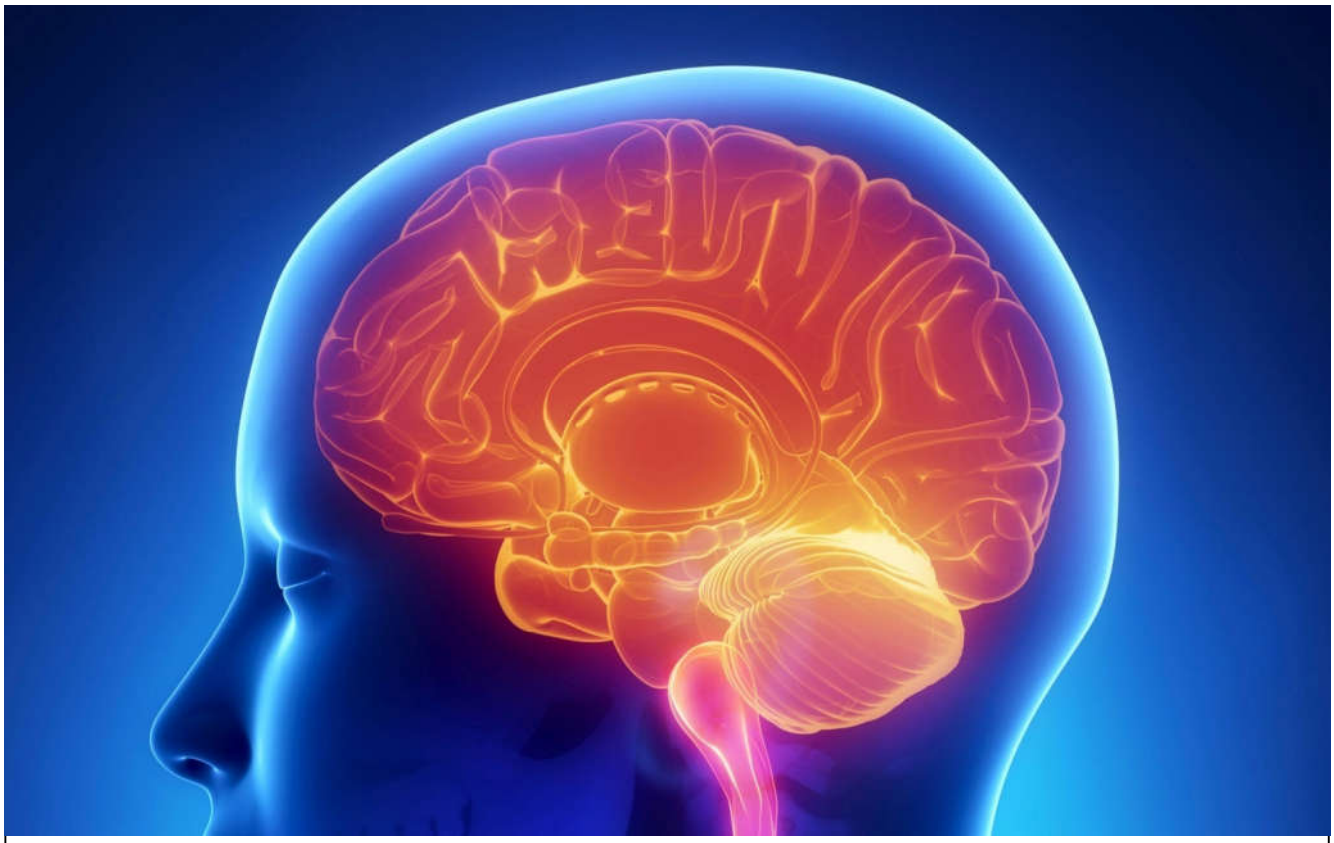

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FORMULATION, NUTRIENT ANALYSIS AND STORAGE STUDY OF PROCESSED TOMATO PRODUCTS

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ABSTRACT

Tomato is considered to be a protective food for its high antioxidant property. Processing and preservation of tomatoes is a dire need during seasons to utilize the thrown out tomatoes due to less selling price. This study aims in developing tomato products using preservation techniques and analyse the basic nutrients present in the formulated products. Products like dehydrated tomatoes, tomato jam, tomato candy, instant tomato bath powder and instant tomato rasam powder were formulated and the recipes standaridised. Organoleptic evaluation was carried for all the formulated recipes for its best acceptability and shelf life. The developed products showed better acceptability with good shelf life of 90 days in the refrigeration temperature and 45 days in the room temperature.

