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Research Article

Process Optimization for Whey-Based Tomato Soup

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Abstract

Tomato soup is liked for its taste, colour and aroma. While tomato is rich in ascorbic acid and carotene, whey, an effluent from dairy industry with high biological oxygen demand, is rich in protein, vitamins and minerals. Keeping it in view, whey-based tomato soup (WTS) was developed using different levels of whey, tomato pulp and garam masala by evaluating sensory and physical attributes. Further, the starch-based thickener (arrowroot) was replaced with different levels of carrageenan. Soup prepared using whey and tomato pulp in the ratio of 80:20 along with 1.0% garam masala (incorporated by bag method with condiments and spices) gave high scores for flavour (7.6), body- texture (7.8), colour- appearance (7.5) and overall acceptability (7.7). Carrageenan at 0.1 per cent was found to successfully replace arrowroot with overall acceptability score of 7.9. The optimized WTS was hot-filled under aseptic conditions into glass bottles with screw caps and was found to have a shelf-life of 6 days/30 ± 1^{0}C and 18 days/6 ± 1^{0}C.

Keywords: Carrageenan; Soup; Tomato; Viscosity; Whey

Introduction

Tomato (*Solanum Lycopersicum*) is the second most important vegetable crop after potato [1]. It is cultivated in about 809'000 Ha annually in different agro climatic zones of India with an estimated annual production of 20,573,'000 MT with a productivity value of 25.3 MT/Ha for the year 2019 - 20 [2]. India is the second largest producer of tomatoes with 11% share of global production. Fully ripe tomatoes can be stored for a short period of 4 - 7 days even at 5 - 10^0 C. Prolonged storage under refrigeration results in low temperature breakdown. It is a rich source of ascorbic acid, carotene and minerals like potassium and phosphorus [3]. It has been reported to have medicinal properties such as promoter of gastric secretions, blood purifier, and as being useful to the patients of Bronchitis and Asthma. Compositionally, tomato contains carbohydrates (2.44 to 4.70%), protein (0.9 to 1.1), fat (traces to 0.3%) and acids (mainly citric, malic and oxalic acids as 390, 150 and 7.5mg/100g, respectively). It has got a good buffering capacity because of the presence of various salts like Na, Ca, K etc. It is a good source of carotene and fair source of ascorbic acid and nicotinic acid. Its carotene serves as a precursor of vitamin A. Total carotenoids have been reprorted to be 67.43 mg kg$_{-1}$ for Pera-Girona variety and 56.34 mg kg^{-1} for Caramba variety of tomatoes while ascorbic acid was found to be 274.9 mg kg$_{-1}$ and 341.5 mg kg$_{-1}$ for the two varieties, respectively [4]. It also contains appreciable amount of Thiamine (0.1mg/100g) and Riboflavin (0.04mg/100g) along with many bioactive compounds, such as phenolics, which may have synergistic effects on human disease prevention [5,6].

