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Studies on development of process technology for formulation, sensory evaluation and storage studies of fresh turmeric rhizome juice-based orange RTS beverage

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Abstract
The present investigation entitled was carried out to develop fresh turmeric rhizome juice added orange RTS beverage with the formulations of orange juice to the fresh turmeric rhizome juice in the ratio of T_1 (95:05); T_2 (90:10); T_3 (85:15) and studied with reference to the T_0 (100:0). The formulated fresh turmeric rhizome-based orange RTS beverage then subjected for sensory evaluation and the sample T_2 found to be superior among all with respect to sensory qualities such as color, flavour, overall acceptability and taste. The selected sample was subjected for storage studies was found acceptable up to 90 days at refrigerated storage 4 ^{0}C. Overall it can be summarised that the turmeric-orange RTS beverage with T_2 (90:10) can be stored safe up to 90 days at refrigerated temperature with desirable sensory qualities.

Keywords: Turmeric, orange, *Curcuma longa*, nutraceutical, curcumin, RTS, rhizome

Introduction

Oranges form a rich source of vitamin C, flavonoids, phenolic compounds and pectins. The main flavonoids found in citrus species are hesperidine, narirutin, naringin and eriocitrin. Just one orange provides 116% of the daily requirement for vitamin C. Vitamin C is the primary water- soluble antioxidant, which prevents free radical generation in the body and damage to the tissues in the aqueous environment both inside and outside cells. Drinking of orange juice without salt and sugar is associated with reduced severity of inflammatory conditions, like asthma, osteo- arthritis, and rheumatoid arthritis. Vitamin C is also necessary for the proper functioning of immune system. Vitamin C is good for preventing cold, cough and recurrent ear infections. Parle and Chaturvedi (2012) [1].

Turmeric is a product of *Curcuma longa*, a rhizomatous herbaceous perennial plant belonging to the ginger family *Zingiberaceae*, which is native to tropical South Asia. As many as 133 species of *Curcuma* have been identified worldwide. Most of them have common local names and are used for various medicinal formulations. The turmeric plant needs temperatures between 20 °C and 30 °C and a considerable amount of annual rainfall to thrive. Individual plants grow to a height of 1 m, and have long, oblong leaves. Plants are gathered annually for their rhizomes and are reseeded from some of those rhizomes in the following season. The rhizome, from which the turmeric is derived, is tuberous, with a rough and segmented skin. The rhizomes mature beneath the foliage in the ground. They are yellowish brown with a dull orange interior. The main rhizome is pointed or tapered at the distal end and measures 2.5–7.0 cm (1–3 inches) in length and 2.5 cm (1 inch) in diameter, with smaller tubers branching off. When the turmeric rhizome is dried, it can be ground to a yellow powder with a bitter, slightly acrid, yet sweet, taste. Turmeric is most extensively cultivated in India, followed by Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, and the Philippines. It is also cultivated on a small scale in most tropical regions in Africa, America, and Pacific Ocean Islands. However, India is the largest producer, consumer, and exporter of turmeric Ravindran, (2007) [2]. Turmeric is used as an herbal medicine for rheumatoid arthritis, chronic anterior uveitis, conjunctivitis, skin cancer, small pox, chicken pox, wound healing, urinary tract infections, and liver ailments (Dixit *et al.*, 1988) [3]. It is also used for digestive disorders; to reduce flatus, jaundice, menstrual difficulties, and colic; for abdominal pain and distension and for dyspeptic conditions including loss of appetite, postprandial feelings of fullness, and liver and gallbladder complaints. The main clinical targets of turmeric are the digestive organs: in the intestine, for treatment of diseases such as familial adenomatous polyposis in the bowels, for treatment of inflammatory bowel disease and in the colon, for treatment of colon cancer. Prasad and Agarawal, (2011) [4]

Curcumin in turmeric have some promising effects have been observed in patients with various pro-inflammatory diseases including cancer, cardiovascular disease arthritis, uveitis, ulcerative proctitis, Crohn's disease, ulcerative colitis, irritable bowel disease, tropical pancreatitis, peptic ulcer, gastric ulcer, idiopathic orbital inflammatory pseudotumor, oral lichen planus, gastric inflammation, vitiligo, psoriasis, acute coronary syndrome, atherosclerosis, diabetes. Dose-escalating studies have indicated the safety of curcumin at doses as high as 12 g/day over 3 months Gupta *et al*. (2013) [5].

