STUDIES ON CONSUMER APPEAL PROPERTIES OF TOMATO PUREE PREPARED WITH HERBAL INGREDIENTS

Synopsis submitted to
West Bengal University of Technology
in partial fulfillment of the Degree of
DOCTORATE OF PHILOSOPHY

CHAITALI DUTTA

SCHOOL OF ENGINEERING & TECHNOLOGY
West Bengal University of Technology
BF-142, Salt Lake City, Sector – I
Kolkata-700064, West Bengal, India
CONTENTS

CHAPTER 1 INTRODUCTION
1.1 Tomato and the lycopene present in it
1.2 Changes in lycopene during blanching and processing of tomatoes
1.3 Methods of processing to make the puree from tomato
1.4 Treatment of tomato puree during processing to improve physical and sensory characteristics.
1.5 Improvement of the antioxidant property by using beet root and herbs
1.6 Consumer appeal properties and attitudes towards a new processed food
1.7 Future scope of the treated tomato puree samples

CHAPTER 2 LITERATURE SURVEY
2.1 Impact of blanching on tomato and associated fruits and vegetables
2.2 Influence of processing on the lycopene and physicochemical properties of tomato and its product
2.3 Impact on colour, pH and texture of tomato and tomato products
2.4 Role of beet root and culinary herbs in health and their uses in the processed fruits and vegetables
2.5 Effect of thermal processing on the antioxidant activity of beet root, culinary herbs and other vegetables
2.6 Consumers’ attributes to be considered for processed fruits and vegetables

CHAPTER 3 AIMS AND OBJECTIVES

CHAPTER 4 THEORETICAL ANALYSIS
4.1 Model for visual colour analysis
4.2 Flow Model

CHAPTER 5 MATERIALS AND METHODS
5.1 Preparation of turmeric, lime (CaO) and lemon juice (Citrus lemonii) treated tomato puree
5.2 Preparation of tomato puree mixed with beet puree in different proportions
5.3 Preparation of tomato puree mixed with most available culinary herbs
5.4 List of the equipments
5.5 List of the chemicals
5.6 Photographs

CHAPTER 6 RESULTS, DISCUSSIONS AND CONCLUSION
6.1 Incorporation of turmeric-lime mixture during the preparation of tomato puree
6.2 The effect of turmeric, lime and lemon on the colour and rheological characteristics of tomato puree
6.3 Physical and sensory characteristics of turmeric, lime and lemon juice treated tomato puree
6.4 Studies on colour, pH, rheological properties of the tomato puree treated with the beet root puree
6.5 Effect of turmeric, lime (CaO) and lemon juice on the antioxidant property of the developed tomato puree and herbal fortification of the consumer acceptable product
6.6 Studies on the consumers appeal characteristics of the developed tomato puree samples

CHAPTER 7 CONCLUSIONS
Introduction

1.1. Tomato and the Lycopene present in it


<table>
<thead>
<tr>
<th>Nutrition Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amounts 100 g tomatoes</td>
</tr>
<tr>
<td><strong>Protein &amp; Amino Acids</strong></td>
</tr>
<tr>
<td>Protein – 0.9 g</td>
</tr>
<tr>
<td><strong>Total Carbohydrates</strong></td>
</tr>
<tr>
<td>Total Carbohydrate – 3.9 g.</td>
</tr>
<tr>
<td>Sugars – 2.6 g.</td>
</tr>
<tr>
<td>Dietary fiber – 1.2 g.</td>
</tr>
<tr>
<td><strong>Fats &amp; fatty acids</strong></td>
</tr>
<tr>
<td>Total Fat – 0.3 g.</td>
</tr>
<tr>
<td>Polyunsaturated Fat–0.1 g.</td>
</tr>
<tr>
<td>Total Omega</td>
</tr>
<tr>
<td>3 fatty acids – 4.5 mg.</td>
</tr>
<tr>
<td>Total Omega</td>
</tr>
<tr>
<td>6 fatty acids – 119 mg.</td>
</tr>
<tr>
<td><strong>Water</strong></td>
</tr>
<tr>
<td>94.5g</td>
</tr>
</tbody>
</table>

Lycopene (molecular formula C_{40}H_{56}) is a bright red carotenoid pigment, a phytochemical found in many fruits and vegetables, but excessively found in tomatoes and tomato products. (Gartner, Stahl & Sies 1997)

1.2. Changes in Lycopene during Blanching and Processing of Tomatoes

Lycopene, being lipid soluble carotenoids leaching into water soluble medium during blanching is not significant. However lycopene is sensitive to oxidation and the extent of degradation during processing is dependent on temperature, light, acidity and amount of available oxygen. Thus carotenoids like lycopene are susceptible to loss of provitamin A activity through oxidation during processing. (Processed fruits and vegetables, C R C Press, 1991).

Thermal processing is used in the food industry to preserve food products and maintain the nutritional quality. Moisture content is closely related to lycopene degradation. When moisture is retained, the water soluble compounds will react as catalyst during lycopene degradation. When moisture is retained, the water soluble compounds will react as catalyst during lycopene degradation. Goula et al (2006) reported that degradation of lycopene in tomato pulp was reduced when the moisture content decreased from 95% to 55%, with a minimum degradation rate in between 50 to 55% of moisture content.

1.3. Methods of processing to make the puree from tomato

Tomatoes were washed thoroughly with water by rubbing its surface and rinsing it with running water. The washed tomatoes 100 gm. of each portion were dipped in blanching water (250 ml.) for two minutes until skin split. The turmeric-lime (CaO) mixture was added to the blanching water before dipping the tomatoes in hot water. The hot water consequently turned into brick red colour (due to formation of curcumin) and helped to develop the brightness and colour of red tomatoes.

Next, the tomato puree is treated with different proportions of turmeric and lime poured in the sterile container. Each 50 gm. of treated tomato puree was mixed with 5 ml. of fresh lemon juice (citrus lemonii) and stirred thoroughly.

1.4. Treatment of Tomato Puree during processing to improve physical and sensory characteristics

An attempt has been made to minimize the colour degradation during the time of blanching and to improve the textural property of tomato puree by adding turmeric and quick lime (CaO) mixture in the proportion of 0.02% (w/w), 0.04% (w/w), 0.06% (w/w) in the blanching water of tomato for 1 min, 2 min and 3 min. The temperature for blanching is maintained at 90 – 100°C and blanching for 2 mins has shown the best result in respect to colour and rheology. The turmeric lime treated samples were marked as 2 TL, 4 TL and 6 TL. In presence of lime or alkaline medium the turmeric converted to curcumin, which might be the cause of increase of a value (redness) of tomato puree in comparison to the non treated sample (control), when the mixture of turmeric-lime used at the time of blanching of tomatoes. Lycopene and curcumin are oleoresins, probably due to this reason the treated samples exhibited the better colour in comparison to the non-treated one (control).
1.5 Improvement of the antioxidant property by using beet root and herbs.
Beet root is a low price vegetable and its juice is a convenient way for people to consume a high level of dietary polyphenols. The researchers reported that beet root juice antioxidants are more bioaccessible than those from other vegetable juices and provides a convenient method for increasing polyphenol consumption (Nathan 2011).

To improve the colour, consistency and antioxidant property of the best treated tomato puree sample, it is mixed with the beet root puree in different proportions. The physical and sensory characteristics of each puree sample was evaluated to assess the consumers’ acceptability.