Soup is the assimilation of the fluids of flavours and nutrient and it is served as appetizer before meal. Soup acts as an ultimate comfort food to people sick with cold or flu. With its many different varieties making possible a wide assortment of global and culinary flavours, soup can be considered not only as an indulgence but as an appetizer too. The Indian market for soup has been growing annually at the rate of 26%. Amongst the large variety of soups, tomato soup is the most common and internationally known. FSSAI (2011) allows the use of milk solids in tomato soup, along with other permitted ingredients like spices, sugar, salt, starch and butter. The minimum T.S.S. requirement (w/w free of salt) for tomato soup is 7.0% [7]. Whey is the fluid portion of milk obtained by coagulation of casein during the manufacture of channa, paneer and cheese. It is opaque and greenish yellow in colour. It represents about 80-90 per cent of original milk used for manufacture of cheese, paneer or casein and its composition varies according to the type of product from which it is derived. It contains about 50 per cent of milk solids, 70 per cent of milk sugar and 20 per cent of milk protein. Nearly about 70 - 90 per cent of milk minerals pass on to the whey. It is rich in protein (0.8 - 1.0%), lactose (4.55 to 5.8%), vitamin A, vitamin B_6, Biotin, Vitamin C, organic acids like citric acid, formic acid and minerals [8,9]. Whey proteins have the highest biological value of 104, even higher than the whole egg which is100. Due to Covid-19 outbreak, malnutrition has increased many folds for example, according to the National Family Health Survey (NFHS) 2019-21 [10], in India 7.7% of children are severely wasted, 19.3% are wasted and 35.5% are stunted, and among women 18.7% and among men 16.2% are still below normal BMI (< 18.5Kg/m^2), therefore, wastage of food in any form e.g., 'whey thrown as unused into drains' should be unacceptable. Also, if unused, because of its high biological oxygen demand (35 - 45 kg/m^3) whey poses big threat to the environment. According to an estimate, about 40,000 L of untreated whey can led to contamination of rivers and lakes equal to that produced daily by 250,000 people [9]. Thus, its disposal is of great concern to the environmentalists. World whey output is approximately 180 million tonnes in 2013 which contains some 1.5 million tonnes of increasingly high-value protein and 8.6 million tonnes of lactose, a very important source of carbohydrate for the world [11]. The latest research shows that whey protein is arguably the most nutritionally valuable protein available for the nutritional markets such as sports, clinical and infant nutrition. Packed with full of 'natural goodies' such as beta-lactoglobulin, mother's milk equivalent protein alpha-lactalbumin, lactoferrin, and immunoglobulin and as a pre-cursor to the probiotic galacto oligo saccharides (GOS), whey is proving to be one of the most exciting nutrient sources available today. Therefore, development of whey-based-tomato-soup (WTS) can help solve the problem of its disposal and can supply better nutrition to the health-conscious consumers as tomato soup is liked for its taste, colour and aroma. Further, Carrageenan, a food hydrocolloid, commonly used as functional ingredients in the food industry in the preparation of milk gels and to stabilize milk-based products [12] is tested in the present study for its suitability in WTS to replace arrowroot, a starch-based thickener.

Materials and Methods

Source of materials

Fresh, sweet whey was collected from Student Dairy Plant, Department of Food Science and Technology, G.B. Pant University of Agriculture and Technology, Pantnagar (India). Fresh, firm ripe tomatoes were purchased from the local market, Pantnagar.

Preparation of raw materials

Whey was pasteurized at 70 ± 1^0C for 30 min. and then filtered through muslin cloth followed by cooling to 5^0C. Tomatoes were selected for uniform red colour having no sign of damage or infections. They were then washed with cold running water and then put into boiling hot water for 3.0 min and immediately put into cold water to loosen the skin by thermal shock. Skin and seeds were removed manually, in a separate clean and sanitized pan. Pulp was mashed and heat treated to one boil (hot break method) and then filtered through muslin cloth to obtain the tomato pulp with juice. Similarly, tomato skin and seeds were heated to one boil and extracted through muslin cloth. WTS was prepared as detailed in the flow diagram (Figure 1).

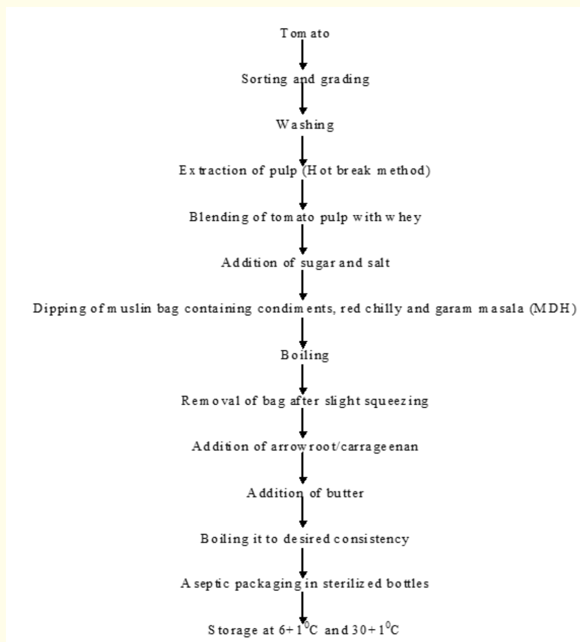

Figure 1: Flow diagram of the preparation of whey tomato soup.