(Deka, 2000) [6], (Deka and Sethi 2001) [7] reported that two or more fruits juice/pulp may be blended in various proportions for the preparation of nectar, RTS beverages etc. the blending of juice may also improve aroma, taste and nutrients of beverages Looking to the demand of natural beverages, there is great scope for the preparation of juices and other fruit-based beverages. RTS is a type of fruit beverage containing at least fruit juice (10%), total soluble solids (10%) and acidity (0.3%). Therefore, the present study was carried out to evaluate the organoleptic qualities of turmeric based orange ready-to-serve (RTS) beverages.

Materials and Methods

Materials

The fresh turmeric rhizomes and oranges were obtained from local village market, Parbhani. The proposed research was carried out in Department of Food Engineering, College of Food Technology, VNMKV, Parbhani.

Methods

Preparation of fresh turmeric rhizome juice and orange juice

Freshly harvested turmeric rhizomes were washed and cleaned by removing all the dirt and impurities. Then peeling was carried out for obtaining clear turmeric juice. After removing the peel, the rhizomes were cut into small pieces for the extraction of juice through juice extractor. The obtained juice then filtered through muslin cloth to obtain clear juice.

Organoleptic evaluation of turmeric based orange RTS beverage

Organoleptic evaluation of turmeric based orange RTS beverage for colour and appearance, flavour, after taste and overall acceptability was carried out by using standard method of (Amerine *et. al.* 1965) [8]. For these 10 semi-trained judges were used and 1 to 9-point hedonic scale was used for rating the quality of the turmeric-based orange RTS beverage. The mean of ten judges was considered for evaluating the quality.

Preparation of Turmeric based Orange RTS Beverage

Fruit
↓
Washing
↓
Juice extraction
↓
Mix sugar +citric acid+ water and heat till sugars dissolves (Stir thoroughly)
↓
Cooling
↓
Filter through muslin cloth
↓
Addition of turmeric juice as per ration given in recipes
↓
Pasteurization (80 ^{0}C for 10 min)
↓
Addition of KMS (@ 750ppm+ 500ppm)
↓
Cool at room temperature
↓
Storage

Source: Nitu *et al*. 2010) [9]

Fig 1: Process flowchart for preparation of turmeric based orange RTS beverage

After extraction of juice from all the fruits its total soluble solids (TSS) and acidity were measured. Then according to different recipe treatment, the quantity of juice, sugar, citric acid, preservative (KMS) and water were calculated. For the preparation of turmeric based orange RTS beverage of different recipe, syrup of sugar, water and citric acid was prepared. The prepared turmeric-based orange RTS beverage filled in clean sterilized plastics bottle of 200 ml capacity. Prepared orange based blended RTS beverage bottle were stored in dries place at ambient temperature**.**

Results and Discussions

Effect of addition of different proportion of fresh turmeric rhizome juice on organoleptic characteristics of turmeric-orange RTS beverage

The organoleptic evaluation of turmeric based orange RTS beverage was carried out by a ten members of semi trained panel and the scores were given by evaluating color and appearance, flavour, taste and overall acceptability which was compared with control sample and presented in table 1

Table 1: Organoleptic evaluation of turmeric based orange RTS beverage

Samples	Colour and Appearance	Flavour	Taste	Overall Acceptability
T0 (100:00)	8.7	8.5	9	8.8
T1 (95:05)	7.5	8.0	8.5	8.1
T2 (90:10)	8.5	8.5	9	8.6
T3 (85:15)	7.0	7.5	7.5	7.4

*Each value represents the average of three determinations.

Control (T_0) –Without addition of turmeric juice
T_1 – With addition of turmeric juice 5 percent in beverage
T_2 – With addition of turmeric juice 10 percent in beverage
T_3 – With addition of turmeric juice 15 percent in beverage