Culinary herbs and spices usually used to season dishes, are an excellent source of phenolic compounds. Deterioration of food quality occurs during processing and storage and is related to oxidative processes. Thereby an attempt has been made to enrich the antioxidant property of treated tomato puree by adding the paste of culinary herbs to bring distinguish flavour and variety in use.

1.6 Consumer appeal properties and attitudes towards a new processed food.
The product developed in this research work includes different types of tomato puree treated with turmeric, lime (CaO) and fortified with lemon juice, beet root puree and culinary herbs like curry leaves, parsley, basil, mint leaves, coriander leaves. These types of developed products introduced a new variety of tomato puree, with the proven characteristics in the traditional market.

We know that turmeric turns into red coloured curcumin in alkaline medium. Therefore to improve the colour of the tomato puree, this innovative idea has been introduced to improve the hue. Along with development of sensory characteristics like colour, texture and flavour, attention was given to develop antioxidant rich, different flavoured tomato puree which may be exploited in the Indian market.

1.7 Further scope of the treated tomato puree samples
The present study dwells on the improvement of physical attributes like colour, flavour, taste of tomato puree by treating the tomatoes with turmeric and lime (CaO) during blanching and by adding lemon juice (Citrus Lemonni) after making the paste of tomato. Other ingredients like beet root puree and grated culinary herbs are added to improve the antioxidant property and variety in use.

There is enough scope of further studies with the treated tomato puree, like the uses of other herbs and analysis of antioxidant property. Along with the herbs, other spices can be used on experimental basis. Other purees like pumpkin, carrot may be added in different proportions for improvement of texture and other physical properties.

Literature Survey

2.1 Impact of blanching on tomato and other fruits and vegetables
Enzymatic reactions are not desirable in ripe fruits and vegetables. Enzyme activity may discolor or toughen vegetables during freezing which results in quality loss during transportation, storage and processing. Blanching is a pre-treatment operation whose aim is to inactivate enzymes such as polyphenolase, peroxidase and pectinase and blanching may induce sensory and chemical changes studied by Lidia Dorautes – Alvarez et al, 2011.

Enzyme inactiveness kinetics and colour changes in garlic (Allum Sativum L.) blanched under different conditions were observed by Luciane Fante et al 2012 and concluded that colour parameter L increased with increase in blanching time, the samples becoming lighter in colour and the parameters a and b decreased.

2.2 Influence of Processing on the Lycopene and Physicochemical properties of Tomato and its products.
The influence of thermal processing on degradation, isomerization and bio accessibility of lycopene isomers in tomato pulp, without adding any other ingredient was studied by Ines Colle et al, 2010. The results confirmed high thermal stability of lycopene in tomato pulp, but the improvement was only significant upon treatment at temperatures of 130 and 140°C. Such intense process conditions may affect other qualities and nutrient parameters.

Tomato (lycopersicon esculentum) is grown extensively throughout India for raw consumption and commercial processing. The physicochemical properties and nutritional composition of two tomato genotypes (HAS – 7 and ARTH – 3) was studied and indicated that there was no significant difference between the two genotypes in carotene content by Aditi Gupta, A. Kavatra and S. Sehgal, 2011.
2.3 Impact on influence of additives for improvement of colour, pH and texture of tomato and other fruits and vegetables.

The combination of physical treatments like use of ultraviolet C, modified atmosphere, ozone treatments and chemical treatments like use of acidic or alkaline electrolyzed water (AcEW), chlorine oxide have proved useful in controlling microbial growth and maintaining quality during storage of fresh-cut produce.

The influence of various sugar solution concentrations on the characteristics of candied dried tomatoes was studied by Wawan Buntaran, 2010. Soaking in a solution of sugar concentration of 40%, 50%, 60% and 70% with 0.2% and CaCl$_2$ as preservatives, were used to make candied tomatoes. It was observed that immersion in 40% solution produced candied dried tomatoes with the best characteristics of taste, flavours, colour and texture.

Tomato juice was prepared with three different additives namely potassium meta-bisulphate (KMS), sodium benzoate, sorbic acid and the effect of chemical additives on the shelf-life of tomato juice was studied by Md. Nur Hossain, Md. Fakruddin and Md. Nurul Islam 2011. There were variations in colour and flavour in prepared juice with three different chemical additives. It was found that Na-benzoate is a better preservative than Potassium Meta bisulphate (KMS) and sorbic acid for tomato juice.

2.4 Role of beet root and culinary herbs in the promotion of health and their uses in processed fruits and vegetables.

The herbs, their active ingredients, biochemical action and herbal formula composition to design anticancer remedy according to the approved pharmaceutical limits for human use was studied by Rakesh Sharma, 2010. Chemically the active components in bioactive herbs are classified as isoprenoid derivatives, phenolic compounds, isoflavones, flavones, carbohydrate derivatives, fatty acids and structural lipids, amino acid derivatives, microbes and minerals. Most of the herbs are biochemical metabolites either by direct intermediary metabolism or regulatory cancer pathways and stimulating immunity.

Neutraceuticals are food product that provides health as well as medical benefits, including the prevention and treatment of disease. Neutraceuticals may range from dietary supplements to genetically engineered foods, herbal products and processed foods. The therapeutic application, adverse effect and interaction of different neutraceuticals were studied by Swati Chaturvedi et al, 2011 and suggested that neutraceutical products are used in prevention of disease but not in cure of disease.

2.5 Effect of thermal processing on the antioxidant activity of beet root, culinary herbs and other vegetables.

The influence of home cooking methods like boiling, microwaving, pressure cooking, frying and baking on the antioxidant activity of vegetables like beet root, green bean, garlic have been studied by A. M. Jimenez et al, 2009. The highest losses were observed in cauliflower after boiling and microwaving, peas after boiling, but beet root, green bean and garlic kept their antioxidant activity after most cooking treatments.

Herbs and spices are one of the most important targets to search for natural antioxidants from the point of view of safety.

The effect of thermal processing on the antioxidant activities and protein of Tom-Kha on galangal coconut soup were determined and studied by Sunisa Siripongvutikorn, 2010. An ingredient of Tom-Kha paste has been addressed as natural antimicrobial and antioxidant activities. Moreover, thermal processing and protein nutrient did not reduce antioxidant activity of the Tom-Kha paste extract and therefore in consuming Tom-Kha soup may promote healthy benefit.

2.6 Consumers’ attributes to be considered for processed foods (fruits and vegetables).

The relationships between the various variables relating to the personal characteristics of the consumers were studied by Phang Ing@ Grace et al, 2010. The study showed that consumers’ food habits and consumers’ willingness to pay play a significant role in the food choice. In this study it has proved that peer influence have no significant relationship with the acceptance of the developed product (seaweed).

New process technologies for the processed food can potentially offer superior advantage in the market place, sometimes manufacturers ignore consumers’ needs and value systems during the new product development (NPU) process. Douglas Sorenson et al, 2011 studied that the consumers were generally receptive towards the concept of high pressure processed chilled ready meals and perceived food safety risks related to high pressure processed foods.
Under the study, products would be prepared with the following aims and objectives:

3.1. Development of bright red coloured tomato puree by adding equal proportion of turmeric and lime (CaO) at the time of blanching of tomatoes. (Colour Improvement)

3.2. Assessment of the colour, textual property of the turmeric, lime (CaO) and lemon juice (citrus lemonii) treated tomato puree samples. (Colour & Texture Improvement)

3.3. Study of the physical and sensory characteristics of the turmeric, lime (CaO) and lemon juice treated puree samples.