INTRODUCTION

Tomato is an edible, often red berry-type fruit of the nightshade *Solanum lycopersicum*, family commonly known as a tomato plant. There are around 7,500 tomato varieties grown for different purposes. The word "tomato" comes from the Spanish tomate, which in turn comes from the Nahuatl word tomatl. Tomato is warm season crop. It cannot be grown successfully in places of higher rainfall. Warm and sunny weather is most suited for proper ripening, colour, quality and high yield. It is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, salads, drinks etc. At present, it is an important crop cultivated all over the world, and its production and consumption continue to increase.

Tomato is considered a protective food because of its particular nutritive value as it provides important nutrients such as lycopene, beta-carotene, flavonoids, vitamin C and hydroxycinnamic acid derivatives. Tomatoes provide 40% of the daily requirement of Vitamin C, 15% of Vitamin A, 8% of potassium, and 7% of iron (Bhowmik *et al*., 2012) Furthermore, this crop has achieved tremendous popularity in recent years as studies revealed lycopene's anti-oxidative activities and anti-cancer functions (Li *et al*., 2013). It also reduces the risk of kidney stones, helps to keep diabetes in control, and reduces damage caused due to smoking, improving the vision and many more.

The need for tomatoes is tremendously increasing all over the world. The availability of tomatoes varies from season to season. Tomatoes are available during summer at cheaper rates and prices start shooting up during off-season where the production is less and increasing its demand. As tomatoes are perishable, preservation of it using new techniques seems to be very essential. Abundant research work has been carried out on the organic constituents of this fruit while little attention has been paid on the formulation and preservation of tomato products. Hence this study aims at formulation and preservation of tomato products and analyse the basic nutrients available in the developed products and to make it available globally during off-seasons.

LITERATURE SURVEY

Tomatoes possesses number of medicinal properties like antimicrobial, anti-oxidant, cytotoxic properties, anti-ulcerogenic, and hepatoprotective activity (Sultana *et al*., 2014). Lycopene is the main phytochemical in tomato for its strong antioxidative role associated with its ability to act as free radical scavenger from reactive oxygen species (ROS), generated by partial reduction of oxygen (Friedman, 2013)

Lycopene is a polyunsaturated molecule containing 13 double bonds that can exist in *trans* and *cis*-configurations (Figure1). In fresh tomatoes, lycopene is mainly found in *trans*-conformation, while thermal treatments, light, acids, oxygen, and digestion can cause transformation into the more bioactive *cis*-form (Hernandez *et al*., 2013, Boileau *et al*., 2002).

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Figure 1 Structure of Lycopene

Tomato is a potential herbal alternative as anti-cancer agent and its one of the active principle Diosgenin reported to be responsible for this activity (Sultana *et al*., 2014). A number of studies showed that lycopene inhibited the growth of human cancer cells grown in cultures. The growth-inhibitory effects of lycopene were observed not only in lung cancer cells, but also in other cell types, including prostate, breast, hepatoma, stomach, colon and oral cancer cells (Levy *et al*., 1995). In some studies, lycopene has been reported to be more effective as an anticancer agent than α or β-carotene (Paloxxa *et al*., 2010).

High lycopene content in plasma leads to lower rates of gastric cancer. Compared to the intake of other fruits and vegetables, tomatoes have the most consistent and strongest protective effect on gastric cancer (Giovannucci, 2005). Lycopene is thought either to protect prostatic cells from reactive oxygen species or to block Insulin Growth Factor (IGF) mediated cellular proliferation. Lycopene inhibits the growth of benign and malignant prostatic epithelial cells (Sonn *et al*., 2005)

Tomatoes contain large amount of Vitamin A and Vitamin C. These vitamins and β-carotene work as antioxidants to neutralize harmful free radicals in the blood. The ability of tomato lycopene as a natural antioxidant can reduce the lipid oxidation with the same efficiency of synthetic antioxidant (Basuny *et al*., 2009).

