STORABILITY OF TOMATO PULP

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A THESIS

BY

SULTANA YASMIN
REGISTRATION NO: 1105031
SEMESTER: JANUARY-JUNE/2013
SESSION: 2011-2012

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IN

FOOD PROCESSING AND PRESERVATION

DEPARTMENT OF FOOD PROCESSING AND PRESERVATION
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY DINAJPUR-5200

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DEDICATED
TO MY
BELOVED PARENTS

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The Author

ABSTRACT

Storability of Tomato pulp was studied by using steam heat and treated with 0.1% potassium metabisulfite (KMS). The prepared tomato pulp was stored at room/normal (28-30^{0}C), refrigeration (4^{0}C) and freezing (<-10^{0}C) temperature. The shelf life was studied by examining the chemical composition (TSS, acidity, vitamin C and lycopene) during six months of storage period. Chemical analysis (TSS, acidity, vitamin C) of tomato pulp (with or without KMS) was carried out at an interval of 7 days during 1st month in normal and refrigeration temperature. Again chemical analysis (TSS, acidity, vitamin C and lycopene) of tomato pulp (with or without KMS) was also carried out at an interval of 30 days during six months storage period keeping the product in normal, refrigeration and freezing temperature. Tomato pulp (without KMS) at normal temperature was spoiled after 3 days; at refrigeration temperature was spoiled after 3 months. Tomato pulp (with KMS) at normal temperature was spoiled after 4 months and at refrigeration temperature was spoiled after 5 months. Tomato pulp (with or without KMS) at freezing temperature was not spoiled after six months. It was observed that TSS of tomato pulp (with or with KMS) was slightly decreased during storage and at refrigeration temperature (without KMS) showed the lowest value (4.1^{o}Brix), where freezing temperature (with KMS) showed best result (4.5^{o}Brix) during six months storage period. Again, Acidity of tomato pulp (with or with KMS) was also slightly decreased during six months storage period. Refrigeration and normal temperature (with KMS) showed the highest value (0.150%) and freezing temperature (with or without KMS) showed best result (0.08%) during six months storage period. In case of vitamin C and lycopene content in tomato pulp treated with KMS were 17.71 mg/100gm and 6.69 mg/100gm respectively in refrigeration temperature where tomato pulp treated with KMS in freezing temperature showed best the result (18.93 mg/100gm of vitamin C and 7.57 mg/100gm) during six months storage period. Therefore, this study showed that tomato pulp treated with KMS can be preserved at refrigeration (4^{0}C) condition at least 5 months and more than 5 months at freezing condition (<-10^{0}C) with acceptable quality.

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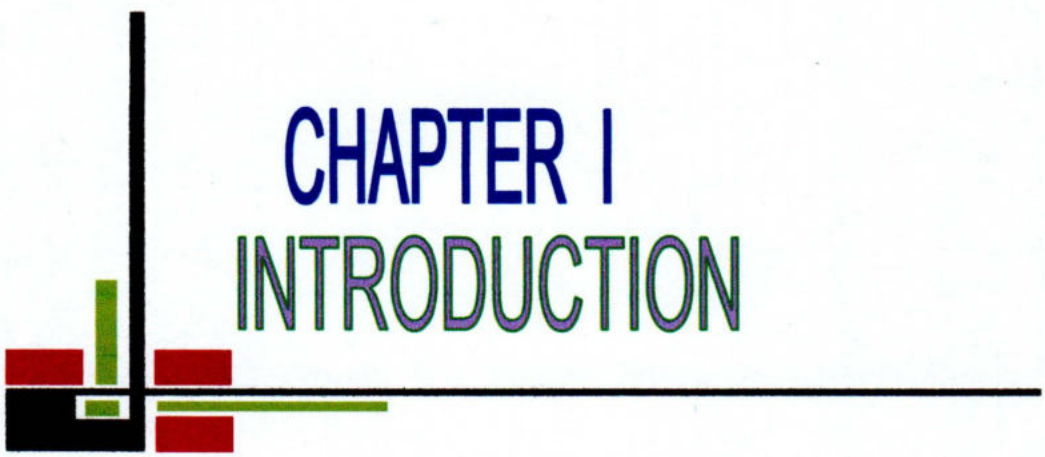


CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most important and nutritious vegetable crop in Bangladesh as well as in the world. It is belongs to the family solanaceae. Its centre of origin is presumed to be in the present state of Mexico (Heiser, 1969). It is believed that the tomato was introduced Indian Subcontinent during British regime. As an important source of vitamin, minerals and health acids, it ranks next to potato and sweet potato in respect of production in the world (FAO, 2007). But in Bangladesh, it ranks second which is next potato (BBS, 2009) and top list of canned vegetables (Ahmed, 2008).

It is cultivated in almost all home gardens and also in the field for its adaptability to wide range of soil and climate in Bangladesh. The best growing areas of tomatoes in Bangladesh are Chittagong, Comilla, Rajshahi, Panchagar and Dinajpur (Sharfuddin and Siddique, 2000). In spite of its importance and well adaptability in agro-climatic condition, the average yield performance is very low compared to other developed country (FAO, 2007). Recent statistics shows that average yield of tomato in Bangladesh is 16.72 t ha^{-1} (BBS 2009) that is quite low compared to the tomato growing countries like Japan (62.99 t ha^{-1}), USA (66.57 t ha^{-1}), Turkey (42.50 t ha^{-1}), Brazil (54.55 t ha^{-1}) and Italy (53.22 t ha^{-1}) (FAO, 2007). The total productions of Tomato were approximately 232 thousand tons in 24686 ha of land Bangladesh in the year 2010-2011 (BBS, 2011). Tomatoes are available during months of March and April. It has a great potentiality to grow in summer also. Its demand in general is increasing day by day throughout the year due to palatability and vitamin content and other health benefit nutrients.