Preparation of different blends of whey-based tomato soup

Effect of different levels of whey, tomato pulp, garam masala (spice mix) and carrageenan on the sensory characteristics (flavour, body and texture, colour and appearance and overall acceptability), viscosity and total soluble solids (TSS) was evaluated to optimize the development of WTS.

Optimization of level of whey

Different blends of whey and tomato pulp was used to prepare whey-based tomato soup. Whey was incorporated to replace 75% to 90% of tomato pulp to develop WTS. For every 100 ml of blend, 2.0g Garam masala, 1.0g sugar, 0.9g salt, 0.75g red chili, 0.75g butter, 0.5g arrowroot and 1.75 g condiments (by Bag method) were used.

Optimization of level of garam masala

To the WTS, developed with the optimized level of whey, different levels of garam masala (0%, 1% and 2%) was added for the study of its effect on sensory acceptability. For every 100 ml of blend sugar, salt, red chili, butter, arrowroot and condiments (by Bag method) used were 1.0 g, 0.9g, 0.75g, 0.75g, 0.5g and 1.75g, respectively.

Replacement of arrowroot with carrageenan

Different levels of Carrageenan (viz. 0.01, 0.05, 0.1, 0.15, 0.3 and 0.5%) were used to replace arrowroot in the optimized WTS.

Analytical procedures

Physico-chemical and sensory analysis of WTS

The samples were analyzed for sensory characteristics viz. flavour, body and texture, colour and appearance and overall acceptability on 9-point Hedonic scale by 10 untrained sensory panelists as given by IS:6273 (Part II) 1971 [13]. For the measurement of Viscosity, samples were taken in 500ml tall beaker and the viscosity was measured with Brookfield viscometer using spindle No.1 at 12 rpm. pH was determined with a combined electrode CL- 51B) Elico pH meter, Model LT-127 and titratable acidity was determined using Phenolphthalein as indicator [14]. TSS was measured with the help of Abbe Refractometer calibrated at 25^{0}C.

Biochemical tests of WTS

Samples were filled hot into sterilized bottles aseptically and kept for storage. The samples were analyzed for different biochemical tests during storage at 6 ± 1^{0}C and 30 ± 1^{0}C at an interval of 5 and 3 days respectively. Non enzymatic browning was determined by AOAC (1995) method [15]. Five gram of sample was soaked in 100 ml of 60 per cent Ethyl alcohol for 12 hr., filtered and the transmittance of filtrate was measured at 440 nm in a spectrophotometer (Make GS 5701 SS) using 60% Ethanol as blank. The results were expressed as% transmittance. Viscosity was measured with the help of viscometer using spindle No.1 at 12 rpm. Vitamin C losses during storage was estimated by 2, 6 Dichlorophenol-indophenol visual titration method [16].

Microbiological tests

WTS were enumerated for the microbial counts. One ml sample was taken aseptically and suspended uniformly in 9 ml sterilized distilled water. From this, further serial dilutions were made and plated in duplicate. Plate count agar media was used to enumerate total plate counts. Plates were incubated at 37 ± 1^{0}C for 24 - 48 h and the no. of colonies were counted [17] using colony counter. For determining Coliform count, samples were plated on violet, red bile agar and incubated at 37 ± 1^{0}C for 18 - 24 hrs and then no. of colonies was counted. Potato Dextrose Agar (PDA) media was used for determining yeast and mould count in the samples. After plating the samples were incubated at 22 ± 1^{0+}C for 3 - 5 days. For estimating Spore count, samples at first dilution were heated at 100^{0}C for 3 - 4 min and then plated on plate count agar media followed by incubation at 37^{0}C for 24 - 48 h. Then the no. of colonies was counted [16].

Statistical analysis

All the experiments were conducted in triplicates and the data was analyzed for ANOVA using MS Excel software (2010).