An intervention study among the Asian population revealed that Lycopene helps in lowering Systolic Blood Pressure, and hence lycopene or tomato extract can be used as an effective addition for antihypertensive treatment (Li and Xu, 2013). Tomato lycopene could prevent an increase in total and LDL serum cholesterol in high cholesterol fed rats (Figure 3) as also reported by (Kuhad *et al*., 2008).

Studies showed that lycopene content and total anti-oxidant activity significantly increased with thermal processing (Bhowmik *et al*., 2012). This will have a direct impact on consumers food selection and increase the awareness of health benefits of processed fruits and vegetables in the prevention of chronic diseases.

The tomato fruits, like those of many other plant species that are part of our diet, are an important source of substances with known beneficial effects on health, including vitamins, minerals, and antioxidants (Frusciate *et al*., 2007). Indeed, tomato fruit consumption has been associated with a reduced risk of inflammatory processes, cancer, and chronic non-communicable diseases (CNCD) including cardiovascular diseases (CVD) such as coronary heart disease, hypertension, diabetes, and obesity (Canene *et al*., 2005)

METHODOLOGY

Selection of the Sample

For this study fully grown or matured and ripe tomatoes from the Madukkarai block during the months of March to May were selected. Local availability, ease of procurement and low cost formed the secondary criteria for the choice of the ingredients. The selected tomatoes were thoroughly washed preferably in running water to make it free from dirt and soil.

Formulation and Standardisation of Tomato Products

In this study, five products namely dehydrated tomatoes, tomato jam, tomato candy, instant bath powder and instant rasam powder were formulated and the necessary standardization has been done.

Dehydrated Tomatoes: The selected tomatoes were cut into quarter halves and placed in the hot air oven at 70°C for a period of 12-14 hours. Make sure that it is completely dehydrated and packed in air tight containers.

Tomato Jam: The selected fresh tomatoes were allowed to blanch in hot water for 10 -15 minutes and the skin is peeled off. The blanched tomatoes were made into puree and filtered the seeds. The puree was then boiled at a high temperature (100°C). Sugar is added to tomato in the ratio of 1:2.5 and allowed to boil till it reaches the consistency of soft ball stage. The content is cooled and packed in airtight containers.

Tomato Candy: The blanched tomatoes were made into puree and filtered the seeds. The puree was then boiled at a high temperature (100°C). Sugar is added to tomato in the ratio of 1:2 and allowed to boil till it reaches the consistency of hard ball stage. The contents were transferred to a separate tray and made into different shapes when it is still bearable hot.

Instant Bath Powder: Raw materials like dehydrated tomatoes, dry chillies, cumin seeds, fennel seeds, cloves, dehydrated garlic, dehydrated curry leaves, and salt were selected. The selected ingredients were cleaned, dried, roasted and powdered separately. For standardization of the recipe they were tried in different ratios for suitability with its colour, texture, taste, flavor and appearance. The above mentioned combinations were prepared in the Foods Science Laboratory of Amrita Vishwa Vidyapeetham University, Coimbatore, Tamil Nadu.

Instant Rasam Powder: Raw materials like dehydrated tomatoes, dry chillies, cumin seeds, pepper, dehydrated garlic, dehydrated curry leaves and salt were selected for formulation of Instant Rasam Powder. Similar procedure was done for the standardization of the recipe.

Organoleptic Evaluation

Sensory evaluation is a scientific discipline that analysis and measures human responses to the composition of food with respect to its appearance, touch, odour, texture, temperature and taste for the acceptability of food products (Chandrasekhar, 2002).

Sensory qualities of the recipes were assessed by a numerical scoring for sensory quality attributes namely; appearance, colour, flavor, texture, taste and overall acceptability. Evaluation was done by semi-trained panel members of Amrita Vishwa Vidyapeetham University, Coimbatore using 5 point rating scale. The average scores obtained in the acceptability trials were analyzed for the best acceptable and suitable product.