Today, it is recognized as one of the important commercial and dietary vegetable crops. It is a rich source of lycopene, ascorbic acid, β-carotene and minerals. In recent years, it has attracted the attention due to the anti-carcinogenic and antioxidant property of lycopene and ascorbic acid. Lycopene being efficient quencher of singlet oxygen and free radicals, provides protection against a broad range of epithelial cancers (Di Mascio *et al.*, 1991). Lycopene has the highest value, with antioxidant and curative specific feature on some diseases, and consequently, the lycopene-rich

products may be used for obtaining food and bioactive food supplements (Goerge *et. al.*, 2004). Several researchers have reported the existence of epidemiological evidence that dietary intake of lycopene from tomato based products contributes to prostate, digestive-tract and lung cancer risk reduction (E Giovannucci *et al.*, 1995). It is also popular because it supplies vitamin-C and adds variety of colors flavors to the foods. It has many other uses, as tomato seed contains 24 percent oil and this extracted from the pulp and residues in canning industry (Purseglove *et. al.*, 2001).

The supply of tomato is abundant during harvesting season. The grower however, face problem for selling their produce and it results in low demand and low cost. Spoilage occurs and ultimately growers become economically loser. On the other hand, during end period of harvesting season the tomato price becomes 2 to 3 times higher. Hence short time preservation like making pulp will help the grower by reducing loss.

Tomato is highly perishable vegetables and rapidly deteriorates after ripening. About 35 percent of total product of fruit and vegetables are spoiled and lost after harvesting due to lack of processing, storage and transport facilities (Ahmed, 1995). Several processed items like puree, juice, ketchup, drinks soup can be prepared on a large scale from tomato pulp. There are some fruit processing industries in Bangladesh, where tomato pulp is processed for various end-products. Hence it is indispensable to make tomato pulp available throughout the year for the viability of sustainable industrial production. The possible easy solution of this problem is to find out the appropriate technology for preservation of tomato pulp through the whole year round availability.

In order to achieve wholesome, safe, nutritious and acceptable tomato pulp throughout the year, the following objective carried out in this research,

- Processing of tomato pulp
- To determine the shelf life of tomato pulp at different storage conditions with nutritional changes

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This chapter includes the available information in respect of processing and preservation of tomato and or its products in Bangladesh as well as other countries of the world.

2.1 General introduction on Tomatoes

Tomatoes (*Lycopersicon esculentum* L.) are the world's most commercially produced and used vegetable crop Gupta and Nath (2004). The annual worldwide production of tomatoes has been estimated at 125 million tons in an area of about 4.2 million hectares. It is very important in the economic point of view and hence the global production of tomatoes (fresh and processed) has been increased by 300% in the last four decades (FAO, 2005) and the leading tomato producers are in both tropical and temperate regions Dhaliwal *et al.* (2003).

2.2 Cultivation of Tomato

Tomato is grown throughout the tropical and the temperate region of the world (Okorie *et al.* 2004). In term of climatic tolerance, tomato is highly noted as one of the most adaptable cultivated plant. Although, it is susceptible to frost (Smith, 1994; Okorie *et al.*, 2004) it requires different climate range for seed germination, seedling growth, flavor, fruit set and fruit quality. It thrives well in temperature 10^0 C to 30^0 C with optimum range of temperature of 21^0 C- 24^0 C. It requires low to medium rainfall and does well under average monthly temperature of 21^0 C to 23^0 C. Tomato does very well most minerals soils, but it prefers deep, well drained sandy loams. Under layer of soil should be porous with little sand and good clay in the subsoil. Soil depth 15 to 20 cm proves to be good for healthy crop to a wide pH range. A pH of 5.5-6.5 is preferred. Through tomato is moderately tolerant to acid soil that is pH of 5.5. The soils with proper water holding capacity, aeration, free from salt aeration, free from salt are selected for cultivation.

Table-2.1: Top Tomato producers

Country	Top Tomato Producers — 2011 (in MT)
China	48,572,921
India	16,826,000
United States	12,526,070
Turkey	11,003,433
Egypt	8,105,263
World Total	129649883

Source: "Production of Tomato by countries". Food and Agriculture Organization. 2011. Retrieved 23 August 2013

2.3 Tomato harvesting in Bangladesh

Tomato is the third most important vegetable crop of Bangladesh in terms of area (1307 Acres) and production (73940 MT), but seven in position with respect to production, where potato is the highest (BBS, 2002). The average yield is 2765 kg/acre which is far as compared to the average yield of tomato in other countries (BBS, 2011). The best growing areas of tomatoes in Bangladesh are Chittagong, Comilla, Rajshahi, Panchagar and Dinajpur (Sharfuddin and Siddique, 2000). Its harvesting is mostly contained to the months of January, February and March. Tomato requires dry temperature of 21^0 C to 28^0 C and cool at night temperature of $(15\text{-}20)^0$ C for proper fruit setting. Presently, some parts of fresh tomato products are being processed and marketed in Bangladesh in the form of traditional products like, puree, paste, catch-up, sauce, pickles, chutney etc.

Table 2.2: Production of Tomato in Bangladesh

Year	Production ('000' Metric Ton)
2002-2003	102
2003-2004	120
2004-2005	122
2005-2006	131
2006-2007	137
2007-2008	143
2008-2009	151
2009-2010	190
2010-2011	232

Source: (BBS, 2011)

2.4 Physico-chemical changes associated with ripening and senescence

Ripening refers to changes in physical, physiological, biochemical and sensory traits of harvested fruits which render them acceptable to eat by consumers (Biale, 1975 and Matto *et al.* 1975).

2.4.1 Physiological loss in weight

Early Pear type and S-12 cultivars of tomato had 55 and 33 per cent loss in physiological weight, respectively harvested at red ripe stage after seven days of storage at room temperature. While, minimum loss of 23 and 46 per cent, respectively were observed when harvested at breaker stage (Kaur *et al.*, 1977).

A minimum loss in weight was reported in tomatoes harvested at turning stage when compared to those harvested at red ripe stage after 12 days of storage (Gaur and Bajpai, 1982). Tomatoes stored at room temperature recorded a maximum weight loss as compared to those packed in polyethylene bags due to higher rate of transpiration and water loss (Lingaiah, 1982).