Results and Discussions

Selection of best combination among whey and tomato pulp

In the developed WTS, tomatoes imparted colour, appeal and flavour while whey added volume, richness of proteins and minerals. Table 1 shows that effect of different per cent of whey and tomato pulp on sensory attributes, viscosity and TSS of whey-based tomato soup. WTS made from 80:20 (whey: tomato pulp) was rated most acceptable by sensory panelists. The higher percentage of whey in WTS had decreasing effect on sensory characteristics and WTS made from 20:80 ratio of tomato pulp and whey had maximum sensory characteristics in terms of flavour (7.58) body and texture (7.7), colour and appearance (7.7), overall acceptability (7.72). The physical characteristics such as viscosity and TSS decreased as the percentage of whey increased in the soup being maximum (22.5cp and 12%, respectively) in 25:75 ratio and lowest in 10:90 ratio (15.0cp and 9.0%, respectively). Statistical analysis showed that flavour, body and texture, colour and appearance and overall acceptability had significant difference ($P < 0.01$) within the treatments.

Tomato pulp: whey (%)	Mean sensory score				Viscosity (cp)	TSS (%)
	Flavour	Body and texture	Colour and appearance	Overall acceptability		
25:75	7.0	7.2	7.6	7.54	22.5	12
20:80	7.58	7.7	7.7	7.72	20.5	11
15:85	6.2	6.9	7.1	7.0	17.5	10
10:90	5.7	6.0	6.6	6.6	15	9
F-value	319.14	167.1	117.3	36.03		
	**	**	**	**		
Sem ±	0.46	0.57	0.49	0.8		
CD at 1%	0.18	0.22	0.19	0.31		
CD at 5%	0.13	0.16	0.14	0.23		
CV	1.86	2.16	1.77	2.92		

Table 1: Effect of incorporation of whey on sensory attributes, viscosity and TSS of WTS.

Optimization of the level of garam masala

Mean sensory scores for WTS with different level of garam masala are given in table 2. WTS with 1.0 per cent garam masala was rated most acceptable (flavour score 7.9) in comparison to sample with 2.0 per cent level of garam masala. It is interesting to note that sensory panelists rated control as better than the sample treated with 2.0 per cent garam masala. This could be attributed to higher intensity of irritating effect due to higher percentage of spices in comparison to other samples. However, different levels of garam masala did not have any effect on viscosity as well as TSS of whey-based tomato soup. Statistical analysis revealed that different levels of garam masala had significant effect on flavour, body and texture, colour and appearance and overall acceptability ($P < 0.01$). On the basis of above experiment it was observed that 1.0 per cent level of garam masala is the optimum level which was selected for use in the further experiments.

Garam masala (%)	Mean sensory score				Viscosity (cp)	TSS (%)
	Flavour	Body and texture	Colour and appearance	Overall acceptability		
0	7.14	7.2	7.3	7.3	20.5	11
1	7.91	7.7	7.8	7.9	20.5	11
2	6.9	7.0	7.0	6.9	20.5	11
F-value	37.6	54.2	58.4	104.6		
	**	**	**	**		
SEm±	0.82	0.48	0.52	0.46		
CD at 1%	0.33	0.19	0.21	0.19		
CD at 5%	0.24	0.14	0.15	0.13		
CV	2.98	1.73	1.86	1.6		

Table 2: Mean sensory score of whey-based tomato soup with different levels of garam masala.

Optimization of different levels of carrageenan

Figure 2 shows that effect of carrageenan on sensory attributes, viscosity and TSS of WTS. Among the various levels of carrageenan used, the sample treated with 0.1 per cent exhibited highest score for flavour (7.8), body and texture (7.5) colour appearance (7.4), overall acceptability (7.9) being lowest in samples treated with 0.5 per cent carrageenan (Table 3). It is apparent from the table that samples treated with carrageenan from 0.01 to 0.15 per cent exhibited steady increase in viscosity whereas samples treated with 0.3 and 0.5 per cent exhibited significant increase in viscosity. The samples treated with carrageenan (0.01 to 0.5%) showed steady increase in TSS. Statistical analysis revealed that different levels of carrageenan had significant effect on flavour, body and texture, colour and appearance and overall acceptability. Among the carrageenan levels used 0.1 per cent level was rated best to improve the sensory score of WTS.