3.4. Development and studies on colour, pH, rheological properties of the tomato puree treated with the beet root puree.

3.5. Development of antioxidant rich flavoured treated tomato puree samples with commonly available culinary herbs.

3.6. Studies on the consumers appeal characteristics of the developed tomato puree products.

Theoretical Analysis

4.1. Model for visual colour analysis.

In expressing a rate equation for degradation kinetics, a general equation is written as follows (Levenspiel 1982):

$$\frac{dc}{dt} \propto [C]^n$$  \hspace{1cm} (1)

Where $[C]$ is the concentration of products of the degradation reaction, $t$ is the time of degradation and $n$ is the order of reaction.

By integrating the above equation (1) for $n = 1$, we get,

$$\ln \left( \frac{C}{C_0} \right) = -kt$$ \hspace{1cm} (2)

Where $C_0$ is the measured Hunter colour value (L, a, b) at time zero (dimensionless); $C$ is the measure Hunter colour value (L, a, b) at time $t$ (dimensionless); $k$ = temperature rate constant (min$^{-1}$); $t$ = storage time.

For a reaction following the first order Kinetic model, the plot of $\ln \left( \frac{C}{C_0} \right)$ vs time would be a straight line and the slope would be equal to – $k$ at a constant temperature.

The total colour difference ($\Delta E$) of any sample may be calculated from Hunter-Scotfield equation (Avila & Silva, 1999).

$$\Delta E^2 = (\Delta a)^2 + (\Delta b)^2 + (\Delta L)^2$$

Where L, a, b are the brightness, redness and yellowness of the samples.

4.2. Flow Model:

The power law model with or without yield term describes the flow behaviour of viscous food over wide ranges of shear rate (Vitali and Rao, 1984). The rheological model that has been generally used for non-Newtonian fluids, is the Herschel – Bulkley model (Power Law Model with yield stren term) as shown in equation 3 below:

$$\tau = \tau_0 + k\gamma^n$$  \hspace{1cm} (3)

Where $\tau$, $\tau_0$, $k$, $\gamma$ and $n$ are the shear stress (Pa), yield stren (Pa), consistency index (Pa.S), Shear rate ($S^{-1}$), and flow behaviour index (dimensionless) respectively.
MATERIALS & METHODS

5.1 Preparation of turmeric, lime (CaO) and lemon juice (citrus lemoniii) treated tomato puree

5.1(a). Preparation of tomato puree with turmeric and lime:
Mature red coloured fresh tomatoes (Lycopersicon esculentum) were purchased from the local market in Kolkata. The tomatoes were sorted and washed in clean water. Then each 100gm of tomatoes were blanched at 100°C for short time periods, i.e 1, 2 and 3 min, separately and 0.02g, 0.04g and 0.06g of each of turmeric and quick-lime (CaO) mixture were added to 250 ml blanching water. At a pH>7.5, the yellow colour of curcumin pigment present in turmeric changes to red colour (Stankovic, 2004). The samples were marked as turmeric-lime treated tomato puree of the concentration of 0.02% (w/w), 0.04% (w/w), 0.06% (w/w) respectively. After blanching, the tomatoes were cooled by rinsing in cold water to reduce the surface temperature, (Chiang, et al, 1994) deskinned and cut into two halves. Then the seeds were separated and the pulp was mixed in a Food Processor (Insalsa Appliances Ltd., India) at 5000 rpm for 5 min. The excess water was discarded through a strainer to obtain tomato puree and each sample stored in a sterile glass container (Borosil, India) at 4-5°C in the refrigerator. The samples were marked as turmeric-lime treated tomato puree of the concentration of 0.02% (w/w), 0.04% (w/w) and 0.06% (w/w) respectively.

5.1(b). Preparation of tomato puree with turmeric, lime and lemon-juice (Citrus lemonii):
At first turmeric-lime(CaO) treated tomato puree samples were prepared. Then 5ml of lemon-juice (Citrus lemonii) was added to each of the puree samples to prepare turmeric-lime-lemon juice treated tomato puree samples. Yield-stress evaluation of certain fruits and vegetables is very significant in the presence of citric acid (Tabilo-Munizaga, et.al. 2005).

5.1(c). Control tomato puree sample:
Tomato puree prepared without the addition of turmeric, lime and lemon juice (Citrus lemonii) was considered to be the control sample.

5.2. Preparation of tomato puree mixed with beet puree in different proportions

5.2(a). Preparation of tomato puree:
Matured red coloured fresh tomatoes (lycopersicon esculentum) were purchased from the local market in Kolkata. The tomatoes were sorted and washed in clean water. Then 200g of tomatoes were blanched in 500ml. of water at 100°C for 2 minutes and 0.04g of each of turmeric and quick-lime (CaO) mixture were added to 500 ml blanching water. At a pH>7.5 the yellow colour of curcumin pigment present in turmeric changes to red colour (Stankovic, 2004). After blanching, the tomatoes were cooled by rinsing in cold water to reduce the surface temperature,(Chiang, et al,1994) deskinned and cut into two halves. Then the seeds were separated and the pulp was mixed in a Food Processor (Insalsa Appliances Ltd., India) at 500 rpm for 5 minutes. The excess water was discarded through a strainer to obtain tomato puree and each sample stored in sterile glass container (Borosil, India) at 4-5°C in the refrigerator.

5.2(b). Preparation of beet puree:
Soft matured purple coloured beet root (betalains) were purchased from the local market in Kolkata. The beet roots were sorted and washed in clean water. Then 200g of beet roots were blanched in 500ml. of water at 100°C for 5 to 8 minutes. The beet roots were cooled by rinsing in cold water to reduce the surface temperature (Chiang et al, 1994) after blanching and the skin rubbed off from the beet and sliced for making paste in a Food Processor (Insalsa Appliances Ltd., India) at 500 rpm for 5 minutes. The mixture was then heated over low heat for 5 minutes with simultaneous thorough mixing.
5.2(c) Preparation of beet puree based tomato puree:

A new type of puree is developed by mixing beet puree and tomato puree in different proportions. The proportion in the mixture of tomato puree and beet puree were in the ratio of 9g tomato puree:1g beet puree, 8g tomato puree:2g beet puree, 7g tomato puree:3g beet puree, 6g tomato puree:4g beet puree, 5g tomato puree:5g beet puree, 4g tomato puree:6g beet puree, 3g tomato puree:7g beet puree, 2g tomato puree:8g beet puree and 1g of tomato puree:9g of beet puree.

5.2(d) Preparation of Control:

The pure tomato puree treated with turmeric and lime (CaO) were considered as Control A and pure beet puree as Control B.

5.3 Preparation of tomato puree mixed with commonly available culinary herbs.

5.3(a) Preparation of tomato puree with turmeric, lime and lemon:

Mature red coloured fresh tomatoes (Lycopersicon esculentum) were purchased from the local market in Kolkata. The tomatoes were sorted and washed in clean water. Then each 100gm of tomatoes were blanched at 100°C for a short time period, i.e 2 min. 0.04g of turmeric and quick-lime (CaO) mixture were added to 250 ml blanching water. At a pH>7.5, the yellow colour of curcumin pigment present in turmeric changes to red colour (Stankovic, 2004).