2.4.2 Total soluble solids

Total soluble solids increased throughout the fruit development in tomato (Boe *et. al.*, 1967). In cultivars like Best of All and Large Red, TSS increased from mature green to red ripe stage but in cv. Sioux, it decreased at red ripe stage (Saimbhi, 1969). An increase in TSS from 5.2 to 5.9 per cent and 5.8 to 5.9 per cent was noted after eight days of storage in fruits harvested at turning and pink stage respectively, but there was a decline in TSS from 6.6 to 4.3 when the fruits were harvested at red ripe stage (Gaur and Bajpai, 1982).

The increase in TSS upto 8 days of storage was observed in tomatoes harvested at mature green stage, but this increase varied with cultivars (Bhatnagar *et al.*, 1980, Siddiqui *et al.*,1986) reported that no definite trend was observed in total soluble solid contents of tomato with advancement of maturity except in SG-12 and Pusa Hybrid-1 where TSS progressively increased from green mature to red ripe stage. Maximum TSS content was reported in Marglobe (5.75%) followed by Roma (5.70%); whereas, it was minimum in Pusa Ruby (4.85%) after 12 days of storage (Syamal, 1991).

2.4.3 Titratable acidity

Titratable acidity was found to be maximum at pink stage of tomato fruit (Sands, 1950). Tomatoes had a maximum acid percentage at immature stage and increased at colour initiation, then decreased rapidly as ripening progressed (Winsor *et al.*, 1962). Maximum citric acid content was reported at breaker stage (0.41%) and it decreased with ripening to 0.28 per cent at red ripe stage in field ripened cv. V.R. Moscow (Boe *et al.*, 1967).

With an increase in the degree of ripeness, a decrease in acidity was observed in all the tomato varieties under study. Sabour Prabha showed highest acidity (2%) at firm ripe stage and lowest (1.92%) at soft ripe stage (Singh *et al.*, 1983). At turning stage, a maximum acidity of 0.67 per cent was noted which reduced to 0.43 per cent after 12 days of storage. In pink and red ripe stages, acidity decreased from 0.56 to 0.39 per cent and from 0.34 to 0.26 per cent, respectively after 12 days of storage at room temperature (Gaur and Bajpai, 1982).

2.4.4 Lycopene content

Lycopene content of tomato fruit increases with the advancement of ripening (Hirota *et al.*, 1982). The pigment changes during ripening is characterized by a loss of chlorophyll and rapid accumulation of carotenoids, particularly lycopene due to conversion of chloroplasts to chromoplasts (Hobson and Davies, 1971).

The carotenoids in tomato fruits harvested at green and turning stage increased progressively during storage and the lycopene content of red ripe fruits increased over a storage period of 9 days; while in turning and green fruits, it increased continuously in the beginning and decreased at the end of storage (Kaur and Bajaj, 1987).

2.4.5 Ascorbic acid content

Ascorbic acid content of field grown tomatoes increased to a maximum level when the fruits turned almost red (Markakis *et al.*,1974). Maximum concentration of ascorbic acid (20.03 and 13.81 mg/100 g) was reported in cultivar S-12 and Early Pear type, respectively during initial stage of storage. Maximum ascorbic acid content in turning stage fruits was noticed during subsequent storage (Kaur *et al.*, 1977).

Ascorbic acid content was higher in firm ripe tomato fruits but varied among the cultivars ranging between 18.44 to 23.28 mg/100 g. In soft ripe fruits, the ascorbic acid content decreased (16.48 to 21.72 mg/100 g) in all the cultivars (Singh *et al.*, 1983).

2.5 Nutritional composition of Tomato

Nutritional Composition of tomato fruits differs among different tomato varieties. Ripe tomato contains about 94% water Okorie *et al.* (2004). The size of the fruit is influenced by the availability water to the plant (Leibovits, 2004). The large amount of waters also makes the fruit perishable. As the tomato fruits develops, the percentage of fresh weight that is Sucrose decreases; while carbohydrate such as starch and reducing sugar increase (Jones, 1999). Sugar is mostly in unripe fruit; and starches are in ripe tomato fruits, about 5-7% of tomato fruit in solids. The main sugar in tomato is glucose. Citric acid is the main acid in tomato juice; and the pH of the juice is normally between 4.0 and 4.5 (Jones, 1999). The pH of the fruit increases throughout the development. Growing plant cell are surrounded by primary wall made of polysaccharide. The cell wall is a complex

matrix which contains cellulose, hemicelluloses, pectin and structural protein and other components. The molecules are used to determine downstream phenotypic expression of the plant. One medium tomato provides 40% of the USRDA of vitamin C and 20% of United States Recommended Daily Allowances (USRDA) of Vitamin A which comes from Beta-carotene (Jones, 1999). Tomato also provides potassium, iron, calcium, phosphorus, magnesium, sodium and Vitamin such as C, B, A, Thiamine, Riboflavin, Niacin and are also a good of dietary fibers.

Table-2.3: Chemical Composition of Tomato

Components	Percent of dry matter
Sugar	
Glucose	22
Fructose	25
Sucrose	1
Alcohol insoluble solids	
Proteins	8
Pectin substances	7
Hemicelluloses	4
Cellulose	6
Organic acid	
Citric acid	9
Malic acid	4
Minerals (Mainly K, Ca, Mg, P)	8
Lipids	2
Dicarboxylic amino acid	2
Pigment	0.4
Ascorbic acid	0.5
Volatiles	0.1

Source: (Davies and Hobson, 1981)

Table-2.4: Vitamin Content of Ripe Tomato Fruit

Vitamin contents	(Range of value µg/100g fruit)
Vitamin A (ß-carotene)	900-127 IU*
Vitamin B1 (Thiamine)	50-60
Vitamin B2 (Riboflavin)	20-50
Vitamin B3 (Pantothenic acid)	50-750
Vitamin B6 Complex	80-110
Nicotinic acid (Niacin)	500-700
Folic acid	6.4-20
Biotin	1.2-4.0
Vitamin C	15000-19000
Vitamin E (α-tocopherol)	40-1200

Source: (Davies and Hobson, 1981)
*I.U (International unit) = 0.6µg ß-carotene

Nguyen *et al.* (1999) stated Lycopene is a natural pigment synthesized by plants and microorganisms but not by animals. It is a carotenoid, an acyclic isomer of β-carotene. Lycopene is a highly unsaturated hydrocarbon containing 11 conjugated and 2 unconjugated double bonds. As a polyene it undergoes cis-trans isomerization induced by light, thermal energy and chemical reactions.

