INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 1, p. 484-494, 2014

RESEARCH PAPER OPEN ACCESS

Physico-chemical characterization and product development from turmeric (*Curcuma Longa*) germplasm available in South Western Region of Bangladesh

Prosanta Kumar Dash[1*], Afroza Akhtar[2], Md. Abdul Mannan[3]

[1]*Agrotechnology Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh*
[2]*KCC Women College (Under Khulna University), Khulna, Bangladesh*
[3]*Agrotechnology Discipline, Life Science School, Khulna University, Khulna-9208, Bangladesh*

Key words: Physico-chemical, germplasam, rhizome, product, ingredient.

http://dx.doi.org/10.12692/ijb/4.1.484-494 Article published on January 11, 2014

Abstract

An investigation was carried out to study the physico-chemical characteristics of 10 selected turmeric germplasm of South Western region of Bangladesh from August 2012 to January 2013. The experiment was carried out in completely randomized design. The physico-chemical characters of 10 germplasam of turmeric species were studied. There was significant variation among the germplasms in relation to rhizome characteristics and organoleptic evaluation. Better performance of turmeric was found in germplasm No.1 in respect of total rhizome weight, rhizome length, rhizome width, rhizome height, pulp weight, pulp thickness, skin weight, skin thickness and percents of edible part. Turmeric germplasm No. 5 and germplasm No. 4 gave better performance in respect of pH (6.90) and vitamin C (5.70) content of rhizome pulp, respectively. The total soluble solids (13.67 %) found higher in germplasm No. 10 and titratable acidity (7.15 %) in germplasm No.1. Carotenoids (14.81 mg/100g) found maximum in germplasm No. 2. Germplasm No. 9 and 7 was better in respect of anthocyanin (0.92 mg/100gm) and flavonoids (7.67 gm.) content of turmeric pulp. Product development from turmeric laddu was successfully prepared by using 400 g sugar containing treatment consisting 300-500 g of sugar with 100 g variation in three treatments without changing other ingredient. Turmeric nimky was successfully prepared by using 400 g flour containing treatment consisting 300-500 g of flour with 100 g variation of flour in three treatments without changing other ingredient. All turmerics are not available year round in the country. So it is possible to preserve these rhizomes by development of products like laddu, nimky etc. to meet the nutritional requirement of people of the country.

* **Corresponding Author:** Prosanta Kumar Dash ✉ pro.shanto@yahoo.com

Introduction

Turmeric (*Curcuma longa*) is a rhizomatous herbaceous perennial plant of the family Zingiberaceae (Chan, 2009). It is native to tropical South Asia and needs temperatures between 20 °C and 30 °C (68 °F and 86 °F) and a considerable amount of annual rainfall to thrive (Tahira, 2010). Plants are gathered annually for their rhizomes, and propagated from some of those rhizomes in the following season. Phytochemicals found in turmeric have been investigated in preliminary research for their potential effects on diseases, such as cancer (Lin and Ke, 1998). Alzheimer's disease, arthritis, diabetes(Boaz *et al.*, 2011) and other clinical disorders. As an example of such basic research, turmeric reduced the severity of pancreatitis-associated lung injury in mice (Seo, 2011). Research activity into curcumin and turmeric is increasing (Lin and Ke, 1998). The U.S. National Institutes of Health currently has registered 71 clinical trials completed or underway to study use of dietary curcumin for a variety of clinical disorders. Some research shows compounds in turmeric to have anti-fungal and anti-bacterial properties; however, curcumin is not one of them (Ragasa *et al.*, 2005).

Turmeric (*Curcuma longa*), the bright yellow of the spice rainbow, is a powerful medicine that has long been used in the Chinese and Indian systems of medicine as an anti-inflammatory agent to treat a wide variety of conditions, including flatulence, jaundice, menstrual difficulties, bloody urine, hemorrhage, toothache, bruises, chest pain, and colic. Ten (10) healthy volunteers consumed 500 mg of curcumin per day for 7 days, not only did their blood levels of oxidized cholesterol drop by 33%, but their total cholesterol droped 11.63% , and their HDL (good cholesterol) increased by 29% (Soni and Kuttan , 1992). Turmeric's cholesterol-lowering effects are the result of the curry spice's active constituent, curcumin, which research reveals is a messaging molecule that communicates with genes in liver cells, directing them to increase the production of mRNA (messenger proteins) that direct the creation of receptors for LDL (bad) cholesterol. With more LDL-receptors, liver cells are able to clear more LDL-cholesterol from the body. LDL-receptor mRNA increased sevenfold in liver cells treated with curcumin at a concentration of 10 microM, compared to untreated cells. (Liver cells were found to tolerate curcumin at levels of up to 12. MicroM for 24 hours). (Peschel *et al.*, 2007).