After blanching, the tomatoes were cooled by rinsing in cold water to reduce the surface temperature, (Chiang, et al, 1994) deskinned and cut into two halves. Then the seeds were separated and the pulp was mixed in a Food Processor (Inalsa Appliances Ltd., India) at 5000 rpm for 5 min. The excess water was discarded through a strainer to obtain tomato puree and the sample stored in a sterile glass container (Borosil, India) at 4-5°C in the refrigerator. The sample was marked as turmeric-lime treated tomato puree of the concentration 0.04% (w/w). Then 5ml of lemon-juice (Citrus lemonii) was added to the puree sample to prepare turmeric-lime-lemon juice treated tomato puree sample and named as 4TLL.

5.3(b) Preparation of herbal treated tomato puree

The fresh herbs basil, coriander, mint, curry and parsley were taken and washed thoroughly with clean running cooled boiled water and then grated separately. Then each type of herbs viz. basil, coriander, mint, curry and parsley were mixed (25mg of each grated herbs in 50g of tomato puree) uniformly in the sample 4TLL.

5.3(c) Control tomato puree sample:

Tomato puree prepared without the addition of turmeric, lime, lemon juice (Citrus lemonii) and herbs was considered to be the control sample

5.4 LIST OF THE EQUIPMENTS

1) Food Processor (Inalsa Appliances Ltd., India).
2) pH Meter (Systronics, India, Model No. 355).
3) Hunter Lab Colour Measurement System (Model Colour Flex 45/0, Hunter Association laboratory, Inc.).
4) Rheometer (Anton Paar, Model Physical MCR 51, Germany).
5) Soxhlet Apparatus.
6) Kjeldahl Flask.
7) Kjeldahl’s Distillation Apparatus.
8) Silica Cruceble.
9) Muffle Furnace.
10) Spectrophotometer.
5.5 LIST OF THE CHEMICALS
1) Calcium Oxide (CaO)/ Quick Lime.
2) Petroleum Ether.
3) Digestive Mixture (100ml Saturated Potassium Sulphate+100ml. Nitrogen free Sulphuric Acid and 200mg of Copper Sulphate).
4) 40% NaOH solution in water.
5) 2% Boric Acid solution in water.
6) N/10 Sulphuric Acid solution.
7) Bromocresol Green.
8) Ethanol (Analytical grade).
9) DPPH (1,1-Diphenyl 2-Picrylhydrazyl).

6.1. Incorporation of turmeric-lime mixture during the preparation of tomato puree

Retention of natural pigment is one of the symbols of livelihood. Thermal treatment is one of the most important methods of preservation of vegetables (Lund, 1975). Thermal processing inactivates pathogens and other microorganisms and also improves the bioavailability of lycopenes since it breaks down the cellulose structure and plant cell. However, unfortunately thermal processing is also responsible for the degradation of red coloured lycopene pigment present in tomatoes. Therefore discolouration during thermal processing (blanching) renders tomato puree unmarketable and leads to poor consumption.

To compensate the reduction of red colour of tomato puree during its preparation, an attempt is made by adding equal proportion of turmeric and lime at the time of blanching of tomatoes. The objective of this paper is to intensify the colour of tomato puree for its better use and consumption. Another objective of this research work is to measure the rheological characteristics of fortified tomato puree as fortification of turmeric-lime mixture might be responsible for the appetizing characteristics of tomato puree such as colour and consistency (rheology).

Results And Discussions

Colour and rheology of tomato puree are important appetizing properties of tomato puree. It was observed from Figures 6.1.1 and 6.1.2 that the colour parameters; L and a values of both the control and treated samples increased with the time of blanching and a value of the treated samples were significantly (P < 0.05) higher than the corresponding control samples. However, b (i.e. yellowness of the samples) of the treated samples decreased with increasing of blanching time and was significantly (P < 0.05) lower than the corresponding control samples (Figure 6.1.3). This finding indicated that the treatment with turmeric and lime increased the redness of the tomato puree. In alkaline medium (due to presence of lime), the yellow coloured curcumin pigment of turmeric turns into red and the addition of turmeric-lime mixture in the blanching water of tomato puree preparation minimizes the conversion of trans-form of lycopene (red coloured tomato pigment) into cis-form of lycopene (yellow coloured pigment in tomato) and minimizes the cause of discoloration.

Rheology of tomato puree products can be measured in terms of yield stress (in Pascal unit) and data were fitted by Herschel Bulkley model. The yield stress, regression coefficients and corresponding R (percentage of model fitness) of different tomato puree samples were shown in Table 6.1.3. It was observed that the yield stress of both the treated and control samples decreased with blanching time. However, of 2 min-blanchered puree showed no significant (P < 0.05) difference of yield stress value from 1 min-blanchered tomato puree products.
Table 6.1. 3. Yield stress values and corresponding Model-fitting parameters of different tomato puree products.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Blanching time (min)</th>
<th>Regression coefficients</th>
<th>Regression (%)</th>
<th>Yield stress (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>a</td>
<td>B</td>
<td>p</td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td>102.27</td>
<td>-0.09</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>90.25</td>
<td>-18.18</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>86.73</td>
<td>-2.36</td>
<td>0.61</td>
</tr>
<tr>
<td>Treated</td>
<td>1</td>
<td>132.94</td>
<td>-12.22</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>126.84</td>
<td>-0.41</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>112.45</td>
<td>-2.68</td>
<td>0.68</td>
</tr>
</tbody>
</table>

<sup>a</sup><sup>b</sup> Different letters corresponds to the same type of samples differ significantly (P < 0.05).

Figure 6.1.1. L-value colour parameter of tomato puree samples. <sup>a</sup> – <sup>b</sup> Different letters corresponds to the samples of a particular blanching time differ significantly (P < 0.05)

Figure 6.1. 2. a-value colour parameters of tomato puree samples. <sup>a</sup> – <sup>b</sup> Different letters corresponds to the samples of a particular blanching time differ significantly (P < 0.05).

Figure 6.1. 3. b-value colour parameter of tomato puree samples. <sup>a</sup> – <sup>b</sup> Different letters corresponds to the samples of a particular blanching time differ significantly (P < 0.05).
6.2 The Effect of Turmeric, Lime and Lemon on the Colour and Rheological characteristics of Tomato Puree

Tomato puree is a processed food usually consisting of only tomatoes. However it may also consist of different other additives viz. sodium chloride, citric acid etc. Tomato puree can be used as a direct replacement of raw tomatoes in all types of cooked food products. It is also used in the production of tomato juice, ketchup, sauces, soups, curries etc.

Tomato contain lycopene which is an acyclic isomer of β-carotene which show a distinct colour shift during thermal processing as heat induces cis-trans isomerisation reaction (Klaui & Bauernfeind, 1981), oxidation to epoxy carotenoids and apocarotenals (Rodriguez-Amaya, 1999) and even hydroxylation (Marty & Bersit, 1988). The level of cis-isomers increases as treatment time increases but only for a short period during the beginning of the treatment (Shi et al. 2003). The redness of tomato depend upon the concentration of trans-form of lycopene pigment.

