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Studies of the Compositional Characteristics of Commercial Roasted Beet Root Chips Snacks

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Beta vulgaris L. (beetroot) contains high amounts of active substances. The amounts of various compounds sucrose, glucose, fructose, micronutrients and physical properties were found in roasted beet root chips of two varieties cultivated in Jessore (BRJS) and Kustia (BRKS), Bangladesh. Large differences were found between the varieties for some nutrients (such as sucrose), whereas others showed only minor variation (physical properties and acceptability).
The study aims to estimate the composition characteristic of commercial roasted beet root chips snacks. The total sucrose content was found to range between 73.6 g/kg and 82.6 g/ kg of roasted chips samples. Other detected glucose, which accounted for up to 4.1% to 3.2% and fructose 1.31% to 1.21%. The % CV of sucrose, glucose and fructose were 14.5%, 43.3% and 52.6% respectively. Physicochemical properties of beet root Chips was studied and is shown in Table 4 for accepted sample BRTJS. The average weight of one piece of beetroot chips was 2.22 gm, diameter 5.15 cm, thickness 0.35 cm, height 0.7 cm and bulk density was 0.35g/cm^3. The average apparent moisture diffusivity was calculated as 5.35X10^{-9} m ^{2}s $^{-1}$ with standard deviation 2.43X10^{-9} m ^{2}s $^{-1}$. The highest value of moisture diffusivity recorded as 1.9X10^{-9} of the MHSDT method and

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lowest value of $2.25X10^{-9}$. Proximate values was 2.2% moisture, 0.7% ash, 17% protein, 1.25% fat, 1.7% crude fiber and 74.02% carbohydrate respectively. Sensory evaluation for acceptances of the sample-RBJS got a highest sensorial score (9.0) for all parameters like the color (9.2), taste (9.25), texture (8.5), after taste (7.0) and overall acceptability (9.0) than other BRKS sample.

Keywords: Beet root; roasted chips snacks; physical and chemical characteristics; sensory evaluation.

1. INTRODUCTION

Beet (*Beta vulgaris*) is cultivated for the production of sugar, organic food grade colour and food as snacks or functional agent for a human. It is classified different varieties with root type colour ranging from whitish to radish (Fig. 1). At present, the red-coloured beet roots are the most popular for human choice, both cooked and raw as salad or juice or dry ready to eat snacks [1]. But in food processing areas, as compared with anthocyanin, carotenoids, and betalains are the lower amount used, although these water-soluble pigments are stable between pH ranges 3-7. Beets contain phytonutrients called betaine, which plays an important role in the conversion of homocysteine to methionine as important amino acid and can, therefore, help reduce excess homocysteine from intestinal tracts [2]. The betaine becomes extra important for those with micro biological deficiencies in physiological organs, since it provides a bio-exchange route for this important metabolism, bypassing any genetic deficiency [1]. The Beets are also high in ascorbic acid, dietary fibre, potassium, amino acid, folic acid, and manganese etc.

The Beet root and its products help to reduce blood pressure (bp), remove the cancer, and also support detoxification in human body for rapid relaxation. Beetroot contain the all nutrients per 100 g such as, Carbohydrates (9.96 g), Sugars (7.96 g), Dietary fiber (2.0g), Fat (0.18 g), Protein (1.68 g), Vitamin A (2 µg), Vit.B_1 (0.031 mg), Riboflavin (0.027 mg), Niacin (0.331 mg), B5 (0.145 mg), B6 (0.067 mg), Folate (80 µg), Vitamin C (3.6 mg), Ca (16 mg), Fe (0.79 mg), Mg (23 mg), P (38 mg), K (305 mg), Zn (0.35 mg), Na (77 mg) [2].