Figure 2: Effect of Carrageenan on sensory attributes of WTS.

Carrageenan (%)	Mean sensory score				Viscosity (cp)	TSS (%)
	Flavour	Body and texture	Colour and appearance	Overall acceptability		
Control	7.4	7.1	7.0	7.0	20	11
0.01	7.0	6.1	6.6	6.2	7.5	7.4
0.05	7.0	6.3	7.1	6.7	15.5	9.2
0.1	7.8	7.5	7.4	7.9	18.5	10.3
0.15	6.8	6.1	6.0	6.2	20.0	11.1
0.3	6.2	5.9	6.0	6.0	50.0	13.5
0.5	5.4	5.6	5.4	5.3	77.5	14.5
F-value	16.63	72.74	56.34	90.51		
	**	**	**	**		
SEm±	0.19	0.79	0.94	0.87		
CD at 1%	0.75	0.3	0.35	0.33		
CD at 5%	0.56	0.22	0.26	0.24		
CV	7.72	3.27	3.8	3.5		

Table 3: Effect of carrageenan on sensory attributes, viscosity and TSS of whey-based tomato soup.

Characteristics of optimized WTS

Whey can be used as substrate to produce industrially important and valuable products e.g., kefir-like-beverages [18,19]. In the present study, the optimized WTS (prepared using whey and tomato pulp in 80:20 ratio with 1.0% garam masala and 0.1% carrageenan and sugar, salt, red chili powder, condiments and butter) had total solids 10.8 per cent, protein 0.89 gm/100gm, fat 2.3 gm/100gm, titratable acidity (TA) 0.56 per cent, pH-4.7, ash-1.23 per cent, total soluble solids (TSS) 9.8 per cent. It was having high overall sensory acceptability value of 7.9.

Sensory, biochemical and microbiological changes in the optimized WTS during storage

During storage at 30 ± 1^0C, WTS was rated acceptable up to 6 days by sensory panel afterwards it was found unacceptable due to higher acidity, unacceptable flavour and fading of colour (Table 4). At 6 ± 1^0C, WTS was rated acceptable upto 15 days of storage. The statistical analysis revealed that flavour, body and texture, colour and appearance and overall acceptability had significant effect ($P < 0.01$) within days of storage at both the storage conditions.

Due to the biochemical changes during storage of WTS at 6 ± 1^0C, the viscosity, non-enzymatic browning and tithable acidity showed an increasing trend in values whereas, pH and vitamin C exhibited decreasing trend. Increase in viscosity (from 20.5 to 25.0 cp) may be attributed to the thickening of soup at lower temperature (Table 4). The changes in WTS were comparatively higher at near ambient storage i. e. 30 ± 1^0C than under refrigeration storage (6 ± 1^0C). Increase in the tithable acidity might be due to the growth of acid producing bacteria. The total plate count (cfu/g) increased from zero to 28 x 10^3 while coliform count remained absent throughout the storage period showing sanitary conditions were observed during processing of whey-based tomato soup.

Temperature	Days	Biochemical attributes					Microbiological Counts			
		NEB	Viscosity (cp)	Vit. C (mg%)	pH	T.A. (%)	TPC	Yeast and mould	Coliform	Spore count
6 ± 1^0C	0	0.081	20.5	42	4.7	0.38	Nil	Nil	Nil	Nil
	5	0.140	22.5	40	4.67	0.38	95 x 10^1	Nil	Nil	Nil
	10	0.147	23.5	38	4.65	0.41	102 x 10^1	Nil	Nil	3 x 10^1
	13	0.293	25.00	32	4.65	0.41	152 x 10^1	6 x10^1	Nil	7 x 10^1
	15	0.312	25.0	30	4.63	0.44	20.3 x 10^2	43 x10^1	Nil	11 x 10^1
	18	0.334	26.00	28	4.63	0.44	95 x 10^2	51 x10^1	Nil	12 x 10^1
30 ± 1^0C	0	0.081	20.5	42	4.7	0.38	Nil	Nil	Nil	Nil
	3	0.122	22.50	42	4.69	0.38	97 x 10^1	Nil	Nil	Nil
	6	0.150	24.00	40	4.66	0.41	166 x 10^1	9 x10^1	Nil	1 x 10^1
	9	0.182	24.50	36	4.66	0.41	20.5 x 10^2	52 x10^1	Nil	5 x 10^1
	12	0.312	25.00	30	4.52	0.44	28 x 10^3	65 x10^1	Nil	8 x 10^1

Table 4: Biochemical and Microbiological changes during storage of WTS.