To compensate the reduction of red colour of tomato puree during its preparation, an attempt is made by adding equal proportion of turmeric and lime in water at the time of blanching of tomatoes and lemon juice in tomato puree. The different sources and concentration of calcium oxide, calcium chloride and calcium sulfate application were found (Subbiah and Perumal, 1990) to be better to improve lycopene (responsible for the colour of the tomato fruit), ascorbic acid content and firmness index of tomato fruit. Enzymatic inactivation may be one of the causes of discoulouration, and loss of colour is influenced by pH, acidity etc (Garcia et al, 1999). Again there is evidence that citric acid addition can improve the colour retention of garlic puree (Maga and Kim, 1989). The various factors affecting the rheological behaviour of fruit purees include temperature (Holdsworth, 1971; Vitali & Rao, 1984; Oomah et al, 1999); concentration (Harper & El-Sahrigi, 1965; Ilicali, 1985) & pH (Dik & Ozilgen, 1994).

The objective of this study is to compensate the degradation of the red colour of tomato puree during blanching with the use of turmeric, lime and lemon juice (Citrus lemonii).

Addition of these ingredients also lead to maximum bio-availability, intensified colour and better texture of the product developed.

RESULTS & DISCUSSIONS

Characteristics of Control tomato puree

It was observed that variation in blanching time had no influence on pH, soluble solid content and visual colour of control tomato puree. However, the texture (measured as yield stress in Pa) of pure tomato puree sample decreased significantly (P<0.05) with increasing blanching time.

pH of treated-tomato puree

It was noted that the pH of turmeric-lime treated puree significantly (P<0.05) increased with increasing additive concentration. This may be due to the alkaline effect of lime. However, the pH of turmeric-lime-lemon juice treated puree product decreased significantly (P<0.05) due to the acidic effect of lemon juice, which was used to compensate the alkalinity of the turmeric-lime treated product.

Colour of tomato puree

During thermal processing (blanching) it was observed that all the three Hunter values L, a and b increased with time at a fixed blanching temperature of 100°C (Fig 6.2.1, Fig 6.2.2, and Fig 6.2.3). The tomato puree samples at initial blanching time had a, b and L values of 18.63, 11.45, 27.34 respectively (data not shown in Table) and are denoted as L_o, a_o and b_o respectively. Control tomato puree products had a-values of 20.80, 22.66, 24.79; b-values of 12.11, 12.63, 12.70; and L-values of 26.89, 27.00, 27.20 (values not shown in Table) at 1min, 2min and 3 min blanching time respectively. a-value (redness) and b-value (yellowness) of tomato puree increased with the increase in blanching time, which might be due to the softening of tomato tissues and degradation of lycopene with blanching time. However addition of turmeric-lime mixture during blanching controlled the degradation of red colour as observed by the increase of a-value (Fig. 6.2.1) in turmeric-lime treated and turmeric-lime-lemon juice treated samples. Again it was noted that turmeric-quick lime-lemon juice treated samples had higher a-value compared to the corresponding turmeric-lime treated samples. Higher a-value i.e. redness of turmeric-lime treated samples compared to the corresponding control samples might be due to the additional redness of curcumin pigment (present in turmeric) in alkaline medium (quick lime, pH>7). Both curcumin and lycopene are oleoresins, which dissolve in each other. Lemon juice was added to turmeric-lime treated samples after blanching to partially neutralize the
alkalinity of the medium which also increases the brightness and yield stress of the product (Plaza et. al., 2003)

**Rheological behaviour of tomato puree**

Rheology of tomato puree products can be measured in terms of yield stress. Table 6.2.6 shows the change in textural properties in terms of yield-stress (Pa) value. It was observed that yield-stress values of tomato puree samples were affected significantly (P<0.05) by blanching treatments, blanching time and additive concentrations, both individually as well as the interactive effects of these factors. With change in additive concentrations, yield-stress values changed significantly (P<0.05). The values of yield-stress in different puree samples were in the range of 30.52 Pa – 125.99 Pa.

**Table 6.2.6 Variation of texture (Yield Stress, Pa) in different tomato puree samples**

<table>
<thead>
<tr>
<th>Additive concentration (%)</th>
<th>Type of blanching treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turmeric + Lime (blanching time in mins)</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>0.02</td>
<td>cy</td>
</tr>
<tr>
<td>0.04</td>
<td>by</td>
</tr>
<tr>
<td>0.06</td>
<td>ax</td>
</tr>
</tbody>
</table>

**Source of variance**

<table>
<thead>
<tr>
<th></th>
<th>Degrees of freedom</th>
<th>Sum of square</th>
<th>Mean sum of square</th>
<th>F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>89</td>
<td>62709.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor A</td>
<td>1</td>
<td>2266.53</td>
<td>2266.53</td>
<td>18731.65*</td>
</tr>
<tr>
<td>Factor B</td>
<td>2</td>
<td>24345.90</td>
<td>12172.95</td>
<td>100602.89*</td>
</tr>
<tr>
<td>Factor C</td>
<td>2</td>
<td>32437.86</td>
<td>16218.93</td>
<td>134040.74*</td>
</tr>
<tr>
<td>A x B</td>
<td>2</td>
<td>162.66</td>
<td>81.33</td>
<td>672.15*</td>
</tr>
<tr>
<td>A x C</td>
<td>2</td>
<td>312.66</td>
<td>156.33</td>
<td>1291.98*</td>
</tr>
<tr>
<td>B x C</td>
<td>4</td>
<td>2552.12</td>
<td>638.03</td>
<td>5272.98*</td>
</tr>
<tr>
<td>A x B x C</td>
<td>4</td>
<td>623.30</td>
<td>155.83</td>
<td>1287.85*</td>
</tr>
<tr>
<td>Error</td>
<td>72</td>
<td>8.70</td>
<td>0.121</td>
<td></td>
</tr>
</tbody>
</table>

*abc: Different superscripts in a row have significantly (P<0.05) different values.

*xyz: Different superscripts in a column have significantly (P<0.05) different values.

***Factor A, B, C: three factors were the type of blanching treatment, blanching time and additive concentration.

****Values higher than LSD value

------------------------------------------------------------------------------------------------------------------
Fig. 5.1. L-value colour parameter of different tomato puree samples.

Fig. 5.2. a-value colour parameter of different tomato puree samples.

Fig. 5.3. b-value colour parameter of different tomato puree samples.
6.3 Physical and Sensory Characteristics of Turmeric, Lime (CaO) and Lemon Juice Treated Tomato Puree

Lycopene is the red coloured pigment abundantly found in red coloured fruits and vegetables such as tomato, papaya, pink grapefruit, pink guava and watermelon. This red coloured pigment was first discovered in tomato by Millardet in 1876. It was later named lycopene by Schunck (1993). Lycopene is a phytochemical nutrient element that is found in many fruits and vegetables but excessively found in tomatoes and tomato products.

Tomato puree is such a processed food of ripe tomatoes from which most of the tomato based products [tomato-ketch-up, tomato sauce, tomato soup] can be made as and when required. Thus, a bright red coloured tomato puree is developed with the addition /treatment of turmeric in presence of lime during blanching. Considerable research work has been done on developed tomato puree. This study investigates physical and sensory characteristics of developed Tomato puree, formulated with six levels of tomato puree with and without lemon juice and the results are compared with the conventional tomato puree.

As the tomato puree is a processed product of tomato, therefore the amount of fat present in it is very negligible. An accurate by weighed amount of the finely divided of all samples were taken in a porous thimble. Then these thimbles containing the materials were introduced into the extraction chamber of the Soxhlet apparatus and then sufficient amount of the solvent is poured (petroleum ether) into the chamber for siphoning down of the solvent. The distillate was removed from each samples by distillation and finally the flask weighed with the fat left in it.