A) Beet root plant

B) Beet slice

C) Raw slice

Fig. 1. Pictures containing A) Beet root plant; B) Beet slice & C) Raw slice

Improve the red colour of tomato pastes, sauces, soups, desserts, jams, jellies, ice creams, sweets and breakfast cereals, fresh beet/beet powder or extracted pigments are used [3]. Beetroot is one of the original "super foods" [4]. It also contributes to consumers' health and wellbeing because it is known to have antioxidants because of the presence of nitrogen pigments called betalains, mainly comprise of red– violet-coloured betacyanins and yellow– orange-coloured betaxanthyns [5]. Beetroots are rich in valuable, active compounds such as carotenoids [6]. glycine betaine, [7], saponins [8], Betacyanines [9] and Folates [10], polyphenols and flavonoids [11]. Betanin [12]. The extracts used as a natural colourant for food products have been shown to possess effective antioxidant properties, reducing lipid oxidation in cooked meat [13]. The antioxidant capacity of beet has been associated with the constitutive presence of phenolic compounds, which allow nutraceutical benefits in the promotion of the human health and in the prevention of degenerative diseases and cancer [14]. The use of betalains as food colourant is approved by European Union and betalains are labelled as E-162. Betalains are particularly suited for use colouring food products [15,16].

Originally, anthocyanin compounds are the most widely used organic colouring agents for red colour appearance however, betalains are strongly stable for acidic media and different temperature. Betalains exhibit broad pH stability which is suited for low-acid foods where colouring with anthocyanins usually not possible [17]. Yellowish colour indicates the presence of carotenoids, the functional agents but due to weaker dissolve capacity in water, beta-xanthin might be used as orange food colour in products [18]. Betalain pigment mixtures can be used as a natural additive for food, drugs and cosmetic products in the form of beet juice concentrate or beet powder [19].

These properties are due to its proximate or due to the production process, it passes through the biological path. Whatsoever, it is reliable for the poor nutrients, necessary to acuity ensure every food used by specific requirements. Therefore, it is important to produce for snacks processing with higher nutritional values that could be useful to remove malnutrition to associate vulnerable group and nutrient deficiency areas in different clusters. As a snacks product that might be consumed on a massive scale, and would be important to enhance its nutritional value to remove malnutrition from nutritional deficiency areas. Addition of vegetable protein such as textured vegetable protein could be one way of raising the nutritional value of the product by introducing more protein into it [20].

Beetroot is agro-based food products belonging to the Chenopodiaceae family having, radish colour. It is nutritious for fresh juice with nutritional high value and medicinal properties in the human body. This crop is a good healthy food product for good life style [21]. The fresh results suggested that beetroot intake can be a useful means to the prevention of development and progression of cancer diseases [22]. Beetroot's effect on the vasculature of which largely attributed to its higher inorganic nitrate content (250 $mg.kg^{-1}$ of fresh weight [23]. This has a positive interest in a suitable role for beetroot crops in clinical pathologies identified by biological stress and inflammation like liver diseases [24], arthritis [25,26]. It is rich phytochemical compounds containing functional crops that includes vitamin C, Beta-carotene, antioxidants and flavonoids [27]. Beetroot is also a vegetable that contains a group of highly bioactive nutrients known as betalains.

Members of the betalain family are categorized as either betacyanin pigments that are red-violet in colour or beta-xanthin pigments that are yellow-orange in colour [28]. The aim of this study was to investigate the effect of heat-processing technique (drying) on the antioxidant potential and phenolic content found in raw beet (cv. Early wonder) slice in MHST, appearance, Shape, crispiness, colour and sensory acceptances. The beetroot is consumed as a valuable vegetable for the culinary purpose to produce frozen food, concentrated juices, and coloring agent as additives in the food manufacturing industry. Its peel contained maximum antioxidant thus promising a more intense utilization of the peels in food decoration or salad and also dietary supplements as nutriceutical products. Beetroot colour is used commercially as a food grad red colour [29].