Curcumin has been traditionally used as a good source of coloring matter for foods, cosmetics, textiles and as a medicinal ingredient in formulations of the several medicines for ailments from jaundice, other liver disorder, ulcers, parasitic infections, various skin diseases, sprains, inflammation of the joints, cold and flu (Anonymous, 1950). It possesses anti-inflammatory, hepatoprotective, antimicrobial, anticancer, antitumor, blood purifying, stomachic, antisepticand anti-viral activities (Ghani, 2003). Curcumin also possesses the remarkable activities of preventing or treating alzheimer disease, immune modulation and correcting cystic fibrosis defects (Balasubramanian, 2006). Turmeric grows abundantly in India, Indonesia, Srilanka and Cambodia; whilst in Bangladesh it grows at Sreemongal, Bogra, Joydebpur, Comilla, Satkhira, Chittagong, Barisal and Khulna. Enormous work has been done on various activities of *Curcuma longa* (Kitsupa *et al.*, 2004). The rhizome oil of *Curcuma longa* L. oil is also used as scenting agents in detergents, soaps, air fresheners and insect repellents, intermediate in the synthesis of perfume chemicals and as a pharmaceutical aid (Bakowski and Michalik, 1986). The physico- Chemical characterizations of any spices (Turmeric, Ginger) crops are very important for their proper utilization. Characteristics of each turmeric gernplasms are not same. So, it is very essential to categorise each germplam on the basis of physico- Chemical characterization. The physico-chemical characterization and product development from turmeric germplasm available in South-Western region of Bangladewsh is meagre. The present study was, therefore, conducted with the following objectives:

i) To study the pattern of physico-chemical properties

of some selected turmeric germplasm.

ii)To develop the product from turmeric to meet nutritional requirement of people of the country for increasing availability during out of season.

Materials and methods

Turmeric is herb used for spices as well as herbal medicine. Many research works have been done in different part of the world to study the physic-chemical and product development from turmeric. The experiment on physico-chemical characteristics and product development from turmeric was carried out during the period from August, 2012 to January, 2013. In the study 10 turmeric from 10 germplasm were studied which were collected randomly from south western region of Bangladesh. The collected turmeric germplasm were brought to the Molecular Horticulture Laboratory of the Agrotechnology Discipline of Khulna University, Khulna. In the laboratory, the turmeric was studied to determine their physico-chemical characteristics and was used to make some products.

Physico-chemical characteristics of turmeric germplasm of the south western region of Bangladesh

Experimental Design and Analysis

The experiment was laid out in Completely Randomized Design (CRD) with three replications. After collection of some turmeric they kept in ambient temperature for the study of physico-chemical characteristics. The collected data from experiment were statistically analyzed by Analysis of Variance (ANOVA). Duncan's New Multiple Range Test (DMRT) was used to compare the means of different parameters and the means were calculated by using "MSTATC" programme in computer.

Experimental Materials

Ten germplasms of mature turmeric were selected as the experimental materials for the investigation. This turmeric was collected from different place of south western region of Bangladesh.

Methods of Studying Parameters

By using the following methods physical and chemical parameters of the collected turmeric germplasms were studied.

Physical Parameter

Weight of turmeric

The weight of turmeric was measured by an electric balance. At first, the balance was adjusted to zero mark. The turmeric was cleaned and weighted by keeping the turmeric on the chamber of the balance. Then the reading was taken in gram (g).

Size of turmeric

Length, width and depth of the turmeric were estimated to determine the turmeric size by a slide calliper. The values of these parameters were taken in centimetre (cm).

Weight of skin of turmeric

The weight of skin of turmeric was measured by an electric balance. At first, the balance was adjusted to zero mark. The skin of the turmeric was separated by using a sharp knife from the turmeric pulp. Then the weight of the skin was estimated by keeping it in the chamber of balance and the reading was taken in gram (g).

Weight of edible portion of turmeric

The weight of edible portion of turmeric was measured by an electric balance. At first, the balance was adjusted to zero mark. After removing the skin from turmeric the remaining edible portion (pulp) was estimated by keeping it in the chamber of balance and the reading was taken in gram (g).

