Asian Journal of Chemistry; Vol. 28, No. 9 (2016), 2073-2076

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2016.19920

Study on Nutritional and Antinutritional Profile of Value Added Products Made from Tapioca Tubers from Assam, India

BILLAL HOQUE CHOUDHURY[1], PRIYANKA DAS[1,*] and MAHADEV UZIR BASUMATARY[2]

[1]Department of Biochemistry and Agricultural Chemistry, Assam Agricultural University, Jorhat-785 013, India
[2]Krishi Vigyan Kendra, Kokrajhar, Assam Agricultural University, Jorhat-785 013, India

*Corresponding author: E-mail: priyanka.aau@gmail.com

Received: 19 February 2016; *Accepted*: 15 April 2016; *Published online*: 1 June 2016; AJC-17945

Tapioca or cassava (*Manihot esculanta* Crantz*)* has emerged as a commercial crop in India. North Eastern states including Assam is a potential tapioca growing state. In the present study, tapioca tubers of Assam, collected from two important tapioca growing locations were utilized to process products like plain flour, rawa (parboiled flour) and also for extraction of starch. These products were analyzed for nutritional and antinutritional quality. The moisture content of various tapioca products ranged from 1.82 to 3.61 % (wet basis). The starch content of various tapioca products ranged from 60.28 to 71.34 % (dry basis). The ash content of various tapioca products ranged from 1.11 to 10.43 % (dry basis). The crude fat content was found to be in between 0.27 and 12.91 % (dry basis). The crude fibre content showed values in between 0.50 and 6.1 % (dry basis). The crude protein content ranged from 0.90 to 5.31 % (dry basis). The sodium and the potassium content ranged from 2.40 to 7.13 mg % and from 0.60 to 6.92 mg % (dry basis), respectively. The calcium, phosphorous and iron content (dry basis) ranged from 15.67 to 57.67 mg %, 17.87 to 78.39 mg % and 0.18 to 0.57 mg %, respectively. The antinutritional component, total cyanogen ranged from 5.18 to 107.39 µg per g (dry basis). It was observed that the sun dried products were safer in comparison to the products (chips) either dried using tray drier at a temperature of 55 °C or treated in hot water for parboiling, both immediately after chipping.

Keywords: Tapioca, Flour, Rawa, Starch, Chips, Cyanogenic glycoside.

INTRODUCTION

Tapioca (*Manihot esculenta* Crantz), is one of the leading food and fodder plants in the world. It ranks fourth among staple crops with a global production of about 160 milllion tons per year [1]. Most of these are grown in three regions, West Africa and the Congo basin, tropical South America and South East Asia [2] while in western countries it is not commonly used, because of the presence of cyanoglycosides (linamarin and lotaustralin). A number of recent studies have reported many biotechnological approaches to improve the safety and quality of cassava flour [3-5] and the effect of different processing methods on the level of these toxic substances and functional properties has been assessed [6-8].

Tapioca, also known as cassava is a staple food that provides carbohydrates or energy to more than 2 billion people in the tropics. Cassava is a higher producer of carbohydrate per hectare than the main cereal crops and can be grown at a considerably lower cost. Cassava pulp is comprised mostly of carbohydrates, protein, crude fat, ash and fibre [9]. It shows a high potential for ethanolic fermentation substrate due to its high residual starch level, low ash content and small particle size of the ligno-cellulosic fibre. Cassava starches are excellent raw materials for food industry to modify the physical properties of many foods [10].

Tapioca has emerged as a commercial crop in India as well as in some other countries, besides its existing catalytic role for rural development. It requires minimum agronomic input and care for its growth. It provides food security, income and employment generation in rural areas. There is need to increase the domestic production of cassava starch, as our country still imports several thousand tones cassava starch per year. The people of North East India consume the peeled, cut tubers after boiling in water. They are unaware about the different methods of low cost value addition of this crop. The tapioca tuber is highly perishable which can be stored hardly for two to three days under natural condition. Assam occupies sixth position in tapioca production within the country. Within the state, Karbi Anglong and Kokrajhar district produced the highest quantity of tapioca. Though, the biochemical analysis report of dried tapioca tubers are available, report on composition of various tapioca products are hardly found. Therefore, the present investigation was taken to popularize the low cost value added products (plain flour, rawa and starch) among the people of tapioca growing areas of Assam and to evaluate the nutritional and antinutritional quality of the products.