For the estimation of protein certain quantity of each sample were taken in the Kjeldahl flask and 5 ml of digestive mixture (containing 100ml saturated potassium sulphate+100ml.nitrogen free sulphuric acid and 200mg of copper sulphate) was added. Then the of each sample was heated for two hours with a low flame until a clear solution was obtained. After cooling the solution of each sample was transferred into a 100ml volumetric flask quantitatively and the volume made up with nitrogen free distilled water. 10 ml of this diluted solution taken in the distilling chamber through a funnel, in the Kjeldahl’s distillation apparatus followed by 15 ml to 18 ml 40% NaOH to make the solution strongly alkaline.

The distillation process was continued till all the ammonia passed over into the measured quantity of 2% Boric acid and titrated with N/10 Sulphuric acid which was standardized previously. The indicator used was Bromocresol Green.

1 ml N/10 H2SO4=0.28mg of N
To get the percentage of protein, the percentage of Nitrogen was multiplied by 6.25. If X ml. of standard \(\text{H}_2\text{SO}_4\) is required to neutralize, and W be the weight of the Substance, then the Protein content in percentage can be calculated.

\[
\frac{X \times 100 \times 6.25 \times F \text{ of the Standard } \text{H}_2\text{SO}_4}{W \times 1000}
\]

A weighed amount of the control and treated samples were taken in a Silica Crucible and placed in a muffle furnace at about 550\(^0\) C to 600\(^0\)C to make complete white ash and weighed to detect the ash content of the samples. The carbohydrate content of the control and the treated samples were calculated from the total calorific value of the Tomato Puree and the calorie derived from the estimated fat and protein. Therefore, the protein content of puree samples were measured by Kjeldahl method and fat content by Soxlet method. Proximate analysis of all the samples have been done to check the changes in nutritive value, i.e. protein, fat and carbohydrate content of the control and treated samples and found that all the changes vary insignificantly.

**Microbial Analysis:** Plate count method (AOAC, 1990) was used for determination of total viable bacterial cell. A Colony counter (ICT, India) was used for counting the viable bacterial cells. It has been noticed that the total count after a week for control 1.74cfu/ml, for 2TL 2.08 cfu/ml, for 4TL 1.85cfu/ml, for 6TL 1.7cfu/ml, for 2TLL 1.54cfu/ml, for 4TLL 1.78cfu/ml and for 6TLL 2cfu/ml. On the contrary the growth rate after two weeks are for control 2.24cfu/ml, for 2TL2.46cfu/ml, for 4TL 2.4cfu/ml, for 6TL 2.36cfu/ml, for 2TLL 2.22cfu/ml, 2.08cfu/ml, for 6TLL 2.36cfu/ml. Similarly after three and four weeks, changes occurred in control and treated samples is negligible in comparison to the first two weeks.

**SENSORY EVALUATION:** Recruitment, selection and training of panelists (18), from among students, staffs and faculty members of food technology department of Jadavpur University, Kolkata, India, were performed following standard sensory evaluation procedures.

**TABLE: 6.3.2. - Proximate Analysis Treated Tomato Puree**

<table>
<thead>
<tr>
<th>Properties</th>
<th>Control</th>
<th>2TL</th>
<th>4TL</th>
<th>6TL</th>
<th>2TLL</th>
<th>4TLL</th>
<th>6TLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture%</td>
<td>35.8</td>
<td>35.01</td>
<td>34.82</td>
<td>34.86</td>
<td>35.06</td>
<td>34.9</td>
<td>34.96</td>
</tr>
<tr>
<td>Fat%</td>
<td>0.16</td>
<td>0.12</td>
<td>0.15</td>
<td>0.19</td>
<td>0.16</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Protein%</td>
<td>1.6</td>
<td>1.62</td>
<td>1.66</td>
<td>1.69</td>
<td>1.64</td>
<td>1.6</td>
<td>1.63</td>
</tr>
<tr>
<td>Carbohydrate%</td>
<td>8.04</td>
<td>8.09</td>
<td>8.13</td>
<td>8.01</td>
<td>8.09</td>
<td>8.19</td>
<td>8.06</td>
</tr>
<tr>
<td>Ash Content%</td>
<td>0.52</td>
<td>0.54</td>
<td>0.56</td>
<td>0.54</td>
<td>0.56</td>
<td>0.56</td>
<td>0.57</td>
</tr>
</tbody>
</table>
Table: 6.3.5-Microbial Analysis of Treated Tomato Puree Sample

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>0 week</th>
<th>1 week</th>
<th>2 week</th>
<th>3 week</th>
<th>4 week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td>1.74</td>
<td>2.24</td>
<td>2.46</td>
<td>2.62</td>
</tr>
<tr>
<td>2TL</td>
<td>0</td>
<td>2.08</td>
<td>2.46</td>
<td>2.61</td>
<td>2.7</td>
</tr>
<tr>
<td>4TL</td>
<td>0</td>
<td>1.85</td>
<td>2.4</td>
<td>2.65</td>
<td>2.75</td>
</tr>
<tr>
<td>6TL</td>
<td>0</td>
<td>1.7</td>
<td>2.36</td>
<td>2.57</td>
<td>2.68</td>
</tr>
<tr>
<td>2TLL</td>
<td>0</td>
<td>1.54</td>
<td>2.22</td>
<td>2.42</td>
<td>2.57</td>
</tr>
<tr>
<td>4TLL</td>
<td>0</td>
<td>1.78</td>
<td>2.08</td>
<td>2.38</td>
<td>2.49</td>
</tr>
<tr>
<td>6TLL</td>
<td>0</td>
<td>2</td>
<td>2.36</td>
<td>2.54</td>
<td>2.64</td>
</tr>
</tbody>
</table>

Table: 6.3.6-Sensory Analysis of Treated Tomato Puree Samples

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>CONTROL</th>
<th>2TL</th>
<th>4TL</th>
<th>6TL</th>
<th>2TLL</th>
<th>4TLL</th>
<th>6TLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>5.0</td>
<td>4.5</td>
<td>4</td>
<td>3.5</td>
<td>3</td>
<td>2.67</td>
<td>2.67</td>
</tr>
<tr>
<td>Flavour</td>
<td>5.0</td>
<td>5.0</td>
<td>5</td>
<td>5.33</td>
<td>4.5</td>
<td>4.43</td>
<td>5.11</td>
</tr>
<tr>
<td>Taste</td>
<td>5.5</td>
<td>5.3</td>
<td>5</td>
<td>5</td>
<td>3.5</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>4.17</td>
<td>4.5</td>
<td>4.5</td>
<td>4.67</td>
<td>4</td>
<td>3.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>4.67</td>
<td>5.5</td>
<td>5.58</td>
<td>5.65</td>
<td>5</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>Overall</td>
<td>5</td>
<td>4.83</td>
<td>4.5</td>
<td>4.5</td>
<td>4</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TREATMENT TOTAL</td>
<td>29.34</td>
<td>29.63</td>
<td>28.58</td>
<td>28.65</td>
<td>24</td>
<td>22.4</td>
<td>26.28</td>
</tr>
</tbody>
</table>

6.4. Studies on the Colour, pH, Rheological characteristics of Tomato Puree samples prepared with the addition of Beet Root Puree

Red Beet is one of the highest natural vegetable sources for folates and provides a nutritious and colorful (red) vegetable ingredient for a wide variety of food and beverage products. Beets are also a great source of fiber and minerals like manganese, potassium, magnesium, iron and copper. Beet is a unique source of phytonutrients called betalains

A new type of tomato puree is developed with the addition of beet puree in different proportions. Considerable research work has been done on developed tomato-beet puree and compared amongst the formulation in respect to the colour, fluidity and sensory analysis

Results & Discussions:

**Colour**: It was observed that the Hunter value viz. L and b decreased with increasing proportion of beet in mixed puree samples. However, the redness parameter viz. a value increased with increasing proportion of beet puree. This might be due to the higher concentration of betalain in beet than the lycopene in tomato.