Weight of non-edible portion of turmeric

Weight of non-edible portion of the turmeric was measured by subtracting the weight of edible portion from the total weight of turmeric. This weight was measured in gram (g).

Percentage of edible portion of turmeric

The percentage of edible portion of turmeric (pulp) was calculated by the following formula:

Percentage of edible portion

$$= \frac{\text{Weight of edible parts}}{\text{Weight of whole rhizome}} \times 100$$

Percentage of nonedible portion of turmeric

The percentage of nonedible (skin) portion of turmeric was calculated by the following formula:

$$\text{Percentage of non-edible portion} = \frac{\text{Weight of non edible parts}}{\text{Weight of whole rhizome}} \times 100$$

Chemical characteristics

The methods for the estimation of pH, TSS, Titrable acidity, vitamin C, Carotenoids, Anthocyanin and Flavonoids of turmeric pulp were followed as described by Mazumdar and Majumdar (2001) and Saini *et al.* (2006). The data were analyzed by fresh weight basis.

Development of products from turmeric

To develop products from the selected rhizomes, the experiment was laid out considering three replications with three formulations. The formulations for this experiment have been shown in Table 1, 2, 3 and 4. Sensory evaluation of turmeric products were done following the method adopted by Hossain and Siddique (1982). The individual product's quality was found by analysing the following characteristics- (i) colour, (ii) taste, (iii) flavour and (iv) texture and Complete Randomized Design (CRD) was applied for the analysis of experimental data.

In this experiment nimky and laddu were developed from turmeric. The ingredients and procedure which were used to develop products are presented below:

Product name

Turmeric laddu

Procedure

There are several stages in the procedure which was used to develop laddu from turmeric. These stages are briefly stated below:

Selection and washing of rhizomes

Properly matured and fresh turmerics were collected and washed thoroughly with fresh water.

Slicing and boiling of sliced rhizome

The turmeric were weighted and made thin slices after peeling. The slices were then kept in an aluminium saucepan adding fresh water. Then the saucepan was placed in a burner to collect turmeric juice through boiling. Boiling was continued from 15-20 minutes.

Cooking

Heat the ghee on a medium flame till hot. Reduce flame a little. After heating ghee, bengal gram flour, sugar, milk, cardamom powder and turmeric juices were added. Cooking them properly for 20 minutes.

Shaping

After cooling the cooked mixture give them ball shape. For this grease hands lightly with some ghee and start forming the mixture into walnut-sized (or slightly larger) balls (Laddu). Press gently but firmly to bind the Laddus together.

Packing

After cooling laddu pack them into clean packet.

Product name

Turmeric nimky

Procedure

There are several stages in the procedure which was used to develop nimky from turmeric. These stages are briefly stated below:

Selection and washing of rhizomes

Properly matured and fresh turmeric were collected and washed thoroughly with fresh water.

Slicing and boiling of sliced rhizome

The turmeric were weighted and made thin slices after peeling. The slices were then kept in an aluminium saucepan adding fresh water. Then the saucepan was placed in a burner to collect turmeric juice through boiling. Boiling was continued from 15-20 minutes.

Dough making

For dough making take flour, baking powder, nigella seed and salt inamxing bowl. Add ghee and mix it well so that it incorporated into the flour. Then slowly add turmeric juice and mix. Make a nice smooth dough and divide them into small ball.

Kneading and cutting

Spreading some oil on rolling board and make ruti from the dough. Making ruti little thinner than usual ruti. Then cutting it into diamond shape or square shape.

Frying

Heating oil in a pan to a medium heat. After heating oil, put few nimky at a time and carefully fry them to nice golden color on both sides.

Packing

After removing nimky from the pan, place on a kitchen tissue to soak extra oil. Pack the crispy nimky after cooling.

Sensory Evaluation

The acceptability of the prepared products of turmeric was evaluated through a taste-testing panel of 9 judges. The taste-testing panel was made for sensory evaluation of turmeric products with teachers and students off different disciplines of Khulna University. All the judges were conversant with the factors governing the quality of the products. The products sample of three treatments were placed in white plates to each judges who independently examined considering the characteristics- i) colour ii) taste iii) flavour and iv) texture / crispiness of individual products. The panellists recorded their preferential comments in the supplied questionnaire. The results have been presented both in percentage figures and in acceptability scores. Acceptability score was computed according to the scale as followed by Hossain and Siddique (1982).