EXPERIMENTAL

Fresh matured tapioca tubers were collected from horticultural orchard, Assam Agricultural University (AAU), Jorhat and also from Regional Agricultural Research Station (RARS), Assam Agricultural University, Diphu, Karbi Anglong District and from farmers' fields of both Karbi Anglong district and Kokrajhar district. Within 1 to 2 h of collection, the tubers were peeled with the help of knife manually. The peeled tuber was washed in fresh clean water to remove the dirt. Then the clean peeled tuber was subjected to chipping using tapioca chipping machine developed by Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, India. Both the plain and parboiled chips (by subjecting the plain chips in boiling water for 4 min immediately after chipping, followed by draining and pouring normal water over it) were dried in sun (for tubers collected from Diphu region) and also in tray drier at 55 °C (for tubers collected from Horticultural Orchard, Assam Agricultural University and from Kokrajhar region). The dried chips were used for production of plain flour and parboiled flour (rawa) by grinding, using a hammer mill. The starch was also extracted from the tubers using mobile starch extractor developed by CTCRI, Thiruvananthapuram, Kerala, India. All the products were stored air tight at 25 °C till analysis.

Moisture content, crude fat, crude fibre and the total ash content were determined by the method of AOAC [11]. The starch was estimated according to the method, described by Clegg [12]. The nitrogen content was determined by Micro-Kjeldahl method. Crude protein was calculated by multiplying the total N value in percentage by a factor of 6.25. The mineral solution was prepared according to the method described in AOAC [11]. This solution was used for the estimation of mineral *viz.* calcium, phosphorous, potassium, sodium and iron. The calcium content was determined according to Hawk and Submersion [13]. The sodium and potassium were estimated by flame photometry method. The iron content was determined by the method of Wong [14]. The phosphorous content was determined by the method of Fiske and Subbrow [15]. The total cyanogen content was determined by the method described by Nambisan [16].

RESULTS AND DISCUSSION

The proximate composition, mineral content and total cyanogen content of different products of *Manihot esculenta* are presented in Tables 1-3, respectively.

The moisture content (fresh basis) of various tapioca products ranged from 1.81 % in flour made from tubers collected from Regional Agricultural Research Station, Diphu to 3.61 % in flour made from tubers collected from Assam Agricultural University, Jorhat. Sarkiyayi and Agar [17] reported that in Nigeria, the moisture content of the dried sweet cassava was higher (0.82 %) than that of bitter cassava (0.14 %).

The starch content (dry weight basis) of various tapioca products ranged from 60.28-71.34 %. Rojas *et al*. [18] reported that the starch content of six cassava varieties ranged 71.6 to 84 % (dry basis). The lowest starch content (60.28 %) was observed in parboiled flour prepared from tubers collected from farmer's field, Diphu and the highest starch content (71.34 %) was found in plain flour prepared from tubers collected from farmer's field, Kokrajhar.

The ash content of various tapioca products ranged from 1.11 % in flour made from tubers collected from Assam Agricultural University, Jorhat to 3.91 % in flour made from tubers collected from Regional Agricultural Research Station,

TABLE-1
PROXIMATE COMPOSITION OF TAPIOCA PRODUCTS

Tapioca products	Moisture (on fresh wt basis) (%)	Starch (dry basis) (%)	Ash (dry basis) (%)	Crude fat (dry basis) (%)	Crude fibre (dry basis) (%)	Crude protein (dry basis) (%)
Flour (tubers collected from AAU, Jorhat)	3.61	68.24	1.11	1.45	2.13	5.10
Flour (tubers collected from farmers of Diphu)	3.54	69.09	10.43	12.91	3.17	4.96
Parboiled flour or rawa (tubers collected from farmers of Diphu)	2.75	60.28	8.74	9.15	6.10	1.16
Flour (tubers collected from RARS, Diphu)	1.82	70.13	3.91	1.32	0.90	5.19
Parboiled flour or rawa (tubers collected from RARS, Diphu)	3.06	65.27	2.67	4.16	1.73	1.34
Flour (tubers collected from farmers of Kokrajhar)	3.00	71.34	2.08	0.62	0.90	5.31
Parboiled flour or rawa (tubers collected from farmers of Kokrajhar)	2.58	61.74	2.32	0.27	0.50	0.90
CD at 5 %	0.07	0.160	0.33	0.10	0.17	0.08