The result of table 1 revealed that there was slight change in color of samples. T_2 observed highest score followed by T_1 and T_3. T_3 scores lower than all the samples due to highly darkened colour and appearance of turmeric-orange RTS beverage, which forced the panel members to rank lower. By comparing scores given by panel members it was clear that color and appearance of beverage depends on amount of turmeric juice added to the beverage.
Selected sample (T_2) scored higher for flavour followed by T_1 and T_3. Sample T_3 was significantly inferior over all, because addition of higher proportion of turmeric juice affects the flavour of the sample. Thus, increase in proportion of turmeric juice was not acceptable by the panel members due to its intense flavour.
Taste of the samples significantly changed with addition of turmeric juice. Selected sample T_2 ranked highest due to significant addition of turmeric juice followed by sample T_1 and T_3. However, T_0 scored the higher due to no addition of turmeric juice and was not acceptable by semi trained sensory panel members. The maximum overall acceptability score was recorded for selected sample T_0 (8.8) followed by sample T_2 (8.6) for color and appearance which was higher than samples T_1 and T_3.
Moreover, among the entire turmeric-orange RTS beverage prepared with turmeric juice sample T_2 containing 10 percent turmeric juice reported the highest score in all the sensory quality attributes and found to be overall acceptable whereas significant difference in sensory score was observed in sample T_3 and T_0.
Moreover, it could also be seen that all the samples were found to be acceptable. The sample T_2 containing 10% turmeric juice was found to be statistically significant over sample T_3 containing 15% turmeric juice. However, sample T_2 and T_1 are found to be statistically at par with each other in color, flavour, and taste except overall acceptability. Considering all the above parameters the selected sample (T_2) was found to be statistically significant over the all samples. Sample T_2 liked very much having moderate acidity content which will fulfil the taste and acceptability requirement for people serving the RTS beverage.

Effects of storage on physicochemical properties of turmeric-orange RTS beverage at ambient temperature (30 °C)
Data pertaining to various physicochemical parameters of turmeric-orange RTS beverage viz. pH, TSS, acidity and ascorbic acid were evaluated at ambient storage up to 90 days of storage were studied and results obtained are given in table 2.

Table 2: Effects of storage on pH, TSS, acidity and ascorbic acid content of turmeric-orange RTS beverage at ambient storage 30 ^{0}C

Storage Days	pH	TSS ^{0}Bx	Acidity (%)	Ascorbic Acid mg/100g
0	3.20	12.00	0.29	32.0
0-30	3.19	12.21	0.30	31.9
30-60	3.16	12.32	0.32	31.8
60-90	3.13	12.56	0.35	31.3

*Each value represents the average of three determinations.

It could be revealed that the increased TSS during storage was probably due to conversion of left-over polysaccharides into soluble sugars. The present findings are in close conformity with the findings of Tripathi *et al*. (1992) [10], who found that the total soluble solids of pineapple and guava blended juice increased continuously during storage period. Similar findings were also reported by Deka *et al*. (2004) [11], who observed that total soluble solids showed an increasing trend throughout the storage period. These results are in good agreement with the findings of Sharma and Singh (2005) [12], who reported that the TSS of lime juice increased with an increase in storage period up to 90 days.
Ascorbic acid (vitamin C) is an important nutrient that possesses antioxidant ability and provides the protection against free radicals Esteve *et al.* (2005) [13]. It is also considered an indicator of the nutritional quality of juices Bull *et al*. (2004) [14]. Storage temperature, type of processing and packaging materials affect the rate of ascorbic acid degradation during storage Ayhan *et al.* (2001) [15]. The ascorbic acid content of the juice decreased significantly during storage with the advancement of storage period, which was probably due to the fact that ascorbic acid being sensitive to oxygen, light and heat was easily oxidized in presence of oxygen by both enzymatic and non-enzymatic catalyst given by Davey *et al*. (2000) [16].

Table 3: Effects of storage on pH, TSS, acidity and ascorbic acid content of turmeric-orange RTS beverage at refrigerated storage 4 ^{0}C

Days	pH	TSS ^{0}Bx	Acidity (%)	Ascorbic Acid mg/100g
0	3.20	12.0	0.29	32.0
30	3.23	12.3	0.28	31.8
60	3.31	12.9	0.25	30.3
90	3.39	13.1	0.22	29.8

*Each value represents the average of three determinations.