Results and discussion

The research was carried out to study the physico-chemical characteristics and quality of developed products of turmeric at the Molecular Horticulture Laboratory of Agrotechnology Discipline, Khulna University, Khulna from August, 2012 to January, 2013. The data have been presented in tables. The results of the experiment are presented and discussed under the following headings.

Table 1. Ingredients for turmeric laddu formulation.

Sl.	Ingredients	T_1	T_2	T_3
01	Turmeric (g)	100	100	100
02	Sugar (g)	300	400	500
03	Ghee (ml)	50	50	50
04	Bengal gram flour (g)	500	500	500
05	Cardamom powder (g)	10	10	10
06	milk (ml)	15	15	15

Physical characteristics of turmeric

Data on physical characteristics of turmeric are presented in (Table 3). The physical characteristics of turmeric are described based on quantitative and qualitative characteristics.

Quantitative Characters

Weight of individual rhizomes

The rhizome weight was significantly varied among the 10 germplasm (Table 3). The germplasm No. 01 gave the maximum rhizome weight (12.26 g) followed by germplasm No. 04 (8.23 g) while it was minimum (3.16 g) in germplasm No. 07 preceded by germplasm No. 06 (4.32 g), No. 09 (4.48 g) and No.10 (4.81 g) (Table 3). Average rhizome weight of turmeric was found 6.72 g.

Length of rhizome

Significant differences were found among the 10 germplasm in respect of length of rhizome (Table 3). The longest rhizome (6.30 cm) was found in germplasm No. 01 followed by germplasm No. 02

(5.37 cm), germplasm No. 08 (4.93 cm) and the shortest rhizome (3.77 cm) was measured from germplasm No. 07 preceded by germplasm No. 06 (4.01 cm), No. 09 (4.29 cm) and No. 03 (4.3 cm) (Table 3). The average length of rhizome was found 4.68 cm per rhizome.

Table 2. Ingredients for turmeric nimky formulation.

Sl.	Ingredients	T_1	T_2	T_3
01	Turmeric (g)	100	100	100
02	Flour (g)	300	400	500
03	Oil (ml)	250	250	250
04	Nigella seed (g)	10	10	10
05	Salt (g)	20	20	20
06	Baking powder	15	15	15
07	Ghee	20	20	20

Width of rhizome

Significant variation was found in width of rhizome among the 10 germplasm (Table 3). The broadest rhizome (1.93 cm) was found in germplasm No.01 followed by germplasm No. 04 (1.72 cm), germplasm No. 03 (1.55 cm), germplasm No. 05 (1.53 cm) and the narrowest rhizome 1.14 cm was measured from germplasm No. 07 preceded by germplasm No. 10 (1.34 cm), germplasm No. 09 (1.35 cm) and germplasm No. 06 (1.46 cm) (Table 3). The average width of rhizome was found 1.51 cm per rhizome.

Table 3. Physical characteristics of Turmeric (*Curcuma longa*).

Germplasm No	Rhizome weight (g)	Length of Rhizome (cm)	Width of Rhizome (cm)	Height (cm)	Pulp weight (g)	Pulp thickness (cm)	Skin Weight (g)	Skin thickness (cm)	% of edible part	% of non edible part
1	12.26a	6.296a	1.933a	1.677a	8.903a	1.617a	3.080a	0.066e	72.78ab	24.96b
2	7.14bc	5.374ab	1.524bc	1.423abcd	5.567abc	1.292a	1.580a	0.071de	77.69a	22.44b
3	6.64bc	4.296bc	1.548bc	1.459abcd	4.573bcd	1.360a	1.983a	0.111bcde	68.63b	30.40b
4	8.23ab	4.738bc	1.718ab	1.647ab	6.017ab	1.517a	2.217a	0.115abcde	73.59ab	26.41b
5	8.23ab	4.581bc	1.529bc	1.580ab	5.817abc	1.400a	2.410a	0.129abcd	70.79ab	29.21b
6	4.32bc	4.008bc	1.461bc	1.210cd	2.547cd	1.299a	1.773a	0.129abcd	58.68c	41.32a
7	3.16c	3.774c	1.141d	1.177d	1.890d	0.984a	1.360a	0.157ab	59.28c	40.72a
8	7.89abc	4.925abc	1.528bc	1.544abc	5.660abc	1.353a	2.327a	0.175a	71.28ab	28.72b
9	4.48bc	4.293bc	1.346cd	1.203cd	2.683bcd	1.212a	1.797a	0.137abc	59.97c	40.03a
10	4.81bc	4.464bc	1.343cd	1.329bcd	2.677bcd	1.260a	2.137a	0.083cde	56.30c	43.7a
Average	6.72	4.675	1.507	1.425	4.633	1.329	2.050	0.117	66.90	32.791
Level of significance	**	*	**	*	**	NS	NS	*	**	**
CV (%)	27.50	16.52	12.83	15.17	28.42	15.58	28.60	29.68	4.72	9.84

N.B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT.