Nutrient analysis

The products were analysed for its nutrient contents like Iron, Phosphorous, Vitamin C and Calcium using the standard procedures adopted from NIN Laboratory manual (Raguramalu *et.al*,. 2003). Triplicate determination for each sample was made and the average obtained was tabulated. The chemicals used for the study were of analytical grade.

Preparation of Test solution: Five grams of the sample was weighed accurately in a platinum or porcelain crucible and heated till all the materials are completely charred. The charred ash is again heated in a muffle furnace for 5-6 hours at about 600°C, cooled. The ash was dissolved in HCl and made up to 100 ml with distilled water. The test solution was further used for the nutrient estimation.

Estimation of Calcium: Calcium was determined by precipitating it as Calcium Oxalate and titrating the Oxalate solution with dilute Sulphuric acid against standard Potassium Permanganate solution

Estimation of Phosphorus: Phosphorous reacts with ammonium molybdate to form phosphomolybdic acid. Phosphomolybdic acid was reduced by the addition of 1, 2, 4 Amino Naphthol Sulphonic Acid (ANSA) reagent to produce blue colour which was apparently a mixture of oxides of molybdenum.

Estimation of Iron: Ferric Iron reacts with ammonium thiocyanate or with Potassium thiocyanate to form ferric thiocyanate which is red in colour. The colour which is a measure of the concentration of iron was measured calorimetrically.

Estimation of Vitamin C: Ascorbic acid, a good reducing agent is oxidised to dehydro ascorbic acid. In the absence of interfering substances, the capacity of an extract of the sample to reduce the standard solution of the dye (2, 6 Dichlorophenol indophenols) as determined by titration is directly proportional to the vitamin C content. Oxalic acid is used to reduce the pH of the extracting medium and it forms complexes with metals preventing the catalytic oxidation, thereby establishing vitamin C content.

RESULTS AND DISCUSSION

Organoleptic evaluation of the formulated products

The scores obtained in the acceptability trials were statistically analyzed for the best acceptable and suitable product and discussed in Table I.

Table I Organoleptic Evaluation of the Formulated Products

Products	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability	Total Score Max : 30
Dehydrated Tomato	4.1±0.1	4.0±0.3	3.9±0.3	4.2±0.1	4.2±0.1	4.2±0.2	24.6
Tomato Jam	4.4±0.2	4.5±0.5	4.3±0.3	4.4±0.3	4.2±0.4	4.4±0.3	26.2
Tomato Candy	4.3±0.5	4.2±0.2	4.3±0.2	4.4±0.4	4.4±0.3	4.3±0.3	25.9
Instant Tomato Bath Powder	4.4±0.2	4.5±0.3	4.5±0.2	4.4±0.5	4.5±0.5	4.5±0.3	26.8
Instant Tomato Rasam powder	4.1±0.1	4.3±0.4	4.0±0.2	4.1±0.4	4.0±0.2	4.1±0.3	24.6

From the table it was observed that instant tomato bath powder with the maximum score of 26.8 and tomato Jam with the maximum score of 26.2 found to the best products with good overall acceptability.

Nutrient Analysis

Table II presents the essential nutrients present in all the formulated tomato products. It is observed that the dehydrated products like dry tomatoes, instant bath powder and instant rasam powder provides more Vitamin A in the form of β-Carotene such as 153.1, 79.2 and 68.4 mg respectively for 100 gm of the developed product. Similarly with regard to the calcium content in the formulated products was higher in the dehydrated products when compared to fresh products like jam and candies. Iron content was 2.6mg for fresh tomatoes whereas it is higher in tomato bath powder and instant rasam powder with 12.6 and 17.6mg per 100 g of the product.