2. MATERIALS AND METHODS

2.1 Raw Beet

Fresh raw beet was used for the processing of dried chip-type beet products, collected from local farmers' farms. All beets grown for this study were planted on the month of May in different fields at Jessore and Kustia areas of northern areas of Bangladesh. The composition of Raw Beet Root samples was depicted in

Table 1. Each beetroot cultivar was seeded in standard rows, the soil consisted pH of 6.8 and after seeding a nitrate-phosphate-potassium (N-P-K) fertilizer (N-P-K ratio of 14:10:20; 600 kg per hectare) was used for manuring. Beetroots in the ripe-state were harvested by hand on November, cleaned with normal water, cut with a knife, and stored at 2–5°C for 4 hours in a water solution containing KMS 200 ppm and 50 ppm ascorbic acid. Before ageing in water solution, the raw beet pellets were boiled and were dried in multi-head solar tunnel drier. On average 1 kg of beetroots yielded about 100 g/dry chips pellet. All analyses were performed on dry pellet prepared from 2 individual beets tested varieties. The mean values obtained from those 2 beets were compared to each other. In addition, the variations between the individual beets of each variety were analyzed. A total of 2 different commercial beetroot pellets were analyzed for their chemical composition. The following beetroot samples were analyzed (Fig. 2).

2.2 Processing of Dried Chip-Type Beet Products

The design was randomized containing three treatments (drying process conditions) and four repetitions. The following temperature conditions were used: 50°C/15 hours; 60°C/18 hours; and 65°C/24 hours. The dried beet slices were placed on the plastic container and kept at room temperature for 24 hours to stabilize the internal moisture, and then stored in the freezer (-37°C) until the time of analysis. At the final stages of edible beet chips processing, the dry pellets were placed in a rotary oven at 105°C for 1 hour until crispiness.

2.3 Determination of Sugar Content

Sugar analysis of an analytical pump with external degasser, auto sampler, temperature-controlled column compartment, a Jasco RI-2031 Plus detector and a UV-Vis detector equipped with Compass software (Jasco Corporation, Tokyo, Japan) was used [31].

Quantitative and kinetic analysis of Grb2-EGFR interaction on micro-patterned surfaces for the analysis of EGFR-modulating substances using PLoS ONE 9:e92151.Determination of sucrose, glucose, and fructose was done by HPLC. Separation was performed on an Aminex HPX-87 H300 carbohydrate column (BIO-RAD, Hercules, USA). The column temperature was set to 80°C and isocratic elution was carried out at 0.8 ml/min. As mobile phase in the HPLC, 5 mM H_2SO_4 in ddH_2O was used. Samples were predigested for 5 hours at room temperature with pectinase (10 µl per 15 ml sample), centrifuged for 10 min at 15,000 rpm followed by 0.45-µm filtration to remove any remaining solids before analysis. The injection volume for all samples was 20 µl and eluted substances were detected at 210 nm and by refractive index. Limit of detection was defined as a signal-to-noise ratio of 2:1 and limit of quantitation as 4:1 (Table 2).

2.4 Statistical Analysis [32]

Statistical differences between the data sets were determined by two-way ANOVA followed by Tukey's multiple comparison tests using Graph Pad Prism (version 6.00 for Windows; La Jolla, California, USA).

Table 1. Composition of raw beet root samples

Parameter	Optimum USAID Value	BRJS	BRKS
Water (%)	87.58	88	89
Carbohydrate (gm)	9.56	10	11
Protein (gm)	1.61	1.5	1.6
Fiber (gm)	2.8	0.9	0.8
Fat(gm)	0.17	0.1	0.1
Vitamin C(mg)	4.9	11	11
Niacin(mg)	0.334	0.4	0.4
Pantothenic Acid (mg)	0.155	0.15	0.15
Thiamin (mg)	0.031	0.05	0.05
Vitamin B6 (mg)	0.067	0.05	0.05

Source: USAID data 2005 [30].