Rhizome height

The rhizome height of the rhizome was significantly varied among the 10 germplasm (Table 3). The germplasm No. 01 gave the maximum rhizome height (1.68 g) followed by germplasm No. 04 (1.65 g), germplasm No. 05 (1.58) and germplasm No. 08 (1.54) while rhizome height was minimum (1.18 g) in germplasm No. 07 preceded by germplasm No. 09 (1.20 g), No. 06 (1.21 g) and No. 10 (1.33 g) (Table 3). Average rhizome height of turmeric was found 1.43 g.

Pulp weight

The pulp weight of the rhizome was significantly varied among the 10 germplasm (Table 3). The germplasm No. 01 gave the maximum pulp weight (8.90 g) followed by germplasm No. 04 (6.02 g),

germplasm No. 05 (5.82 g) and germplasm No. 08 (5.66 g) while pulp weight was minimum (1.89 g) in germplasm No. 07 preceded by germplasm No. 06 (2.55 g) and No. 10 (2.68 g) (Table 3). Average pulp weight of turmeric was found 4.63 g.

Pulp thickness

Non-significant difference was found among the 10 germplasm in respect of skin thickness (Table 3). The germplasm No. 01 gave the maximum pulp thickness (1.62 g) followed by germplasm No. 04 (1.52 g), germplasm No. 05 (1.40 g), germplasm No. 03 (1.36 g) and germplasm No. 08 (1.35 g), while pulp thickness was minimum (0.98 g) in germplasm No. 07 preceded by germplasm No. 09 (1.21 g), No. 10 (1.26 g) and No. 02 (1.29 g) (Table 3). Average pulp thickness of turmeric was found 1.33 g.

Table 4. Chemical characteristics of Turmeric (*Curcuma longa*).

Germplasm No.	pH	TSS (%)	T-acidity (%)	Vitamin-c (mg/100g)	Carotinoids (mg/100g)	Anthocyanine (mg/100g)	Flavonoids (g/100g)
1	6.390b	10c	7.147a	1.700a	14.738abc	0.725b	5.925c
2	6.180c	12abc	6.720a	1.867a	14.816a	0.518d	5.924c
3	6.107cd	14a	7.787a	1.830a	14.761ab	0.447e	5.180d
4	5.980ef	13ab	3.200cd	2.100a	14.710abc	0.422f	6.920b
5	6.900a	11bc	2.847cd	1.900a	14.622bc	0.466e	5.323d
6	5.843g	12.33abc	5.333b	1.700a	14.601c	0.509d	6.050c
7	6.927a	13ab	3.100cd	1.560a	14.808a	0.666c	7.669a
8	6.153c	11.667abc	3.727c	1.930a	14.756ab	0.658c	7.158b
9	5.943f	12abc	1.920d	1.650a	14.436d	0.924a	5.260d
10	6.040de	13.667a	2.027d	1.900a	14.625bc	0.645c	5.177d
Average	6.246	12.267	4.381	1.814	14.687	0.598	6.059
Level of significance	**	**	**	N.S	**	**	**
CV (%)	0.44	7.73	13.09	24.52	0.36	1.91	2.28

N.B. In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT.

Skin weight

Non-significant difference was found among the 10 germplasm in respect of skin thickness (Table 3). The germplasm No. 01 gave the maximum skin weight (3.08 g) followed by germplasm No. 05 (2.41 g) and germplasm No. 08 (2.40) while skin weight was minimum (1.36 g) in germplasm No. 07 preceded by germplasm No. 02 (1.58 g), No. 06 (1.77 g) and No. 09 (1.80 g) (Table 3). Average skin weight of turmeric was found 2.06 g.

Skin thickness

The skin thickness of the rhizome was significantly varied among the 10 germplasm (Table 3).The germplasm No. 08 gave the maximum skin thickness (0.18 g) followed by germplasm No. 07 (0.16 g), germplasm No. 09 (0.14 g) and germplasm No. 05 (0.13 g) while skin thickness was minimum (0.07 g) in germplasm No. 01 (Table 3). Average skin thickness of turmeric was found 0.18g.