Conclusion

The unused whey being nutrient rich and having high BOD requirement forms the largest portion of the effluent of dairy industry. The developed WTS containing 80 per cent goodness of whey and 20 per cent goodness of tomatoes scored high sensory acceptability values. The level of incorporation of spice mix (garam masala) was also optimized in the present study. Carrageenan, used as stabilizer, could successfully replace arrowroot. The developed value-added soup was found to have a shelf-life of 6 days/30 ± 1^0C and 18 days under refrigeration. Development of such valuable products like WTS by large scale dairies can help utilize whey, the byproduct of paneer/cheese units and reduce the burden on environment while simultaneously helping to some extent in addressing the issues of prevalent malnutrition.

Conflict of Interest

There is no conflict of interest.

Bibliography

1. Food and Agriculture Organization of the United Nations. Available online at Tomato. Land and Water, Food and Agriculture Organization of the United Nations. Land and Water. Food and Agriculture Organization of the United Nations (2021).
2. NHB. Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India. National Horticulture Board (2021).
3. Vats S., *et al.* "Unexplored nutritive potential of tomato to combat global malnutrition". *Critical Reviews in Food Science and Nutrition* (2020): 1-32.
4. Erba D., *et al.* "Nutritional value of tomatoes (*Solanum lycopersicum* L.) grown in greenhouse by different agro- nomic techniques". *Journal of Food Composition and Analysis, Elsevier* 31.2 (2013): 245-251.

5. Willcox JK., *et al.* "Tomatoes and cardiovascular heath". *Critical Review in Food Science and Nutrition* 43 (2003): 1-18.

6. Slimestad R and Verheul M. "Review of flavonoids and other phenolics from fruits of different tomato (Lycopersicon esculentum Mill.) cultivars". *Journal of the Science of Food and Agriculture* 89 (2009): 1255-1270.

7. FSSAI. Notification. Food safety and standards authority of India, Ministry of Health and Family Welfare. New Delhi (2011).

8. Mohanti AK., *et al.* "Value added products from whey". *Beverage and Food World* 25.1 (1998): 19-26.

9. De Jesus., *et al.* "Biotechnological alternatives for the utilization of dairy industry waste products". *Advances in Bioscience and Biotechnology* 6 (2015): 223-235.

10. National Family Health Survey (NFHS) 2019-21 India.pdf (rchiips.org). Tetrapak International S. A. by Tetra Pak.486 (2021).

11. Bixler HJ and Porse H. "A decade of change in the seaweed hydrocolloids industry". *Journal of Applied Phycology* 23 (2011): 321-335.

12. IS: 6273 (Part II). "Indian standards for sensory evaluation of foods. Methods and evaluation cards. Indian Standards Institute, Manak Bhawan, New Delhi (1971).

13. FSSAI. "Manual of methods of analysis of foods: Milk and milk products". Food safety and standards authority of India, Ministry of Health and Family Welfare. New Delhi.

14. AOAC. "Official methods of analysis. 16th ed". Association of official Analysis Chemists, Washington, D.C (1995).

15. Ranganna S. "Handbook of analysis and quality control for fruits and vegetables products". second ed., Tata McGraw Hill Publication Co., New Delhi (1991).

16. Gililand SE. "Compendium of methods of the microbiological examination of food". Ed. by M. Speck (1976): 107-131.

17. Prazeres AR., *et al.* "Cheese whey management: a review". *Journal of Environmental Management* 110 (2012): 48-68.

18. Karina TM., *et al.* "Production of fermented cheese whey-based beverages using kefir grains as starter culture: Evaluation of morphological and microbial variations". *Bio Resource Technology* 101.22 (2010): 8843-8850.