**pH**: It has been observed from Fig.6.4.2 that the pH of treated pure tomato puree was 4.28 and the pH increased up to 6.09 with the addition of beet puree which is not a favourable and acceptable pH of the processed food product. Thus with the increase concentration of beet puree, the acidity as well as the sourness of the mixed tomato beet puree decreases.

**Rheological characteristics**: Rheology of different tomato and beet mixed puree samples can be measured in terms of yield stress. Fig.6.4.1 shows the change in texture properties in terms of yield stress (\(\rho_a\)) value. It was observed that the yield stress of puree samples were affected significantly with increasing proportion of beet in the mixed tomato beet puree samples. The values of yield stress shown in Fig.6.4.3 were in the range of 10.78 \(\rho_a\) to 87.18 \(\rho_a\).
Sensory Evaluation: Regarding flavor and taste, acceptance level gradually decreased with increase in the proportion of beet root puree. An explanation for the decreasing score in flavor and taste acceptance may be due to higher proportion of beet puree in sample induced acrid smell and smashy taste in the product. With the increase in proportion of beet root pure in tomato puree, the consistence of the product increased, but due to the more porous structure, the firmness of the product reduced which may be the cause of decreased mouth feel. Therefore, the mixing of beet root puree was accepted by the panelists in all respect up to the level of 40g of beet root puree in 60g of tomato puree, i.e., Sample I, Sample II, Sample III and Sample IV.

Table: 6.4.4-Sensory analysis of control and mixed tomato beet puree samples

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>7</td>
<td>9</td>
<td>8.7</td>
<td>9</td>
<td>7</td>
<td>6.5</td>
<td>6</td>
<td>5.8</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Flavor</td>
<td>9</td>
<td>9</td>
<td>8.9</td>
<td>7</td>
<td>6</td>
<td>6.2</td>
<td>5</td>
<td>4.9</td>
<td>4.2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Taste</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1.8</td>
<td>1.2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>7.5</td>
<td>7</td>
<td>6.7</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Consistence</td>
<td>6</td>
<td>6.5</td>
<td>7</td>
<td>9</td>
<td>8.5</td>
<td>9</td>
<td>8.5</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Overall Acceptability</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>8.5</td>
<td>8.1</td>
<td>7.4</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mean (±)</td>
<td>7.16</td>
<td>8.41</td>
<td>8.26</td>
<td>8.08</td>
<td>7.01</td>
<td>6.51</td>
<td>5.85</td>
<td>5.5</td>
<td>4.9</td>
<td>3.66</td>
<td>3.66</td>
</tr>
<tr>
<td>SD(±)</td>
<td>1.37</td>
<td>0.98</td>
<td>0.96</td>
<td>0.87</td>
<td>1.24</td>
<td>1.86</td>
<td>2.05</td>
<td>2.56</td>
<td>2.04</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Percentage ‘Dislike’ responses</td>
<td>19.13</td>
<td>11.65</td>
<td>11.62</td>
<td>10.76</td>
<td>17.68</td>
<td>28.57</td>
<td>34.98</td>
<td>46.54</td>
<td>41.63</td>
<td>51.91</td>
<td>51.91</td>
</tr>
</tbody>
</table>
6.5. Effect of turmeric, lime (CaO) and lemon juice on the antioxidant property of the developed tomato puree and herbal fortification of the consumer acceptable product

The influence of thermal processing on the degradation, isomerisation and bioaccessability of lycopene isomers in tomato pulp without adding any other ingredient was studied (Ines Colle, Lien Lemmens, Mac handrickx 2010). The visual appearance is the foremost quality considered by the consumers at time of purchasing a product. Many processors utilize the psychological effect of colour to market their product (Maskon, 2000). A new type of bright red coloured tomato puree is developed with the addition of turmeric and lime (CaO) in blanching water of ripe tomato. The antioxidant property of tomato lycopene in the developed tomato puree investigated by using 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay.

Furthermore with the best developed product (sample 4TLL), frequently used different types of herbs used in different cuisine were added. In food choice, Thompson et.al (1994) found that attitudinal beliefs especially those concerning flavour enhancement were important predictors in the subsequent adoption of the new food products and followed by the belief about enhancing one’s health. The herbs used for this purpose were tulsi or holy basil with fifteen medicinal uses, coriander leaves with eleven essential oils, mint or pudina with ample of health benefits, curry leaves with the increase digestive secretions and parsley with a very reliable diuretic remedy and an excellent tonic for the blood vessels.

The objective of this study was to maintain physical characteristics viz. colour, taste, flavour as maximum as along with antioxidant properties with the minimal processing. As consumers are demanding high quality and convenient products with natural flavour and taste and greatly appreciate the fresh appearance of minimally processed food (Oey, Vander Plancken, Vanlocy & Henhrick, 2008).

Results and Discussions:

The consumption of foodstuffs rich in antioxidants provides protection against cancer and cardio and cerebrovascular diseases. This protection can be explained by the capacity of these active compounds to scavenge free radicals, which are responsible for the oxidative damage of lipids, proteins and nucleic acids (Aruoma, 1998, Ramadan et al., 2003). Tomato puree a concentrated product of tomato rich in lycopene were prepared and the total antioxidant potential (TAP) were examined by reduction of DPPH (1,1-diphenyl-2-picrylhydrazyl) in ethanol according to Ramadan et al (2003). Blank was prepared with 3.9 ml of DPPH and 0.1 ml of ethanol. The different samples were mixed in the formula of 3.9 ml of DPPH and 0.1 ml of sample. Against a blank of ethanol without DPPH, the decrease in absorption at 515 nm was measured in 1-cm quartz cells after 30, 60 and 120 min. of mixing using a UV-260 visible recording spectrophotometer (Shimadzu, Kyoto, Japan). Antiradical action toward DPPH radical was estimated from the difference in absorbance with or without the sample (control) and the percent of inhibition was calculated from the following equation:

\[
\text{Percentage (\%) of Inhibition} = \frac{(\text{Absorbance of control} - \text{Absorbance of test sample}) \times 100}{\text{Absorbance of control}}
\]
Table: 6.5.2. Scavenging effect (percentage of remaining DPPH radical) of tomato puree samples during DPPH test as measured by changes in absorbance at 515 nm