Percentage of edible portion

Significant variation was found among the 10 germplasm in respect of percentage of edible portion of the rhizome (Table 3). The results showed that the highest percentage of edible portion (77.69 %) was found in germplasm No. 02 followed by germplasm No. 04 (73.59%), germplasm No. 01 (72.78 %), No. 08 (71.28%), and the lowest percentage (56.30%) was measured from germplasm No. 10 which was statistically similar to the germplasm No. 06 (58.68%), No. 07 (59.28%) and No. 09 (59.97%) (Table 3). The average percentage of edible portion of rhizome was found 66.90%.

Percentage of non-edible portion

The percentage of non-edible portion of turmeric was

significantly varied among the 10 germplasm (Table 3). The highest percentage of non-edible portion (43.7 %) was found from germplasm No. 10 which was statistically similar to germplasm No. 06 (41.32%),No. 07 (40.72%),No. 09 (40.03%) and the lowest percentage (22.44%) was found from germplasm No. 02which was statistically similar to germplasm No. 01 (24.96%), germplasm No. 04 (26.41%), germplasm No. 08 (28.72%), germplasm No. 05 (29.21%) and germplasm No. 03 (30.40%) (Table 3). The average percentage of non-edible portion of turmeric was found about 32.79%.

Table 5. Taste evaluation of turmeric laddu.

Treatment	Colour	Taste	Flavour	Texture
T_1	1.00b	4.33a	4.33	2.33
T_2	1.68ab	4.33a	3.33	2.68
T_3	2.33a	2.68b	4.68	2.68
L.S.	*	*	NS	NS

In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT. L.S.: Level ofsignificance, * Significant at 5% level, NS: Non-Significant.
Note:
T_1= 100 g pulp of turmeric and 300 g sugar
T_2 = 100 g pulp of turmeric and 400 g sugar
T_3 = 100 g pulp of turmeric and 500 g sugar
The amounts of other used ingredients to formulate turmeric laddu were same for three treatments.

Qualitative Characters

Shape of rhizome

There was remarkable variable among the 10 germplasm in respect of rhizome shape. Most of the rhizomes were irregular in shape.

Colour of Skin

Variation was also found in case of type of skin colour among the 10 germplasm. Various skin colour was found in different rhizomes viz. deep brown, yellowish brown and orange like brown.

Chemical characteristics of turmeric

pH of rhizome pulp

The difference of pH was significant among the 10 germplasm (Table 4). The highest pH (6.93) was observed from germplasm No. 07 which was statistically similar to germplasm No. 05 (6.90). The lowest pH of rhizome pulp (5.84) was observed from germplasm No. 06 preceded by germplasm No. 09 (5.94), No. 04 (5.98) and No. 10 (6.04) (Table 4). Average pH was found 6.25.

Table 6. Taste evaluation of turmeric nimky.

Treatment	Colour	Taste	Flavour	Crispiness
T_1	3.68	4.00	4.00a	3.68
T_2	4.00	4.00	3.67a	3.68
T_3	3.33	2.68	1.33b	3.68
L.S.	NS	NS	**	NS

In a column figures having similar letters do not differ significantly whereas figures having dissimilar letters differ significantly as per DMRT.
L.S.: Level of significance, ** Significant at 1% level, NS: Non-Significant.
Note:
T_1= 100 g pulp of turmeric and 300 g flour
T_2 = 100 g pulp of turmeric and 400 g flour
T_3 = 100 g pulp of turmeric and 500 g flour.

Total soluble solids (Brix %) of rhizome pulp

The difference of total soluble solids was significant among the 10 germplasm (Table 4). The highest percentage of TSS (14.00%) was observed from germplasm No. 03 which was statistically similar to germplasm No. 10 (13.67%). The lowest percentage of total soluble solids of rhizome pulp (10.00%) was observed from germplasm No. 01 preceded by

germplasm No. 05 (11.00%), No. 08 (11.67%) and No. 06 (12.33%) (Table 4). Average total soluble solids were found 12.27%. Increase in total soluble solid may be attributed to increase in soluble sugar, soluble pectin, soluble organic acids etc.

Fig. 1. Turmeric laddu.