Rao *et al.* (1998) stated another dietary antioxidant thought to be important in the defence against oxidation is lycopene, of which tomatoes are an important dietary source and Clinton *et al.* (1996), stated in human plasma, lycopene is present as an isomeric mixture, with 50% as cisisomers.

Mascio *et al.* (1989) stated lycopene is one of the most potent antioxidants, with a singlet-oxygen-Tomato lycopene and its role in human health and chronic diseases quenching ability twice as high as that of β-carotene and ten times higher than that of α-tocopherol. It is the most predominant carotenoid in human plasma. Its level is af-fected by several biological and lifestyle factors.

Agarwal *et al.* (1998) stated lycopene has been hypothesized to prevent carcinogenesis and atherogenesis by protecting critical cellular bio-molecules, including lipids, lipoproteins, proteins and DNA.

Rao *et al.* (1998) stated in healthy human subjects, lycopene or tomato-free diets resulted in loss of lycopene and increased lipid oxidation, for 1 week increased serum lycopene levels and reduced en dogenous levels of oxidation of lipids, proteins, lipoproteins and DNA, whereas dietary supplementation with lycopene.

Colditz *et al.* (1985) stated patients with prostate cancer were found to have low levels of lycopene and high levels of oxidation of serum lipids and proteins. A high intake of tomatoes was linked to protective effects against digestive tract cancers in a case–control study and a 50% reduction in rates of death from cancers at all sites in an elderly US population.

Rao *et al.* (1999) stated the estimated intake of lycopene from various tomato products was inversely related to the risk of prostate cancer. This result was not observed with any other carotenoid. A reduction in risk of almost 35% was observed for a consumption frequency of 10 or more servings of tomato products per week, and the protective effects were even stronger with more advanced or aggressive prostate cancer. In recent studies serum and tissue levels of lycopene were shown to be inversely associated with the risk of breast cancer and prostate cancer.

Giovannucci (1999) recently reviewed epidemiological studies, including ecological, case–control, dietary and blood-specimen-based investigations of tomatoes, tomato-based products, lycopene and cancer. In studies there was an inverse association between tomato intake or circu-lating lycopene levels and risk of several types of cancer; in 35 cases the association was statistically significant. None of the studies showed adverse effects of high tomato intake or high lycopene levels.

Waseem *et al.* (1998) stated processed tomato products, such as juice, ketchup, paste, sauce and soup, all are good dietary sources of lycopene. In a recent study in our laboratory, the average daily dietary intake of lycopene, assessed by means of a food-frequency questionnaire, was estimated to be 25 mg/d with processed tomato products, accounting for 50% of the total daily intake.

An increased oxidative stress has been implicated in the incidence of chronic diseases. Dietary intakes of tomatoes and tomato products containing lycopene have been associated with a decreased risk of diseases such as cancer and cardiovascular diseases (CVDs) in numerous studies (Giovannucci *et al.*, 2002).

Tomatoes are a valuable source of several micronutrients and phytochemicals including carotenoids, polyphenols, potassium, folate, ascorbic acid and a -tocopherol. Most of these nutrients in tomatoes can interact with the host to confer a preventive benefit against oxidative stress-associated diseases, through various mechanisms including antioxidant action (Rao and Agarwal, 2000; Rao, 2002).

Minerals commonly found in tomato fruit are K, Ca, Mg and P and may reach to 8% of the dry matter (Davies and Hobson, 1981). Minerals have an effect on pH and titratable acidity and have buffering capacity as well; therefore, they influence the taste of tomatoes. Free amino acids form about 2 - 2.5% of the total dry matter of tomatoes (Petro-Turza, 1987).

2.6 Pretreatment

2.6.1 Effect of hot water treatment on quality parameters

Mature green tomatoes immersed in water at 40°C for 15 min and stored for 21 days at 5°C followed by 12 days at 20°C exhibited lowest incidence of chilling injury and were firmer. These fruits ripened normally at 20°C characterized by climacteric ripening. Complete disappearance of chlorophyll followed by lycopene synthesis was observed after 9 days at 20°C indicating normal ripening (Nagetey *et al.*, 1999). Hot water dips (39°C for 90 min) of mature green cherry tomato fruits and subsequent storage in MAP substantially delayed the colour development (Ali *et al.*, 2004).

Hot water dip treatments at 45°C for 10 and 20 min of 'Fuyu' permission fruits enhanced the visual quality. Carotene and lycopene content increased at the end of storage. Decay, skin blackening was significantly lower and the respiration rates decreased with storage time (Sen *et al.*, 2002).

2.6.2 Effect of hot air treatment on quality parameters

'Rapsody' tomato fruit exposed to 34°C for 24 h in air and stored at 10°C for 30 days developed the best colour when ripened and had the least chlorophyll and highest lycopene content (Yahia *et al.*, 2003). Intermittent warming of tomato fruits at 20°C for one day at 7 days interval reduced the fruit titratable acidity, but no significant differences were observed in soluble solid content. Fruits with good quality

and shelf life were obtained following 3 cycles of intermittent warming at 6°C (Artes *et al.*, 1998)

2.7 Research status of processing of Tomato crop for pulping

Tomato is commercially important throughout the world both for the fresh fruit market and process food industries in Bangladesh. There is a great demand for tomato in vegetable processing industries maker of paste, puree, sauce, ketch-up and juice (FAO, 2000).