<table>
<thead>
<tr>
<th>Sample</th>
<th>30 min incubation time</th>
<th>60 min incubation time</th>
<th>120 min incubation time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure Tomato Puree</td>
<td>23.95</td>
<td>23.16</td>
<td>22.5</td>
</tr>
<tr>
<td>2TL</td>
<td>15.91</td>
<td>13.02</td>
<td>11.88</td>
</tr>
<tr>
<td>2TLL</td>
<td>15.07</td>
<td>12.59</td>
<td>11.05</td>
</tr>
<tr>
<td>4TL</td>
<td>15.68</td>
<td>14.18</td>
<td>12.01</td>
</tr>
<tr>
<td>4TLL</td>
<td>14.68</td>
<td>12.99</td>
<td>10.73</td>
</tr>
<tr>
<td>6TL</td>
<td>17.01</td>
<td>16.25</td>
<td>15.01</td>
</tr>
<tr>
<td>6TLL</td>
<td>16.01</td>
<td>15.25</td>
<td>14.22</td>
</tr>
<tr>
<td>4TLL+Grated tulsi leaves</td>
<td>14.12</td>
<td>12.99</td>
<td>10.73</td>
</tr>
<tr>
<td>4TLL+Grated coriander leaves</td>
<td>12.42</td>
<td>11.86</td>
<td>9.58</td>
</tr>
<tr>
<td>4TLL+Grated curry leaves</td>
<td>13.55</td>
<td>13.55</td>
<td>10.17</td>
</tr>
<tr>
<td>4TLL+Grated pudina leaves</td>
<td>12.99</td>
<td>12.42</td>
<td>8.98</td>
</tr>
<tr>
<td>4TLL+Grated parsley leaves</td>
<td>13.01</td>
<td>12.12</td>
<td>10.05</td>
</tr>
</tbody>
</table>

6.6 Studies on the consumer appeal characteristics of the developed tomato puree samples

Everyone is sensitive to the colour of food products. Appetite is stimulated or dampened in almost direct relation to the observer’s reaction to colour. The colour we see clearly indicates the flavour of the food product. The challenge of the food industry is to provide visually appealing food products that taste good and meet the consumers’ demands on quality and price. However, continually occurring developments to improve the stability and handling properties of colours using formulation technology, new processing methods for processed fruits and vegetables are observable. Food colour materials both natural, artificial and nature identical in terms of market development, regulations and technical limitations was reviewed (Alison Downham et al, 2000). It was discovered that the consumer’s concern lies in the incorporation of natural products into food. There is also further work to complete a full range of GM free colours to meet current consumer / retailer concerns, especially in the nature identical colour area.

Hence, amongst all the sensory attributes special attention should be given towards the improvement of colour of prepared tomato puree samples. Good flavour, convenience and health enhancing properties are key consumer benefits in today’s market place. People are seeking foods with benefits beyond basic nutrition, and products with nutritional appeal are also among the most successful new introductions. Taste is consistently rated as the most important factor that drives consumption and repeated purchase (Cardello et al 2007).

Findings and Discussion: On the basis of 9 points hedonic scale, data was collected from the score sheet with the help of questionnaires distributed for sensory analysis. The result showed all three independent variables (knowledge, customer innovativeness and beliefs) have significant positive relationships with the subject’s acceptance. A consumer who has more knowledge, innovation and belief in tomato puree products will show higher acceptance of developed tomato puree samples.
CONCLUSIONS

The present study is based on the development of new types tomato puree treated with turmeric and lime (CaO) and fortified with lemon juice (citrus lemonii), beet root puree, culinary herbs to improve the colour, flavor, texture and product variety.

As calcium containing salts and liming materials are used by the cultivators since 1940s to improve the textural properties of tomatoes and turmeric terms in brick red curcumin in alkaline medium, this idea has been implemented in this study for the treatment purpose. Degradation of red colour of tomato due to enzymatic action during thermal processing is a major challenge of food processing industry which makes the puree less consumable or addition of natural or artificial colour to make it more colourful. During the blanching process, a mixture of turmeric-lime in equal proportion is added in blanching water and the tomatoes were blanched for 1 min, 2 min and 3 mins. Blanching time gave better results in respect to colour, pH and rheological properties. The turmeric-lime mixture were used in the concentration of 0.02%(w/w), 0.04%(w/w), 0.06%(w/w) respectively in 250ml of blanching water of 100gm tomatoes. The 0.04%(w/w) turmeric lime treated sample had shown the acceptable quality.

To import the appropriate pH and to increase the taste of treated tomato puree, lemon juice (citrus lemonii) were added and the puree had shown better results in respect to colour, pH and rheology.

The developed turmeric-lime treated, lemon juice fortified tomato puree samples were analyzed for its nutrient content and sensory analysis were made for its consumers’ acceptability. Amongst all the developed tomato puree samples, 4TLL [0.04%(w/w) turmeric lime+5ml lemon juice] were accepted unanimously in respect to colour, flavor, texture and taste.

The shelf life of developed tomato puree samples were determined by plate count method for viable bacterial cell. It has been observed that the lemon juice fortified samples 2TLL [0.02%(w/w) turmeric lime+5ml lemon juice], 4TLL [0.04%(w/w) turmeric lime+5ml lemon juice], 6TLL [0.06%(w/w) turmeric lime+5ml lemon juice] were having
less growth rate than the 2TL.02%(w/w) turmeric- lime), 4TL.04%(w/w) turmeric- lime), 6TL.06%(w/w) turmeric- lime) samples.

In another study, a new type of tomato puree is developed with the addition of beet puree in different proportions in the turmeric lime lemon treated 4TLL sample. The colour, flavor, fluidity and sensory analysis were made on the developed tomato-puree samples mixed with beet puree in different proportions. The tomato puree and beet puree mixed in the proportion of 90:10(tomato+beet), 80:20(tomato+beet), 70:30(tomato+beet), 60:40(tomato+beet), 50:50(tomato+beet), 40:60(tomato+beet), 30:70(tomato+beet), 20:80(tomato+beet), 10:90(tomato+beet). It was observed that L and b value of the mixed tomato and beet puree samples decreased with the increased proportions of beet puree which might be due to the more brightness of lycopene pigment of tomato puree than the belalain pigment of beet puree. The rheological observations show that the yield stress of puree samples increased significantly with the increasing proportions of beet puree in tomato beet puree samples. Sensory analysis revealed that the addition of beet puree in tomato puree samples were acceptable up to the level of 40g beet puree in 60g tomato puree samples, beyond this, the dislike responses amongst the consumer were shown negative responses.

Tomato puree rich in lycopene, a carotenoid pigment attracted a lot of attention from various researchers because of its nutritional significance and disease prevention such as chronic and cancerous diseases. In another study, with an increasing understanding of health benefit of lycopene, the culinary herbs like tulsi, mint, curry, parsley, coriander leaves were added to the best tomato puree sample (4TLL) to bestow natural antioxidants in the developed sample. Tender leaves of the above culinary herbs were used in grated forms as the enzymatic status of peroxidase, polyphenol oxidase and non enzymatic antioxidants like ascorbic acid, reducing sugar, phenols and proteins were reported to be more in comparison to mature leaves. The antioxidant property of the herbs fortified turmeric lime lemon treated tomato puree samples were carried out by DPPH assay and the result shown that the total antioxidant potential (TAP) was high than the turmeric lime lemon juice treated tomato puree samples. Therefore, by using turmeric lime in blanching water of tomato to prepare tomato puree samples, the colour, textural property of the puree can be enhanced and as well as the addition of lemon juice in the treated tomato puree samples help to improve the keeping quality, taste without any alteration in nutritional composition. Along with the development of the sensory characteristics of the tomato puree samples, beet root puree and culinary herbs are used to increase antioxidant property of the developed tomato puree samples, which may include the variety also.