Table II Essential Nutrients of the Formulated Products (100g)

Products	Calcium (mg)	β- Carotene (mg)	Iron (mg)	Phosphorus (mg)
Fresh Tomato	9.8	25.2	2.6	48.5
Dehydrated Tomato	43.2	153.1	5.1	77.1
Tomato Candy	20.5	10.8	1.08	50.2
Tomato Jam	21.1	21.6	2.6	49.5
Instant Tomato Bath Powder	51.6	79.2	12.6	57.4
Instant Tomato Rasam powder	41.3	68.4	17.6	50.8

Shelf life Analysis

Shelf life of the developed products was done in the Food Science Laboratory by examining the products under room temperature and refrigeration temperature. Sensory analysis was carried out by the trained panel members at regular interval of 15 days for a period of 90 days (3 months) for the better acceptability of the products. The average scores obtained were tabulated in Table III a and table III b and discussed below.

From Table III a it was noted that the dry products like dehydrated tomatoes, tomato bath powder and instant tomato rasam powder had a good shelf life and acceptability. Instant tomato bath powder had a good acceptability with an average total score of 21.1 after a period of 90 days and 18.9 for instant rasam powder and only 14.2 for dehydrated tomatoes.

The acceptability wet products like jam and candy was good in the 45th day of sensory evaluation with the average score of 18.7 for tomato jam and candy respectively. Later on the acceptability score decreased as there are no added preservatives.

Table III b gives effect of storage time at refrigeration temperature on the sensory attributes like appearance, flavor, texture, taste and colour of the formulated tomato products.

Table III a Effect of Storage Time At Room Temperature on Sensory Attributes of Tomato Products

Days	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability	Total Score (Max: 30)
Dehydrated Tomatoes							
0	4.1±0.1	4.0±0.3	3.9±0.3	4.2±0.1	4.2±0.8	4.2±0.2	24.6
15	4.0±0.2	4.0±0.1	3.7±0.3	3.9±0.3	4.0±0.2	4.0±0.2	23.6
30	3.5±.0.3	3.6±0.1	3.7±0.2	3.9±0.2	3.5±0.2	3.7±0.2	21.9
45	3.5±0.4	3.5±0.2	3.6±0.2	3.5±0.7	3.0±0.5	3.5±0.3	20.6
60	3.2±0.1	3.1±0.5	3.5±.04	3.4±0.2	2.9±0.6	3.2±0.1	19.3
75	3.1±0.1	3.1±0.3	3.5±0.1	3.1±0.3	2.8±0.2	3.1±0.3	18.7
90	2.8±0.2	2.8±0.2	3.3±0.2	2.8±0.1	2.5±0.1	3.0±0.1	17.2
Tomato Jam							
0	4.4±0.2	4.5±0.5	4.3±0.3	4.4±0.3	4.2±0.4	4.4±0.3	26.2
15	4.3±0.1	4.3±0.2	4.1±0.1	4.2±0.1	4.0±0.2	4.3±0.2	25.2
30	4.1±0.5	4.0±0.1	3.9±0.2	4.1±0.3	3.7±0.1	4.0±0.2	23.8
45	3.7±0.2	3.9±0.3	3.8±0.3	3.7±0.1	3.6±0.3	3.8±0.3	22.5
60	3.5±0.3	3.6±0.1	3.7±0.4	3.5±0.2	3.3±0.2	3.7±0.3	21.3
75	3.3±0.8	3.3±0.2	3.2±0.2	3.3±0.4	3.2±0.2	3.5±0.2	19.8
90	2.9±0.1	3.0±0.3	3.0±0.1	2.9±0.1	2.9±0.1	3.0±0.2	17.7
Tomato Candy							
0	4.3±0.5	4.2±0.2	4.3±0.2	4.4±0.4	4.4±0.3	4.3±0.3	25.9
15	4.1±0.2	4.0±0.2	4.1±0.2	4.3±0.3	4.10.5	4.1±0.2	24.7
30	4.0±0.3	3.7±0.2	4.0±0.3	4.1±0.6	4.1±0.3	4.1±0.1	24.0
45	3.8±0.5	3.5±0.3	3.9±0.2	3.5±0.2	4.0±0.1	3.9±0.3	22.6
60	3.7±0.3	3.1±01	3.5±0.4	3.5±0.1	3.8±0.2	3.5±0.5	21.1
75	3.5±0.1	3.0±0.1	3.3±0.6	3.2±0.1	3.5±0.1	3.5±0.2	20.0
90	3.3±0.1	2.7±0.3	3.0±0.2	3.2±0.3	3.0±0.1	3.0±0.3	18.2
Instant Tomato Bath Powder							
0	4.4±0.2	4.5±0.3	4.5±0.2	4.4±0.5	4.5±0.5	4.5±0.3	26.8
15	4.4±0.1	4.4±0.1	4.5±0.2	4.4±0.2	4.4±0.4	4.5±0.2	26.6
30	4.4±0.2	4.4±0.2	4.4±0.2	4.4±0.2	4.4±0.1	4.4±0.5	26.4
45	4.3±0.6	4.4±.0.1	4.3±0.4	4.3±0.2	4.4±0.5	4.4±0.2	26.1
60	4.3±0.4	4.2±.0.4	4.3±0.8	4.2±0.2	4.3±0.3	4.3±0.3	25.6
75	4.2±0.2	4.2±0.1	4.3±0.4	4.1±0.3	4.3±0.1	4.1±0.1	25.2
90	4.2±0.1	4.2±0.4	4.3±0.1	4.1±0.3	4.3±0.2	4.1±0.2	25.2
Instant Tomato Rasam Powder							
0	4.1±0.1	4.3±0.4	4.0±0.2	4.1±0.4	4.0±0.2	4.1±0.3	24.6
15	4.0±0.2	4.3±0.2	4.0±02	4.0±0.2	3.9±0.2	4.0±0.3	24.2
30	4.0±0.5	4.2±0.5	4.0±0.6	4.0±0.4	3.9±0.4	4.0±0.3	24.1
45	3.9±0.1	4.2±0.4	3.9±0.4	4.0±0.2	3.9±0.1	4.0±0.1	23.9
60	3.8±0.1	4.2±0.2	3.8±0.2	3.8±0.2	3.7±0.2	3.9±0.1	23.2
75	3.7±0.3	4.2±0.1	3.8±0.3	3.8±0.4	3.7±0.2	3.9±0.2	23.1
90	3.7±0.5	4.1±0.2	3.8±0.1	3.7±0.1	3.6±0.2	3.5±0.3	22.4