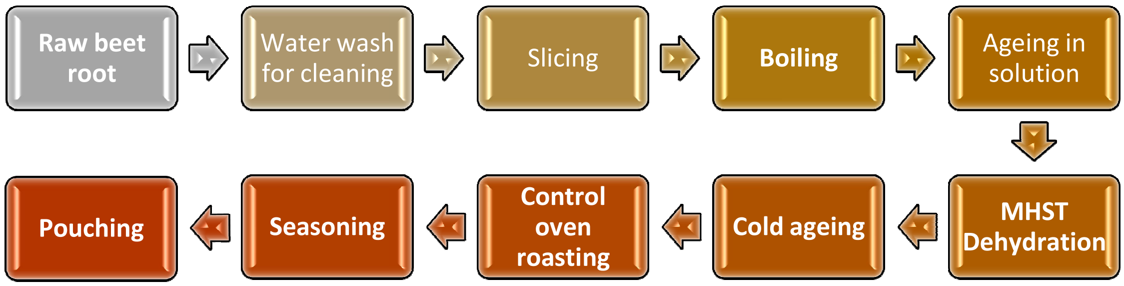

Fig. 2. Preparation of beet root roasted chips snacks [22]

Table 2. Sugar contents of 2 beetroot varieties

Beet root varieties	Sucrose g/kg	Glucose g/kg	Fructose g/kg	Total g/kg
BRJS	69.0 ±12.1 3	3.51 ± 0.525	1.12 ± 0.212	73.6
BRKS	78.9 ± 6.27	2.79±0.541	1.03±0.286	82.6
Mean	73.5	2.62	1.51	77.5
SD	10.6	1.06	0.851	10.2
%CV	14.5%	43.3%	52.6%	13.4%

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation

The sensory quality of product was evaluated by a panel of 30 judges selected from the staff of Department of Nutrition and Food Engineering, FAHS, DIU using 9 point Hedonic scale as described by Ranganna [32].

The beetroot snacks as roasted chips were subjected to sensory evaluation for overall acceptability i.e. color, texture appearance, flavor, by experienced volunteers, through 9 point hedonic scale. It was observed from Fig. 3 that the sample-RBJS got high sensorial score (9.0) for all parameters like color (9.2), taste (9.25), texture (8.5), after taste (7.0) and overall acceptability (9.0) than other samples-BRKS. The selected sample was further taken for large scale production and analysis.

3.2 Physicochemical Properties

Physicochemical properties of beet root Chips was studied and is shown in Table 3 for accepted sample BRTJS. The average weight of one piece of beetroot chips was 2.22 g, diameter -5.15 cm, thickness - 0.35 cm, height -0.7 cm and bulk density was 0.35 g/cm^3. proximate values was 2.2% moisture, 0.7% ash, 17% protein, 1.25% fat, 1.7% crude fiber and 74.02% carbohydrate respectively. Limit of detection was 0.1 g/L and limit of quantitation was 0.5 g/L for sucrose; 10 mg/L and 20 mg/L for glucose; and 1 mg/L and 5 mg/L for fructose, respectively. Being an important nutritional parameters, the total sugar content was quantitated together with one of sucrose, glucose, and fructose. As indicated in Table- 2, the average total sugar content was found at 7.8%, whereas the sucrose was 94.8% followed by glucose 3.3% and fructose 1.9%. The estimated concentrations were in good agreement with measurements performed on beetroot. The differences between individual beets of the same variety were found to be in a similar range as those of the different varieties, % CV = 13. This finding was also confirmed by ANOVA-based analysis of variance. Thus, the data suggested only minor variety-specific differences in the concentration of sugar content of the selected beetroot verities of Bangladesh.

3.3 Bulk Density

The bulk density is the mass of a group of the individual particle divided by the space occupied by the entire mass [32], including the air space and was determined using the following relationship. It was measured by a 500ml flask. Beet roots were poured inside the flask and shacked 10 times manually to fill the pore spaces (Table 4).