Titratable acidity of rhizome pulp

The difference of titratable acidity was significant among the 10 germplasm (Table 4). The highest percentage of titratable acidity (7.79%) was observed from germplasm No. 03 which was statistically similar to germplasm No. 01 (7.15%), germplasm No. 02 (6.72%). The lowest percentage of titratable acidity of rhizome pulp (1.92%) was observed from germplasm No. 09 which was statistically similar to germplasm No. 10 (2.03%) (Table 4). Average titratable acidity was found 4.38%.

Fig. 2. Turmeric nimky.

Vitamin C (ascorbic acid) content of rhizome pulp

Non-significant difference was found among the 10 germplasm in respect of vitamin C content of rhizome pulp (Table 4). However, numerically the highest vitamin C (2.1 mg /100 g) was observed from germplasm No. 04 and that was the lowest vitamin C (1.56 mg /100 g) was found in germplasm No. 07 (Table 4). Average vitamin C was found 1.81 mg /100 g.

Carotenoids content of rhizome pulp

Carotenoids content of rhizome pulp showed significant difference among the 10 germplasm (Table 4). The maximum amount of carotenoids content of rhizome pulp (14.82 mg/100 g) was found in germplasm No. 20 which was statistically similar to germplasm No. 07 (14.81 mg /100 g). The minimum amount of carotenoids content (14.44 mg /100 g) was observed from germplasm No. 09 preceded by germplasm. No. 06 (14.60 mg /100 g), No. 05 (14.62 mg /100 g) and No. 10 (14.63 mg /100 g) (Table 4). Average carotenoids content was 14.69 mg /100 g of rhizome pulp.

Anthocyanin content of rhizome pulp

The difference of anthocyanin content of rhizome pulp was significant among the 10 germplasm (Table 4). The highest amount of anthocyanin of rhizome pulp (0.92 mg / 100 g) was observed from germplasm No. 09 followed by germplasm No. 01 (0.73 mg /100 g), germplasm No. 07 (0.67 mg /100 g). The least amount of anthocyanin of rhizome pulp (0.42 mg / 100 g) was observed from germplasm No. 04 preceded by germplasm No. 03 (0.45 mg /100 g), No. 05 (0.47 mg /100 g) and No. 06 (0.51 mg /100 g) (Table 4). Average anthocyanin content of rhizome pulp was 0.60 mg /100 g.

Flavonoids content of rhizome pulp

There was a significant variation among the 10 germplasm in respect of flavonoids content of rhizome pulp (Table 4). The highest flavonoids content of rhizome pulp(7.67 g /100 g) was found in germplasm No. 07 followed by germplasm No. 08 (7.16 g / 100g), No. 04 (6.92 g /100g) and No. 06 (6.05 g /100g). The lowest flavonoids content of rhizome pulp (5.18 g /100 g) was found in germplasm No. 10 which was statistically similar to germplasm No. 03 (5.18 g /100g), germplasm No. 09 (5.26 g /100g) (Table 4). Average flavonoids content was 6.06 g /100 g of rhizome pulp.

Product Development from Turmeric

Two products were developed from turmeric. From each product three treatments were formulated for this investigation. The quality of products was analysing the fowling parameters.

Turmeric laddu

Colour of Laddu

There was a significant variation among the 3 treatment in respect of colour of laddu (Table 5). The most suitable colour of laddu (2.33) was found in treatment No. 3 followed by treatment No.2 (1.68). The least agreeable colour of laddu (1.00) was found in treatment No. 1 (Table 5).

Taste of Laddu

The taste showed significant variation among the 3 treatment (Table 5). The most agreeable taste (4.33)was found in treatment No. 2 which was statistically similar to treatment No.1 (4.33). The least agreeable taste (2.68) was recorded from treatment No. 3 (Table 5).

Flavour of Laddu

The difference of flavour was significant among the 3 treatment (Table 5). The most suitable flavour (4.68) was found in treatment No. 3. The least agreeable flavour of laddu (3.33) was observed from treatment No. 2 (Table 5).

Texture of Laddu

The taste showed significant variation among the 3 treatment (Table 5). The tighter texture(2.68) was found in treatment No. 3. The least tight texture (2.33) was recorded from treatment No. 1 (Table 5).

In respect of overall consideration of colour, taste, flavour and texture of pakora treatment No. 2 (6.30) showed better performance among the 3 treatment (Table 5).

Turmeric nimky

Colour of Nimky

There was a significant variation among the 3 treatment in respect of colour of nimky (Table 6). The most attractive colour of nimky (4.00) was found in treatment No. 2. The least attractive colour of nimky (3.33) was found in treatment No. 3 (Table 6).