Gloud (1992) described that majority of tomatoes are consumed in the form of industrially processed products. Tomato fruit is processed in a large variety of products such as tomato juice, canned tomato, tomato ketchup, tomato soup, tomato paste, tomato pulp and tomato puree. More than 80% of the processing of tomatoes was done by hot pulping method resulting in discolored tomato pulp with low viscosity level. Processing of tomatoes was done under higher temperature conditions, whereas under normal temperature conditions no work has been registered.

Thakur *et al.*, (1996) stated that the main quality parameters related to these industrial products are color, consistency, flavor, serum separation, nutritional value, total acidity and pH. The study revealed that higher revolutions and inconstant temperature results in pour quality of tomato pulp with respect to color and flavor. The tests were not performed under normal temperature conditions of tomato crop.

Begum (2002) studies on the use of antimicrobial agent for the preservation of tomato pulp of different Brix (4, 6, 8, 10 ^{0}B) at room temperature during 240 days storage period. She found that total soluble solid decreased with the increased storage periods due to the fermentation of sugar, pH increased with the increased of storage periods. She also found that vitamin C decreased in tomato pulp treated with 1000ppm KMS and mixture of preservatives (Na-benzoate:KMS=2.5) during 240 storage periods but decreasing rate was not same. She also found that lycopene content decreased remarkably in tomato pulp without preservatives, decreasing rate was slower 1000ppm KMS treated tomato pulp than 700ppm KMS and mixture of preservatives (Na-benzoate:KMS=2.5) during 240 storage period.

Nwanekezi *et al.*, (2005) studies six sample of bottled intermediate moisture tomato paste were stored at ambient conditions (33-38^{0}C), four samples were preserved with

chemicals. He found that pH, moisture content of tomato pulp (treated with sodium metabisulphite and sodium benzoate) only changes 4.40 to 4.43 and 40.08% respectively, while their acidity, total soluble solids and ascorbic acid contents reduced respectively from 0.29 to 0.27%, 4.95 to 4.85% and 17.00 to 16.70 mg/100g after 40 weeks of storage periods.

Islam (1997) studied on preparation of tomato products from pulp and juice. Toamato pulp and juice were prepared from ripe and disease free tomatoes for the prepareation of puree, ketchup, jam and jelly. He found that, the nutritional qualities and other attributes of tomato remained fresh after 6 months of storage.

Islam *et al.,* (2009) studies about varietals (Manik, Ratan, Anupoma) effect on acceptability and shelf life of tomato juice (treated with 350ppm KMS) at room temperature (28-30^{0}C) and refrigeration (4^{0}C) temperature. They found that tomato juice prepared Manik, Ratan was spoiled after 30 days. They also found that moisture content, acidity, total soluble solids were decreased with the increasing of storage periods for juice from three variety in room and refrigeration temperature. They also found that major loss in case of vitamin C content during the storage time both room and refrigeration temperature. It was also found that degradation of vitamin C was less in juice from Ratan variety than other Manik and Anupoma during the storage time both room and refrigeration temperature.

Manun (2000) studies on the use of antimicrobial agent for the preservation of tomato juice at different temperature. The shelf life of pasteurizied and non- pasteurizied tomato juice were studied throughout the 60 days storage period. He found that negligible change in chemical constituents except vitamin C was observed in the prepared juice throughout the 60 days storage period both at room and refrigeration temperature. He also found that tomato juice preservation with preservation with citric acid and sodium benzoate was spoiled after 30 days with sodium sulfite was spoiled sulfite was spoiled after 45 days.

Goodman *et al.,* (2002) investigated the flavor, viscosity and colour analysis of hot and cold break tomato juice. Tomatoes were chopped and allowed to sit for various time intervals to simulate the cold break process. Zero was hot break and 2-24 min represented cold break. Sensory, volatile, colour and viscosity analysis were conducted to determine which hold time produced the optimum juice. Sensory penelists raed 15 min

cold break most fresh and like over hot break Lypoxygenase initiated volatile increased viscosity decreased from hot to cold break. The cld break process can be used to produce a premium flavoured juice.

Rahman (1995) studied the preservation of tomato juice in semi concentrated from by using salt and sugar. He used salt 1.0% and 1.5%, sugar 10% and sodium benzoate 350ppm. He reported that the juice containing 20.5% TSS was of best quality based on sensory evaluation. He also said that the physiochemical properties i.e. moisture, ash, total sugar, ascorbic acid, pH, colour, taste and flavor of the juice were affected significantly due to long time heating.

Guilbert and Perez (1992) developed a process for preparation of tomato concentrate. They followed the osmotic dehydration method for entire or chopped material having 30-70^0 Brix with or without added NaCl or citric acid. They dried the product for 4-11 hr at 30-60^0C. The concentrated material is then used further process.

Barman *et al.* (1991) described the manufacturing process of concentrated tomato products. After washing, crushing and heating tomatoes, the crushed tomato mass was concentrated to 8-9% wt., soluble-DM, processing to give a residual pulp content of 8-12% wt. and separation and further concentration of the liquid fraction to a soluble DM content of 23-25%. The liquid fraction is then sterilized and mixed with the pulp containing fraction.

Rangana and Bajaj (1996) reported that SO_2 is widely used throughout the world principally for treating food of plant origin. It is also used in the preservation of fruit juice, pulps, beverages and concentrates. The concentration of SO_2in above mentioned food items may vary from 350 to 2000 ppm soluble sulphate salts (eg. KMS) are usually used in treating the acid food products.

Bizri and Wahem (1994) studied on the microbiological stability and quality of tomato juice during storage. They were used different treatment.e. acidification, addition of dimethyle dicarbonate and a mixture of potassium sorbate and sodium benzoate. They found that acidified juice (pH 1.0 to 3.7) or nonacidified, dimethyledicarbonate and sorbate/benzoate were highly effective in diminishing mould and yeast count at 5^0C and 20^0C. Dimethyldicarbonate in juice acidified to pH 3.7 was most effective in controlling plate count.