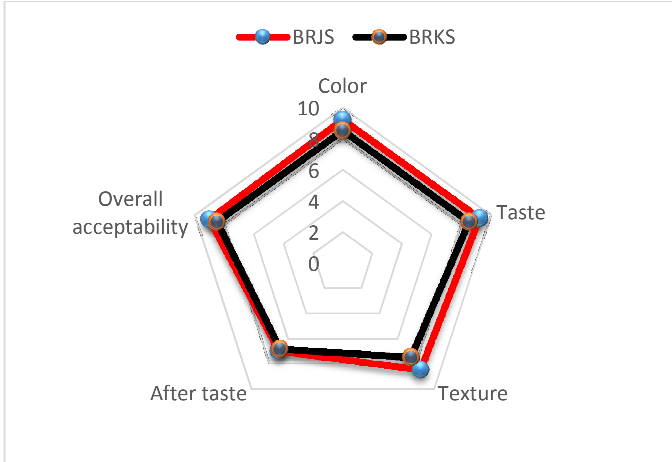

Fig. 3. Sensory evaluation of beet root chips

Table 3. Physical composition of beet root chips

Nutritional parameters	Amount (%)	
	BRTJS	BRKS
Ash	0.7	0.70
Moisture	2.2	2.20
Protein	17	14.50
Fat	1.25	1.24
Carbohydrate	74.02	76.42
Fibre	1.7	1.80
Energy in Kcal /100g	380	355

Table 4. Measurement of bulk density for beetroot roasted chips MC - 88.20% (wb)

Sample code	Mass (g)	Vol. (cm^3)	Bulk Density(g/cm^3)
BRJS	271.40	265.25	1.023
BRKS	252.89	225.83	1.119
	Mean	245.54	1.071
	SD		0.0068
	Max		1.119
	Min		1.023

Table 5. Apparent moisture diffusivity for beet root slices under various conditions of selected both verities

S/N	Drying methods	Drying constant K(s^{-1})	Apparent diffusivity (m^2s^{-1})
	Open Sun	0.0139-0.0141	$5.74x10^{-9}$-$5.5\ x10^{-9}$
	Multi Head Soar Drying Tunnel (MHSDT)	0.006-0.0055	$2.25X10^{-9}$-$2.3\ x10^{-9}$
	Average diffusivity		$5.35X10^{-9}$-$4.88\ x10^{-9}$
	Standard deviation		$2.43X10^{-9}$-$2.37\ x10^{-9}$

3.4 Determination of Apparent Moisture Diffusivity [33]

A quantitative measurement of the rate at which a diffusion process occurs is usually expressed in terms of a diffusion coefficient (diffusivity) and is often treated as an adjustable parameter. Therefore most models depend largely on experimental measurements of diffusivity. The moisture diffusivity of a food material characterizes its intrinsic moisture mass transport property which includes molecular diffusion, vapour diffusion, liquid diffusion etc. Generally, apparent moisture diffusivity is used due to limited information on the mechanism of moisture movement during drying and complexity of the process. The average apparent moisture diffusivity was calculated as $5.35X10^{-9}$ m^2s^{-1} with standard deviation $2.43X10^{-9}$ $m^2s^{-1.}$ The highest value of moisture diffusivity recorded as $1.9X10^{-9}$ of the MHSDT method and lowest value of $2.25X10^{-9}$.

4. CONCLUSIONS

Beetroot roasted chips as snacks having the nutritional value of different nutrients such as protein, carbohydrate, dietary fibre etc. The chemical analysis of beetroot chips snacks confirms that the presence of large amount of protein (17%), carbohydrate (74%), fat (7%), ash (1.7%), moisture (2.35%), and fibre (1.7%) gives higher nutritional value. From the present study the following conclusion has been concluded that the beetroot roasted chips snacks were economically available, rich source of protein, a carbohydrate having high economical or market value.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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