Taste of Nimky

The taste showed significant variation among the 3 treatment (Table 6). The most agreeable taste (4.00) was found in treatment No. 1. The minimum agreeable taste (2.68) was recorded from treatment No. 3 (Table 6).

Flavour of Nimky

The difference of flavour was significant among the 3 treatment (Table 6). The highest agreeable flavour of nimky (4.00) was found in treatment No. 1 which was statistically similar to treatment No. 2 (3.68). The least agreeable of flavour of nimky (1.33) was observed from treatment No. 3 (Table 6).

Crispiness of Nimky

Significant variation was observed among the 3 treatment in respect of texture of nimky (Table 6). Treatment No. 1 found more crispy (3.68), followed by treatmentNo. 2 (3.68) and treatment No.3 (3.68) (Table 6).

In respect of overall consideration of colour, taste, flavour and texture of nimky treatment No. 2 (6.38) showed better performance among the 3 treatment (Table 6).

Acknowledgement

The author reveals immense pleasure to express heartfelt indebtness and deepest sense of gratitude to his honorable teachers, Dr. Md. Abdul Mannan, Professor, and other affiliated teachers and lab technicians, Agrotechnology Discipline, Khulna University, for their kind and painstaking guidance, compassionate help and inspiration in all phases of the study and preparation of the manuscript.

References

Anonymous. 1950. Wealth of India: A dictionary of Indian raw materials and industrial products (CSIR, New Delhi) **2,** 402-405.

Bakowski J, Michalik H. 1986. Suitability of several vegetable species for drying purposes. International Journal of Spices, **8(2),** 191-216.

Balasubramanian K. 2006. Molecular orbital basis for yellow curry spice curcumina prevention of Alzheimera disease. Journal of Agricultural Food Chemistry **54,** 3512-3520.

Boaz M, Leibovitz E, Bar Dayan Y, Wainstein J. 2011. "Functional foods in the treatment of type 2 diabetes: olive leaf extract, turmeric and fenugreek, a qualitative review". Function of Foods Health and Disease **1(1),** 472–481.

Chan EWC. 2009. "Effects of different drying methods on the antioxidant properties of leaves and tea of ginger species". Food Chemistry, **113 (1),** 166–172.

Ghani A. 2003. Medicinal plants of Bangladesh: Chemical constituents and uses. 2nd Ed. (Revised and Enlarged). Asiatic Society of Bangladesh, old Nimtali, Dhaka. 196-197.

Hossain MM, Siddique MA. 1982. Taste and visual acceptability of some exotic and local cultivars of sweet potato. Pakistan Journal of Scientific Research, **34 (24),** 113-119.

Kitsupa N, Kiatying-Angsulee N, Nuttakul W. 2004. In vivo antioxidation of turmeric oil and its role for pepetic ulcer protection. Clinical Experiment on Pharmacology and Physiology **31(1),** 164-166.

Lin LI, Ke YF. 1998. "Curcumin inhibits SK-Hep-1 hepatocellular carcinoma cell invasion in vitro and suppresses matrix metalloproteinase-9 secretion", Oncology **55,** 349-353.

Mazumder BC, Majumder K. 2003. Methods on physico- chemical analysis of fruits, 1-162.

Peschel D, Koerting R, Nass N. 2007. Curcumin induces changes in expression of genes involved in cholesterol homeostasis. Journal of Nutrition and Biochemistry **18(2),** 113-119.

Ragasa C, Laguardia M, Rideout J. 2005."Antimicrobial sesquiterpenoids and diarylheptanoid from Curcuma domestica". ACGC Chemical Research Community **18(1),** 21–24.

Saini RS, Sharma KD, Dhankhar OP, Kaushik RA. 2006. Laboratory manual of analytical techniques in Horticulture. Dr. UpdeshProhit for Agrobios (India). 5-112.

Seo SW. 2011. "Protective effects of *Curcuma longa* against cerulein-induced acute pancreatitis and pancreatitis-associated lung injury". International Journal of Molecular Medicine **27(1),** 53–61.

Soni KB, Kuttan R. 1992. Effect of oral curcumin administration on serum peroxides and cholesterol levels in human volunteers. Indian Jjournal of Physiology and Pharmacology **36(4),** 273-275.

Tahira JJ. 2010. "Weed flora of *Curcuma longa*". Pakistan Journal of Weed Science Research **16(2),** 241–246.