The increase in acidity of nectar during storage might be due to formation of organic acids by ascorbic acid degradation as well as progressive decrease in the pectin content. It is also due to formation of acids from sugar.
The reason for decrease in pH might be due to increase in titratable acidity, as acidity and pH are inversely proportional to each other (Bhardwaj and Mukherjee, 2011) [17]. This gradual decrease in pH has a significant effect as lower pH does not allow pathogenic microorganisms to grow and hence acts as a preservative. The decrease in pH was due to increase in titrable acidity which affects the organoleptic quality of juice (Bhardwaj and Mukherjee, 2011) [17]. (Del C. *et al*. 2004) [18] also found a pH increase in citrus segments and juices stored at 4 ^{0}C.
Titrable acidity was shown to be slightly decreased during entire storage. The decrease in acidity may be attributed to conversion of acids into salts and sugars by enzymes particularly invertase. Similar result was found by Tiwari (2000) [19] in guava and papaya blended RTS beverage and Dhaliwal and Hira (2001) [20] in carrot juice blends.
It is evident TSS increased with gradual passage of storage time, which might be due to hydrolysis of polysaccharides into monosaccharide and oligosaccharides. Similar results were also reported by Deka and Sethi (2001) [7].
The decreasing trend of ascorbic acid content with increase in the storage period was found might be due to oxidation of vitamin-C by trapped oxygen in pet bottles, which resulted in formation of dehydro-ascorbic acid and also due to the effect of processing, storage time and exposure to light. It could also be seen that from table 3 and 4 there was slight change in pH,

TSS, acidity and ascorbic acid content of the samples stored at ambient and refrigerated storage.

Similar results were also noted by Mall and Tondon (2007) [21], in guava-aonla blended beverage, Sharma *et al.* (2008) [22], in guava-papaya RTS beverage and Pebam (2010) [23], in aonla products. The losses in ascorbic acid content of fruit beverages have also been noticed by Kumar (1990) [24], in papaya and Rabbani (1988) [25], in mango beverages during storage at ambient conditions. The results are in conformity with the findings of Baramanray *et al*. (1995) [26], who observed that ascorbic acid content in guava nectar decreased significantly with increasing storage period.

Effects of storage on total sugars, reducing sugars and non-reducing sugars of turmeric orange RTS beverage at ambient storage 30 ^{0}C

Data pertaining to effect of storage on reducing sugar, non-reducing sugar and total sugars of turmeric-orange RTS beverage storage at ambient condition are presented in table 4.

Table 4: Effects of storage on total sugars, reducing sugars and non-reducing sugars of turmeric-orange RTS beverage at ambient storage 30 ^{0}C

Days	Reducing Sugar (%)	Non-reducing Sugar (%)	Total Sugar (%)
0	6.72	5.33	12.05
30	7.18	5.32	12.50
60	8.15	5.32	13.47
90	8.24	5.30	13.54

*Each value represents the average of three determinations.

The increase in reducing sugar during storage may be attributed due to gradual inversion of non-reducing sugars to reducing sugar by the hydrolysis process. These results are in close conformity with the findings of Brekke *et al.* (1976) [27], who studied that the decrease in sucrose content in papaya nectar was correlated with an increase in storage temperature and sulphur di-oxide preserved pulp and showed maximum increase in reducing sugar content, whereas, the non-reducing sugar followed a decreasing trend. Tiwari (2000) [19] reported an increase in reducing sugar content during storage of the RTS beverages prepared from guava- papaya blends.

Data from table 4 revealed that the reducing sugar content were ranged from 6.72 to 7.24 percent and varied significantly with respect storage period.

Results shown an increasing trend in reducing sugar with corresponding storage period.

The negligible deviation was observed in case of non-reducing sugar content and was varied from 5.30 to 5.20 percent. Moreover, total sugar content found to be increased as storage advances.

Effects of storage on total sugars, reducing sugars and non-reducing sugars of turmeric-orange RTS beverage at refrigerated storage 4 ^{0}C

Data pertaining to effect of storage on reducing sugar, non-reducing sugar and total sugars of turmeric-orange RTS beverage under refrigerated condition storage are presented in table 6.

Table 5: Effects of storage on total sugars, reducing sugars and non-reducing sugars of turmeric-orange RTS beverage at refrigerated storage 4 ^{0}C

Days	Reducing Sugar (%)	Non-reducing Sugar (%)	Total Sugar (%)
0	6.72	5.30	12.02
30	6.90	5.28	12.18
60	7.15	5.27	12.42
90	7.24	5.20	12.44

*Each value represents the average of three determinations.

From the above table 5 it could be seen that the gradual decrease non-reducing sugar as the storage period increased from 0 days to 90 days i.e. from 5.30 percent to 5.20 percent respectively. The changes in total sugars and reducing sugars are slightly increased as the storage period increased from 0 days to 90 days.

The increase in reducing sugars with the advancement of storage period could be attributed to gradual inversion of non-reducing sugars into reducing sugars in acidic medium. The reducing sugars content increased gradually with the increasing period of storage.