Table III b Effect of Storage Time at Refrigeration Temperature on Sensory Attributes of Tomato Products

Days	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability	Total Score (Max: 30)
Dehydrated tomatoes							
0	4.1±0.1	4.0±0.3	3.9±0.3	4.2±0.1	4.2±0.1	4.2±0.2	24.6
15	4.0±0.5	4.0±0.2	3.9±0.2	4.1±0.2	4.2±0.1	4.0±0.3	24.2
30	4.0±0.3	3.8±0.3	3.8±0.4	4.1±0.2	4.2±0.5	4.0±0.1	23.9
45	3.5±0.6	3.5±0.4	3.8±0.2	4.0±0.2	4.1±0.6	3.6±0.3	22.5
60	3.6±0.5	3.3±0.2	3.7±0.5	3.8±0.1	4.0±0.4	3.5±0.9	21.9
75	3.3±0.4	3.3±0.3	3.5±0.1	3.5±0.5	4.0±0.5	3.4±0.1	21.0
90	3.0±0.2	3.1±0.1	3.4±.02	3.3±0.1	3.7±0.1	3.4±0.5	19.9
Tomato Jam							
0	4.4±0.2	4.5±0.5	4.3±0.3	4.4±0.3	4.2±0.4	4.4±0.3	26.2
15	4.2±0.4	4.5±0.2	4.3±0.1	4.4±0.2	4.0±0.1	4.4±0.3	25.8
30	3.5±0.2	4.4±0.2	4.2±0.3	4.3±0.3	3.9±0.3	4.2±0.4	24.5
45	3.0±0.3	4.4±0.2	4.0±0.1	4.0±0.7	3.7±0.5	4.1±0.5	23.2
60	3.0±0.1	3.5±0.2	3.8±0.5	3.9±0.4	3.7±0.4	3.9±0.1	21.8
75	2.9±0.2	3.4±0.3	3.4±0.4	3.8±0.5	3.5±0.2	3.6±0.4	20.6
90	2.7±0.2	3.2±0.5	3.2±0.1	3.3±0.2	3.1±0.4	3.2±.0.3	18.7
Tomato Candy							
0	4.3±0.5	4.2±0.2	4.3±0.2	4.4±0.4	4.4±0.3	4.3±0.3	25.9
15	4.3±0.1	4.2±0.4	4.3±0.1	4.4±0.2	4.4±0.4	4.3±0.2	25.9
30	4.2±0.3	4.1±0.1	4.2±0.1	4.1±0.2	4.2±0.3	4.2±0.1	25.0
45	4.2±0.1	3.9±0.3	3.9±0.5	4.0±0.2	3.9±0.4	4.0±0.1	23.9
60	4.1±0.2	3.8±0.3	3.8±0.1	3.8±0.4	3.8±0.4	3.8±0.2	23.1
75	4.0±0.5	3.8±0.2	3.2±0.2	3.6±0.5	3.5±0.3	3.7±0.1	21.8
90	3.9±0.1	3.7±0.1	3.1±0.1	3.3±0.5	3.2±0.1	3.4±0.3	20.6
Instant Tomato Bath Powder							
0	4.4±0.2	4.5±0.3	4.5±0.2	4.4±0.5	4.5±0.5	4.5±0.3	26.8
15	4.3±0.1	4.4±0.2	4.5±0.3	4.4±0.3	4.3±0.1	4.4±0.2	26.3
30	4.3±0.3	4.3±0.1	4.4±0.1	4.3±0.3	4.3±0.2	4.3±0.3	25.9