Krutov and Eish (2000) invented the improved technology technology for processing tomatoes. They were processed 3500t o tomatoes, producing 630t of tomato concentrate, as well as juice from the fresh, oil and protein from the seeds and a food colourant from the skins. Water consumption during processing was 1 m^3/t of raw material.

El-Ghani *et al.,* (1996) evaluated of some new vatieties of tomatoes and suitability for processing. The fresh juice of soria, dora and peto pride contained higher total solids, total soluble solids (TSS), total sugars, total activity and ascorbic acid contents compared with the Jackal and Royal Flush. Jakal and Dora fruits had higher contents lycopene and total pectc substances. However, tomato juice concentrates (25.6% TSS) were prepared from peto pride, Dora and Soria packed in polythene bags and were stored at 18^0C for 6 months. During heat concentration of tomato juice, ascorbic acid and lycopene content decreased sharply. The viscosity of all tomato juice concentrates decreased as the storage period increased. The other chemical constituents remained unchanged.

Anguelova and Warthesen (2000) investigated the storage stability and lycopene content commercial tomato powders. Liquid chromatography and spectral analysis were used to determine lycopene loss and the formation of cis isomers and degradation products. Tomato powders were stored at 6 and 45^0C or under fluorescent light for upto 6 weeks. After 6 weeks, they found that 60% of the lycopene was degraded at 45^0C and at lower temperatures the losses were about 30%. Mchanisms of loss appear to be both isomerization and oxidation.

Rovere *et al.,* (1997) studied on preservation of chopped tomato by high pressure processing. Samples of chopped tomatoes were pretreated 25, 50 or 85^0C, cooled, vacuum packaged, then subjected to pressure treatment at 400, 600 or 800 Mpa for 3, 5 or 7. Effect of pectins, soluble solids, aroma compounds, sugar, pH consistency, colour, sugar content and pH were unaffected by pressure treatment and viscosity decreased with increasing blanching temperature but increased with increasing pressure. Effect of pressure treatment on pectin concentration has a significant inactivating effect on poly galactopurnase type pectic enzymes but slight effect on pectinesterases.

Sharma and Maguer (1996) investigated the kinetics of lycopene degradation in tomato pulp duration heating at 100^0C and storage under different storage conditions (-20, 5 and 25^0C either without light and with air, or with air andlight) were studied. Extent of lycopene degratdaion in tomato insoluble solids dried at different temperatures (freeze

dried, oven dried at 22, 50 and 70^{0}C) was also studied. Lycopene content in tomato decreased during heating under different processing conditions (with and without concentrated of TS). Apparent reaction constant for lycopene degradation increased with increased in lycopene, acids, sugar and overall pulp TS. Kinetics of lycopene degradation followed a pseudo first order reaction at 100^{0}C under different heating conditions. Lycopene degradation was higher increase in freeze dried fibre rich tomato pulp then in samples oven dried between 25 and 75^{0}C. Exposure of tomato pulp solids to air, light and high storage temperature increased lycopene loss.

Anguelova and Warthesen (2000) evaluated the chemical stability of lycopne in 2 commercial tomato powders during storage. Liquid chromatography and spectral analysis were todetermine lycopene loss and the formation of cis isomers and degradation products. Tomato powder products were stored at 6 and 45^{0}C or under fluorescent light for up to 6 weeks. Several lycopene degradation products were tentatively identified in the initial and stored powders. They found that after 6 weeks at 45^0, 60% of the lycopene was degraded. At lower storage temperatures the losses were about 80% after 6 weeks.

Fenericioglus and Gould (1979) found that reconstituted tomato juice sample 19 varieties were higher in ascorbic acid contents, pH and total acid percent than single strength juice samples. Colour scores measured by Hunter colour and difference meter by Agtron E % did not differ much from single strength and reconstituted juice samples.

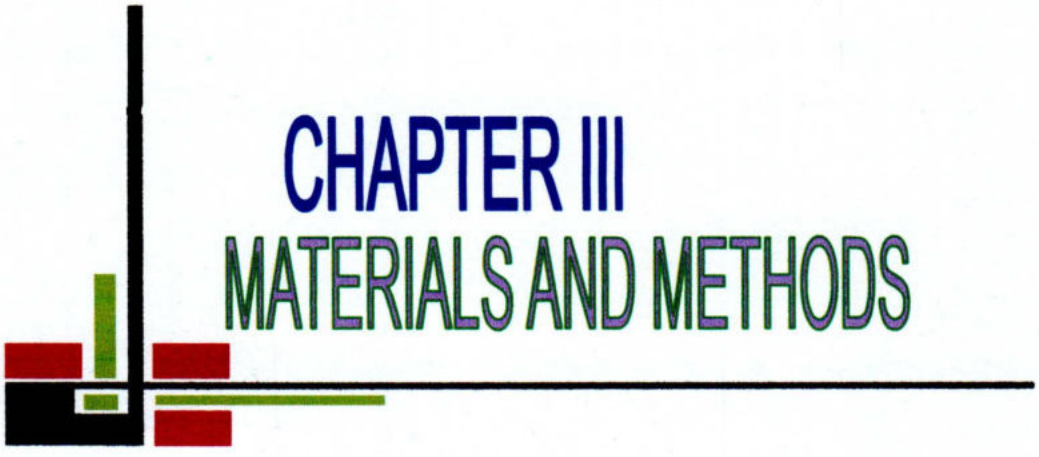
Sandhu and Bhatia (1985) observed the physio-chemical changes during preparation of fruit juice concentrate. They found that inversion of sugars, losses of ascorbic acid and browning were more pronounced at higher concentrates of fruit juice, which indicate the deteriorative changes in quality.

