution to precipitate the lead acetate and the volume was made up to 250 ml using distilled water. The contents were then filtered through Whatman No. 1 filter paper after testing a little of filtrate for its freedom from lead by adding a drop of potassium oxalate. A quantity of 50 ml lead free filtrate was taken in a 100 ml volumetric flask and to it 5 ml of concentrated HCl was added, mixed well and then kept for 24 hours at ambient temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein as an indicator till the pink colour persisted for at least few seconds. The volume was then made up to 100 ml with distilled water. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator and taking brick red colour as an end point.

$$\text{Total Sugars (\%)} = \frac{\text{Factor} \times \text{volume made up} \times 100}{TV \times \text{Weight of sample} \times 1000}$$

TV = Titrated value

3.1.16 Crude Fiber (%)

The crude fibre was assessed using AOAC method (2000) [4]. Two grams of the fat-free sample was used to test for crude fiber. It was digested by boiling 200 ml of 1.25 percent H₂SO₄ for 30 minutes, filtering it through muslin cloth, and then washing it three times. The sample was once again digested for 30 minutes in 200 ml of boiling in 1.25 percent NaOH, filtered and three times washed. The resulting residue was weighed and dried for two hours at 105°C and it was weighed. At 600±15°C temperature, the dried residue was burned, cooled, and reweighed

$$\text{Crude Fiber (\%)} = \frac{\text{Weight after ignition}}{\text{Weight of sample}} \times 100$$

Result and discussion

Physical properties

I Geometric properties of Bitter gourd, Spine gourd and Sweet potato

The summary of measured and calculated geometrical characteristics of bitter gourd, spine gourd and sweet potato

in Table 1. The average values of major, median and minor diameters of bitter gourd, spine gourd and sweet potato were 16.54, 3.35, 2.83 cm, 3.34, 2.18, 1.87 cm, 8.42, 3.02 and 2.77 cm respectively (Table 1). The average Geometric mean, Sphericity and Surface area of bitter gourd, spine gourd and sweet potato were 5.383 mm, 165.58, 90.87 cm², 2.410 mm, 270.43, 14.34 cm², 4.121 mm, 212.09 and 53.31 cm² respectively (Table 1). The shape of bitter gourd spine gourd and sweet potato compared with the standard chart (Mohsenin, 1986) [20] and can be considered as spindle-shaped, oval and circular. The average weight, length, diameter and volume were determined. The required fruits were taken randomly for examination of physical parameters (Kusat *et al.*, 2021) [18].

2. Gravimetric properties of Bitter gourd, Spine gourd and Sweet potato

The gravimetric properties were given in Table 1. The average mass and volume of the bitter gourd, spine gourd and sweet potato were 671 g and 150.47 cm³, 376 g and 38.78 cm³, 914 g and 113.07 cm³ respectively (Table 1). The bulk density and true density of bitter gourd, spine gourd and sweet potato were 0.839 and 2.62 g/cm³, 0.466 and 2.08 g/cm³, 1.15 and 3.16 g/cm³ respectively (Table 1). The averages of bulk density and true density values of bitter gourd seeds/kernels were 0.919/1.659 g/cm³, 5.526/2.642 cm³ (Boyar *et al.*, 2023) [8].

Biochemical properties of Bitter gourd, Spine gourd and Sweet potato

1. Moisture content (%)

The moisture content of fresh bitter gourd, spine gourd and sweet potato slices was recorded an average value of 90.2, 86.5 and 67.2% (w.b) (Table 2). Kusat *et al.* (2021) reported that the moisture content of bitter gourd was 92.3% (w.b) respectively. In spine gourd moisture content 84.1% reported by Karma *et al.*, 2017, and sweet potato moisture content 76% reported by Jain *et al.*, 2022 [16, 17, 18].

2. Protein content (%)

The protein of fresh bitter gourd, spine gourd and sweet potato recorded were 1.46, 2.12 and 1.47% (Table 2) which was more than recorded protein content of papaya (0.61g), mango (0.82), apple (0.26) and pomegranate (0.95g) (Gopalan *et al.*, 2004) [12]. The proteins and carbohydrates present in the plant may be a conglomerate of bioactive sugars, glycoproteins or proteins which gives the plant its medicinal potency against certain diseases (Srivastava *et al.*, 1989; Hokputsa *et al.*, 2004) [14, 29]. The protein content of hybrid bitter gourd reported to 1.9% by Soomro and Ansari (2005) [26] which is very similar to our result.

3. Fat content (%)

The fat content of fresh bitter gourd, spine gourd and sweet potato slices 0.26, 0.31 and 0.11 (Table 2) were relatively medium, when compared to other pulps such as papaya (0.14g), mango (0.38g), apple (0.17g) and pomegranate (0.3g) (Gopalan *et al.*, 2004) [12]. In 2005, Soomro and Ansari reported that hybrid green bitter gourd contained 0.4% fat which is near about our result. This result suggests that bitter gourd is not good source of lipid. Dietary fats function through increase of palatability of food by absorbing and retaining flavours (Antia *et al.*, 2006) [1, 26].