TABLE-2
MINERAL CONTENT OF TAPIOCA PRODUCTS ON DRY WEIGHT BASIS

Tapioca products	Na (mg %)	K (mg %)	Ca (mg %)	Fe (mg %)	P (mg %)
Flour (tubers collected from AAU, Jorhat)	3.30	0.60	15.67	0.33	17.87
Flour (tubers collected from farmers of Diphu)	7.13	4.77	57.67	0.33	60.62
Parboiled flour or rawa (tubers collected from farmers of Diphu)	4.16	2.63	33.67	0.27	56.12
Flour (tubers collected from RARS Diphu)	6.23	3.60	49.33	0.22	41.76
Parboiled flour or rawa (tubers collected from RARS Diphu)	4.70	1.93	33.00	0.18	25.77
Flour (tubers collected from farmers of Kokrajhar)	2.40	6.92	30.67	0.57	41.59
Parboiled flour or rawa (tubers collected from farmers of Kokrajhar)	3.46	1.91	29.33	0.35	78.39
CD at 5 %	0.52	0.18	0.73	0.08	0.75

TABLE-3
TOTAL CYANOGEN CONTENT OF TAPIOCA PRODUCTS (ON DRY WEIGHT BASIS)

Tapioca products	μg cyanogen/g*
Flour (tuber source: AAU, Jorhat)	107.39
Flour (tuber source: Farmer's field, Diphu)	9.090
Flour (tuber source: RARS, Diphu)	10.46
Parboiled flour or rawa (tuber source: RARS, Diphu)	79.69
Parboiled flour or rawa (tuber source: Farmer's field, Diphu)	75.25
Starch (tuber source: Farmer's field, Kokrajhar)	5.18

*Mean value from six observations; AAU = Assam Agricultrual University; RARS = Regional Agricultural Research Station

Diphu, which are in agreement with findings observed by Sarkiyayi and Agar [17] (1.85 to 2.7 %, dry basis) and Rojas *et al.* [18] (1.5 to 2.7 %), dry basis. However, in both parboiled and plain flour prepared from the tubers collected from farmer's field, Diphu, the ash content was detected at higher levels (8.74 to 10.43 %). This might be due to differences in varieties or soil nutrient content.

The crude fat content ranged in between 0.27 % in parboiled flour made from tubers collected from farmers of Kokrajhar and 4.16 % in parboiled flour made from tubers cultivated at Regional Agricultural Research Station, Diphu. The crude lipids content reported by Sarkiyayi and Agar [17] was 3.92 % in the sweet cassava and was 3.82 % in the bitter variety grown in Nigeria. However, in both plain and parboiled flour prepared from the tubers collected from farmer's field, Diphu, the crude fat content was detected at higher levels (9.15 % in parboiled flour to 12.91 % in plain flour). This might be due to yellow pulp coloured varieties rich in pigments.

The crude fibre content showed values in between 0.50 % in parboiled flour made from tubers collected from farmers of Kokrajhar to 6.1 % in parboiled flour prepared from the tubers collected from farmer's field, Diphu. These results are comparable with the results obtained by Sarkiyayi and Agar [17] who reported the crude fiber content of the sweet cassava to be 4.40 % and bitter cassava to be 4.61 %, grown in Nigeria. The observed differences in crude fiber content might be due to differences in stage of harvest and varieties. Rojas *et al.* [18] reported that the crude fiber content ranged from 7.45 to 8.55 % (dry basis) in six cassava varieties grown in Bolivia.

The crude protein content showed values in between 0.90 and 5.31 %. The lowest crude protein content was observed in parboiled flour (tubers collected from farmers of Kokrajhar) and the highest value seen in plain flour prepared from tubers collected from the same place. The values are in agreement with values reported by Sarkiyayi and Agar [17], who observed crude protein content to be 2.69 to 3.37 %. The higher crude protein recorded in plain flour in comparison to parboiled flour might be due to draining of some water soluble nitrogen compounds during parboiling process followed for making the parboiled flour.