Athanasia *et al.*, (2006) stated that Lycopene was the principle pigment found in tomatoes and was important not only because of the color it imparts but also because of the recognized health benefits associated with its presence. Heating and drying of tomato products under different processing conditions to manufacture tomato juice, pulp, powder etc. may cause degradation of lycopene. For an exact calculation of the rest concentration of a nutrient in a drying process one would have to know the material temperature and water concentration at each moment and the dependence of degradation reaction rate constant on temperature and moisture content

Lacorzynski, *et al.,* (1992) observed the analytical values of processed and raw tomatoes in 1998 and extract 5.0-7.3; sugar 2.73-3.69%, total acid (as citric acid) 0.4-0.75%, pH 4.1-4.4; total mesophilic count 2.5×10^4-5.32×10^6g; lactic acid bacteria 1.3×10^3-8.8×10^5, yeast 60-1.5×10^3 and moulds absent. However they stored tomatoes at 22^0 C for 48hr, showed marked determination in aroma test and consistency, but with no marked changes in extract content, total acidity and pH. Although there was an increase in the bacterial count.

Sherer *et al.,* (2000) investigated the bacterial spore inhibition and inactivation in tomato juice, apple juice and beef by pressure, chemical preservatives and mild heat. Sucrose laureates, sucrose palmilate, sucrose stearates, and mondaurin (Lauricidin) were evaluated for inhibitory effects against spores of *Bacillus sp, Clostridium sporegenus* PA 3679 and *Alicyclobacillus* sp, in a model agar system. They found that, the inhibitory effects which were observed on *Bacillus* and *Alicyclobacillus* spores by combined treatment of pressure, mild heat and sucrose lawrate appear promising for food application where afternatives to high heat processing are desired.

So, many researchers have been innovated technology for use of tomato in form of tomato products. All will appreciate the technology which is inexpensive. But innovated technology did not include the tomato as a whole or as food processing industry in the form of crushed tomato pulp with a view in food industry during off season of tomato. Hence an attempt should take to preserve the tomato pulp in the form of crude pulp using preservatives in different storage temperature.



CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The study was conducted in the laboratory of the Department of Food Processing & Preservation and Agricultural Chemistry of Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh.

3.1 Materials

Good quality, fully ripe and fresh summer (BARI hybrid summer tomato-4) tomatoes were procured from local market. The other materials used in this study were potassium metabisulfite ($K_2S_2O_5$), glass bottles, rice cooker, blender, necessary chemicals, equipment and machineries were used from laboratory stock.

3.2 Methods

3.2.1 Preparation of tomato pulp

Tomatoes were soaked, rinsed and washed with water thoroughly. Then washing tomatoes were boiled by steam heat (water vapuor) in rice cooker at 100-105^{0}C for 5-10 min. After that boiled tomotes were blended by blender and thus made tomato pulp. By adding preservatives potassium metabisulphite (0.1% KMS) tomato pulp was bottled and tomato pulp (with/without KMS) was preserved at different storage temperature (room/normal, refrigeration & freezing).

3.2.2 Treatments of tomato pulp

Table 3.1 Treatments of tomato pulp

Sample	Storage Condition		
	Normal/Room Temperature	Refrigeration	Freezing
Tomato Pulp (without KMS)	28-30^{0}C	4^{0}C	<-10^{0}C
Tomato Pulp (with KMS)	28-30^{0}C	4^{0}C	<-10^{0}C

3.2.3 Determination of P^H

The pH means the negative logarithm of hydrogen ion concentration in a solution. The pH of the selected samples was determined by the conventional procedure by a pH meter.

3.2.3.1 Materials

A pH meter (Hanna instruments- ORPP), salinity-sodium tester (ISO-9001 certified company; Woonsocket, RI 02895), the supplied pH 4.0 buffer solution, distilled water and 50 ml beakers.

Using standard buffer solution of pH 4.0 for calibration the pH buffer solution was used to calibrate the pH meter.

3.2.3.2 Procedure

The electrode assembled of the pH meter was dipped into the standard buffer solution of pH 4.0 taken in a clean and dry beaker.

The fine asymmetry potential knob was adjusted to pH 4.0. The electrode assembled pH meter was dipped into the selected fruit and vegetables samples; the pH was then readout washed twice with distilled water. Again it was dipped into another sample to determine the P^H. The pH of all samples was determined by the procedure.

3.2.4 Total Soluble Solid (^{0}Brix)

TSS was measured directly by digital refractometer (HI 96801, Romania). Small amount of tomato pulp was taken on the plate of the refractometer and a total soluble solid was read directly from the scale.

3.2.5 Titrable Acidity

Titrable acidity was determined by the titration method of Rangana (1992).

The samples (tomato pulp) were diluted with distilled water and titrate just below end point with 0.1N NaOH, using phenolphthalein indicator. A measured quantity (2 or 3 ml) of this solution was transferred into approximately 20 ml of neutral water in a small beaker. (In this extra solution, colour of fruit juice becames so pale that the phenolphthalein colour was easily seen). Titrable acidity calculated by using the following formula:-

$$\%\ \text{Titrable acidity} = \frac{\text{Titre} \times \text{Normality of alkali} \times \text{Volume up} \times \text{Equavalent wt of acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{Wt of volume of sample taken} \times 1000}$$

Vitamin C (mg/100gm sample) content was calculated by using following formula:-

$$\text{mg of ascorbic acid per 100 gm} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquote of extract taken for estimation} \times \text{Wt. of sample taken for estimation}}$$

3.2.7 Determination of Lycopene

Lycopene was determined by the titration method of Rangana (1992).

3.2.7.1 Reagents

- Acetone
- Petroleum ethar
- Magnesium oxide
- Sodium Shulphate

3.2.7.2 Procedure

Lycopene was extracted from 10g tomato pulp by blending in mortar and pestle with acetone and separated the residue. The process was continued until the residue become colourless. The acetone extract was transferred to a separating funnel and 10-15ml of petroleum ether was added and mixed gently. The carotenoid pigments present in acetone extract was dissolved in petroleum ether by diluting the acetone (lower phase) with water containing 5% Na_2SO_4. The lower phase was transferred to another separating funnel and the petroleum ether extract containing the carotenoid pigments to an amber colour bottle. Extraction of carotenoid pigments in an acetone phase with petroleum ether was done repeatly until it became colouress and then discarded the acetone phase. To the petroleum ether a small quantity of anhydrous Na_2SO_4 was added and transferred to a volumetric flask and was diluted to mark with petroleum ether.