45	4.3±0.5	4.3±0.2	4.3±0.1	4.3±0.1	4.4±0.2	4.3±0.6	25.9
60	4.2±0.2	4.3±0.5	4.1±0.2	4.3±0.3	4.1±0.2	4.3±0.1	25.3
75	4.2±0.1	4.3±0.2	4.1±0.1	4.3±0.6	4.0±0.1	4.1±0.1	25.0
90	4.2±0.2	4.2±0.1	4.0±0.4	4.3±0.2	4.0±0.6	4.1±0.1	24.8
				Instant Tomato Rasam Powder			
0	4.1±0.1	4.3±0.4	4.0±0.2	4.1±0.4	4.0±0.2	4.1±0.3	24.6
15	4.0±0.2	4.1±0.3	3.9±0.4	4.1±0.2	4.0±0.1	4.1±0.3	24.2
30	4.0±0.3	4.0±0.1	3.8±0.5	4.1±0.2	3.8±0.1	4.0±0.4	23.7
45	3.9±0.1	4.0±0.2	3.7±0.6	4.1±0.1	3.7±0.9	4.0±0.5	23.4
60	3.8±0.5	3.8±0.3	3.7±0.2	3.9±0.2	3.5±0.4	3.9±0.6	22.6
75	3.6±0.3	3.6±0.2	3.3±0.1	3.8±0.1	3.5±0.7	3.6±0.8	21.4
90	3.7±0.3	3.4±0.6	3.3±0.1	3.8±0.2	3.5±0.6	3.5±0.2	21.2

It was clear from the average scores that the acceptability was good for the dehydrated ttomatoes in the 30th day test with an average score of 19.3 and later the acceptability in terms of all the sensory parameters starts decreasing.

With regard to the tomato jam it found to be stable till 45 days with an average score of 19.1 and the tomato candy had acceptability till 60 days with an average score of 19.3. the sensory analysis of tomato bath powder in the 90th day showed a good shelf life and acceptability with an average score of 20.7, whereas in rasam powder the flavor of the product got decreased as the time goes on and was found to be acceptable in the 45th day of sensory test with an average score of 19.4.

CONCLUSION

For processed tomatoes, the consumption pattern had increased in recent days. Tomato being the locally available could be preserved in various methods and even more products could be developed and standaridised. Further studies on the analysis of active components for the developed products could be continued. The formulation of tomato products using various preservation techniques would be beneficial for the community economically during off seasons.

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