The sodium content in the present study ranged from 2.40 to 7.13 mg per 100 g. The lowest sodium content was found in plain flour (tubers collected from farmers of Kokrajhar) and the highest value was observed in plain flour (tubers collected from farmers of Diphu). Rojas *et al*. [18] reported that the average sodium content of six cassava varieties grown in Bolivia was 3 mg/100 g.

The potassium content in the present study ranged from 0.60 to 6.92 mg per 100 g. The lowest potassium content was found in plain flour (tubers collected from Assam Agricultural University) and the highest value was found in plain flour (tubers collected from farmers of Kokrajhar). However, Rojas *et al*. [18] reported the average potassium content of six cassava varieties grown in Bolivia to be 623 mg/100 g.

The calcium content in the present study ranged from 15.67 to 57.67 mg per 100 g. The lowest calcium content was found in plain flour (tubers collected from Assam Agricultural University) and the highest value was found in plain flour (tubers collected from farmers of Diphu). Sarkiyayi and Agar [17] found the calcium content of the sweet cassava variety to be higher (33 mg/100 g) compared to the bitter cassava (30 mg/100 g) grown in Nigeria. Similar result was obtained by Rojas *et al*. [18], who reported the average calcium content of six cassava varieties to be 39 mg per 100 g.

The iron content in the present study ranged from 0.18 to 0.57 mg per 100 g. The lowest iron content was found in parboiled flour (tubers collected from Regional Agricultural Research Station Diphu) and the highest value was found in plain flour (tubers collected from farmers of Kokrajhar). Rojas *et al.* [18] reported the average iron content of six cassava varieties to be 3 mg per 100 g. However, Sarkiyayi and Agar [17] reported iron content in the sweet cassava to be higher (30 mg per 100 g) than the bitter cassava (18 mg per 100 g) grown in Nigeria.

The phosphorous content in the present study ranged from 17.87 to 78.39 mg per 100 g. The lowest phosphorous content was found in plain flour (tubers collected from Assam Agricultural University) and the highest value was found in parboiled tapioca flour (tubers collected from farmers of Kokrajhar). Sarkiyayi and Agar [17] reported that the phosphorus content of the bitter cassava to be higher (80 mg) compared to the sweet variety (52 mg per 100 g) grown in Nigeria. Rojas *et al.* [18] reported the average phosphorous content of six cassava varieties to be 110 mg per 100 g.

The lowest total cyanogen content was observed in starch (tuber source: farmer's field, Kokrajhar) with 5.18 μg/g and the highest value was observed in plain flour (tuber source: Assam Agricultural University, Jorhat) with 107.39 μg/g. Sarkiyayi and Agar [17] reported the cyanogenic glycoside content of the bitter cassava to be higher (6.5 μg/g) compared to the sweet variety (0.46 mg per 100 g or 4.6 μg/g) grown in Nigeria. The lethal dose for linamarin was reported [19] to be 1 mg per Kg live weight. The cause for higher levels of cyanogens detected in plain flour prepared from tubers collected from Assam Agricultural University, Jorhat and parboiled flour prepared in Diphu region might be due to the fact that immediately after chipping, plain chips were dried at 55 °C (for tubers collected from Assam Agricultural University, Jorhat) and the chips were dipped in boiling water (for parboiled chips), respectively. Those chips after chipping were not given sufficient time for the hydrolytic action of linamerase enzyme (present at the tubers itself) on linamarin (cyanogenic glycoside) for which higher levels of cyanogenic glycoside were detected. If the chips are treated with high temperature immediately after chipping, then the enzyme linamerase is inactivated.

Conclusion

Present investigation showed that the products made from tubers collected from main tapioca growing regions of Assam are safe (if sufficient time is given to the linamerase enzyme to act on linamarin) and nutritionally rich, particularly in fiber and carbohydrates. However, the reason for detection of higher levels of total ash and crude fat in the products collected from farmers of Diphu region need to be investigated. It was also observed that the plain flour contains higher starch, crude protein and most of the minerals than those of parboiled flour.

ACKNOWLEDGEMENTS

The authors express their gratitude to Department of Biotechnology, Govt. of India for financial support to carry out the research work.

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