4. Carbohydrates (%): Carbohydrates of fresh bitter gourd, spine gourd and sweet potato slices were 4.2, 4.4 and 20.4 (Table 2) which was higher when compared to the Carbohydrate content of bitter gourd fruit 3.67% (Kusat *et al.*, 2021). Intake of bitter gourd pericarp with high dietary fibre content may have positive health benefits possibly for reduction of colon cancer risk, diabetes, obesity, hypercholesterolaemia, gallstones and constipation (Takeyama *et al.*, 2002) [18].

5. Ash content (%): The ash content of fresh bitter gourd, spine gourd and sweet potato slices were 0.3, 0.7 and 0.8% (Table 2) where as the ash content in other crops are apples (0.3%), banana (0.8%) and cherries (0.5%) given by Gopalan *et al.*, (2004) [12] & he has reported that the ash is not necessarily of exactly the same composition as the mineral matter present in the original pulp as there may be losses due to volatilization or some interaction between constituents. The low ash content reflects that the mineral contents preserved in the food materials is also low. The result therefore suggests a low deposit of mineral elements in the fruit. (Antia *et al.*, 2006) [1].

6. pH and Acidity (%): The pH of bitter gourd, spine gourd and sweet potato slices reported an average value were 5.5, 5.6 and 6.1 (Table 2). The pH of bitter gourd, spine gourd and sweet potato were close to some mango varieties (Sreenath, 1995) [28]. The bitter gourd, slices spine gourd and sweet potato were slightly acidic. The average acidity value of fresh bitter gourd, slices spine gourd and sweet potato slices were 0.38, 0.42 and 0.36% (Table II) of acetic acid equivalent.

7. Ascorbic acid (mg/100g): The fresh bitter gourd, spine gourd and sweet potato slices recorded 42.6, 34.6 and 27.2 mg ascorbic acid per 100g (Table 2). These values were more than that of orange, tomato, broccoli, berries and spinach and on par with vegetables and fruits (Bogacz *et al.*, 2018) [7]. A study conducted by Dey *et al.* (2006) [10] noticed highly significant differences among the bitter gourd genotypes for ascorbic acid and it ranged between 60.20 mg to 122.07 mg/100 g of fresh weight with a population mean of 82.14 mg/100g of fresh weight.

8. Beta carotene (mg/100g): The fresh bitter gourd, spine gourd and sweet potato slices recorded 41.7, 161 and 12.7 mg beta carotene per 100g (Table 2). These values were more than that of orange, tomato, broccoli, berries and spinach and on par with vegetables and fruits (Bogacz *et al.*, 2018) [7].

9. Total sugars (%): The total sugars of fresh bitter gourd, spine gourd and sweet potato slices were 1.36, 0.89 and 1.12% (Table 2). (Sorifa *et al.*, 2018) [27] observed that the total sugar content of bitter gourd was 2.8 per cent, respectively.

10. Crude Fiber (%)

Crude fiber of fresh bitter gourd, spine gourd and sweet potato slices were 2.34, 2.82 and 1.67% (Table 2). These values are higher than when compared with the crude fiber content of bitter gourd fruit 1.26% (Kusat *et al.*, 2021) [18] and Another study carried out by Aziz *et al.* (2011) [6] observed that fresh bitter gourd contains 1.8 g fibre in flesh and 1.9 g fibre in skin.

Table 1: Geometric and Gravimetric properties of bitter gourd, spine gourd and sweet potato

Parameter	bitter gourd	spine gourd	sweet potato
Geometric mean (mm)	5.383±0.35	2.410±0.18	4.121±0.24
Sphericity	165.58±6.26	270.43±8.97	212.09±8.56
Surface area (cm ²)	90.87±8.24	14.34±1.89	53.31±6.23
Volume (cm ³)	150.47±12.27	38.78±7.25	113.07±9.23
Bulk density (g/ cm ³)	0.839±0.01	0.466±0.02	1.15±0.07
True density (g/ cm ³)	2.62±0.19	2.08±0.17	3.16±0.21

Average value for 3 replications

Table 2: Proximate and chemical analysis of bitter gourd, spine gourd and sweet potato

Chemical analysis			
parameter	bitter gourd	spine gourd	sweet potato
Moisture content (%)	90.2±1.92	86.5±1.78	67.2±1.25
Protein (%)	1.46±0.75	2.1±0.86	1.47±0.46
Fat (%)	0.26±0.04	0.3±0.05	0.11±0.01
Carbohydrate (%)	4.2±0.24	4.4±0.27	20.4±1.21
Ash (%)	0.3±0.18	0.7±0.24	0.8±0.32
Proximate analysis			
parameter	bitter gourd	spine gourd	sweet potato
Acidity (%)	0.38±0.03	0.42±0.04	0.36±0.03
pH	5.5±0.14	5.6±0.16	6.1±0.18
Ascorbic acid (mg/100g)	42.6±4.23	34.6±3.89	27.2±2.12
Beta carotene (mg/100g)	41.7±2.67	161±5.56	12.7±0.46
Total sugars (%)	1.36±0.07	0.89±0.03	1.12±0.08
Crude fibre (%)	2.34±0.18	2.8±0.23	1.67±0.09

Average value for 3 replications

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