On the 90th day of storage highest reducing sugars was recorded (12.44%) These results are in confirmation with findings of Ranote and Bains (1982) [28] in kinnow juice, Narayanan *et al*. (2002) [29] in clarified banana RTS, Murtaza *et al*. (2004) [30] in strawberry drinks stored at different temperatures. The results showed a progressive and marked increase in total sugars content throughout the storage period. The increase in total sugars might be due to the hydrolysis of polysaccharides like pectin, cellulose, starch, etc. and its conversion into simple sugars. The total sugars content increased significantly up to 60th day and found nonsignificant at end of storage at refrigerated storage.

Microbial load of selected sample of turmeric-orange RTS beverage (T2) on storage at ambient temperature (30 ^{0}C).

Microbial standard for carbonated beverages and ready to serve beverages described as total plate count - not more than 50 cfu/ml, yeast and mold count - not more than 2 cfu/ml and coliform should be absent in 100 ml of sample as per FSSAI.

The prepared turmeric-orange RTS beverage bottles were pasteurized after packaging which resulted in increased shelf life of prepared beverage by reducing the microbial load during storage. Addition of citric acid acts as a preservative by increasing the acidity of prepared RTS beverage that produces unfavorable conditions for the growth of microbes. Similar results were recorded by Carter *et al.* (2007) [31] and Mehmood *et al.* (2008) [32] during study of the effect of pasteurization and chemical preservatives on the quality and shelf stability of apple juice stored at ambient temperature for three months.

Table 6: Microbial loads of selected sample of turmeric-orange RTS beverage (T2) on storage at refrigerated condition (30 ^{0}C).

Storage life (in days)	Total plate count (cfu/ml x 10^3)	Yeast and Mold (cfu/ml x 10^3)	Coliform count (cfu/ml x 10^3)
0	ND	ND	ND
0-30	6	ND	ND
30-60	14	ND	ND
60-90	22	ND	ND

*Each value represents the average of three determinations.

Microbial load of selected sample of turmeric-orange RTS beverage (T2) on storage at refrigerated temperature (4 ^{0}C).

Microbial load present in turmeric-orange RTS beverage stored at refrigeration temperature (4 ^{0}C) are depicted in Table 7 which shows non-significant presence of microbes in the beverage.

The microbial analysis of selected sample of prepared RTS beverage was studied in terms of standard plating in nutrient agar was carried out to determine the quality and safety of prepared beverage. The total microbial load (TPC) of RTS beverage was determined in nutrient agar media of fresh and stored RTS beverage.

7: Microbial loads of selected sample of turmeric-orange RTS beverage (T2) on storage at refrigerated temperature (4 ^{0}C).

Storage life (in days)	Total plate count (cfu/ml x 10^3)	Yeast and Mold (cfu/ml x 10^3)	Coliform count (cfu/ml x 10^3)
0	ND	ND	ND
30	2	ND	ND
60	5	ND	ND
90	12	ND	ND

*Each value represents the average of three determinations.

It could be seen from table 6 and 7 that as the storage period increased during ambient conditions the gradual increasing trend seen in the number of total plate count which increased from 6 cfu/mlx10^3 to 22 cfu/mlx10^3. However, there is no evidence of yeast and mold growth as well as coliform count. Whereas, during refrigeration condition the small increase in total plate count i.e. 2 cfu/mlx10^3 to 12 cfu/mlx10^3 for 30 days to 90 days of storage.

During entire storage period at ambient and refrigerated conditions there is no any evidence of yeast, mold and coliform count in prepared beverage and hence it can be stored without any detrimental changes up to 90 days. However, there is gradual increase in TPC which is under the limit specified by FSSAI.

The deterioration of fruit products is caused by physical, chemical and biological factors. Most significant changes in fruit products are due to biological factors especially micro-organisms. Low temperature during storage produced unsuitable conditions for growth of microbes in prepared product (Onyango *et al.* 2012) [33].

Conclusion

In present investigation efforts were made to develop turmeric based orange RTS beverage with various proportions of added fresh turmeric rhizome juice**.** The study revealed that the organoleptic characteristics of turmeric based orange RTS beverage viz., colour, taste, flavor and overall acceptability were significantly influenced by different recipe treatments**.** It can be finally concluded that turmeric based orange RTS beverage with 90:10 (T1) orange to turmeric received highest sensory score (i.e., 8.6) in case of all sensory attributes. The prepared fresh turmeric rhizome juice-based orange RTS beverage can be stored and consumed safe up to 90 days.

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