An aliquot (5ml of tomato pulp) was diluted to 50ml of petroleum ether and measure the in a 1 cm cell at 503nm in a spectrophotometer (JASCO V-630) using petroleum ether as blank. The lycopene content of the sample was calculated by the following formulae.

Optical density (OD) of 1.0 = 3.1206 µg of lycopene per ml

$$\text{lycopene}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{(3.1206 \times \text{O.D of sample} \times \text{volume made up} \times \text{Dilution})}{1 \times \text{Wt. of sample} \times 1000} \times 100$$

3.2.8 Statistical analysis

Analysis of variance (ANOVA) was carried out using MSTAT-C software packages (MSTAT-C, 1991). Means were compared using least significant differences (LSD). Correlation between parameters were made when appropriate as suggested by Watts *et al.,* (1989) in analyzing the sensory data, the 5 point scale and the 9 point heronic scales were used and the numerical values for each sample were tabulated and analyzed by ANOVA to determine whether significance differences in mean degree of scoring point exist among the sample or not.

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The study on the processing and preservation of tomato pulp was conducted in the department of Food Processing and Preservation under different storage temperature and treatment. Stability of tomato pulp was studied for 6 months. The tomato pulp prepared by steam heat and KMS were used to inhibit growth and activity of microbes under three different storage condition: one at 28-30^{0}C (normal/room temperature), the other at 4^{0}C (refrigeration) and another at <-10^{0}C (freezing). The shelf life was studied by examining the chemical composition (TSS, acidity, vitamin C and lycopene) at different storage period.

The Total Soluble Solid (TSS), Acidity, Vitamin C and Lycopene content of fresh tomato and processed tomato pulp was determined. Table 4.1 showed initial value of tomato and tomato pulp, which is more or less similar to that obtained by Bose (1985) and Kalloo (1985). Little variation in composition may be due to variety or technical error in measuring procedure.

From the table it was observed that p^H and acidity declines slightly after processing. Vitamin C (L-ascorbic acid) content of processed tomato pulp also declines from fresh tomato. Total soluble solid and Lycopene content increased drastically after processing.

Table 4.1 Comparison between component of fresh tomato and tomato pulp

Component	Fresh Tomato	Tomato Pulp (Initial Value)
P^H	6.69	5.79
TSS (^{0}Brix)	3.8	4.5
% acidity	0.196	0.161
Vitamin C (mg/100gm)	20.98	18.98
Lycopene (mg/100gm)	5.8	11.00

4.1 Effect of potassium metabisulfite (KMS) and temperature on total soluble solids (TSS)

Effect of potassium metabisulfite (KMS) and temperature on TSS of tomato pulp was determined during 1st four week in normal and refrigeration temperature and presented in Figure 4.1. At the beginning day TSS was 4.5^0 Brix in all tomato pulp samples. TSS of tomato pulp of without KMS at normal temperature was not determined because it was destroyed within 3 days. From this Figure 4.1, it was found that TSS is slightly decreased after four week. This may be due to the fermentation of reducing sugar, which present in tomato pulp (Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009). But decreasing rate was slightly greater in tomato pulp without KMS in refrigeration temperature, this due to preservative factor because preservative prevent activity of micro-organisms during fermentation of reducing sugar, which present in tomato pulp (Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009). Decreasing rate of TSS of tomato pulp of with KMS in normal and refrigeration temperature was same during four weeks. But it was statistically found that, there was no significant ($P<0.05$) difference in TSS of tomato pulp in normal temperature with KMS and refrigeration temperature with or without KMS during 1st four weeks storage periods.

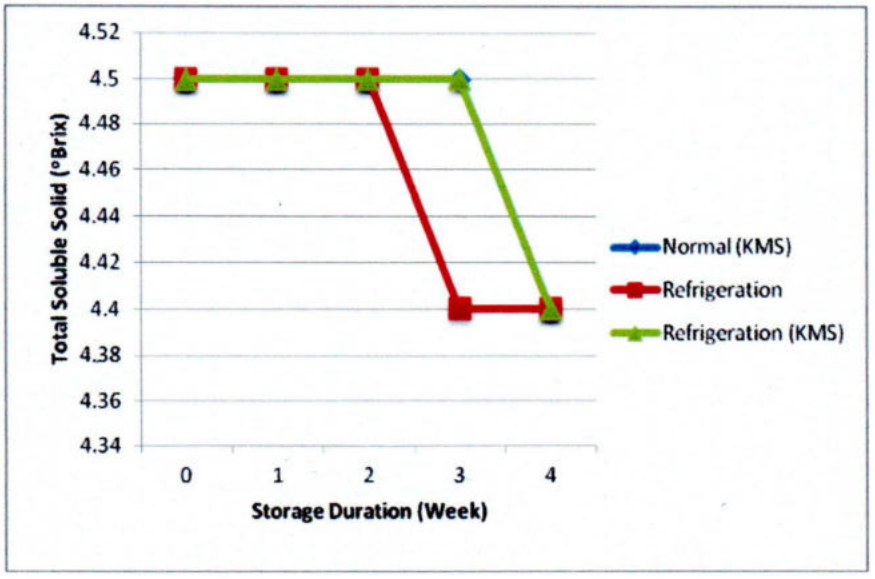


Figure 4.1: Change of TSS in different storage condition during different storage period (Week)

Again, the effect of potassium metabisulfite (KMS) and temperature on TSS of tomato pulp was determined during first six month and presented in Figure 4.2. At the beginning day, TSS was 4.5^0 Brix in all tomato pulp samples. The TSS of tomato pulp of without KMS at normal temperature did not determine because it was destroyed within 3 days. From this Figure 4.2, it was found that TSS was decreased in all tomato pulp samples and significantly ($P<0.05$) not different from each other during six months storage period; this may be due to fermentation of reducing sugar which affect TSS of tomato pulp (Mamun 2000, Begum 2002, Nwanekezi *et al.,* 2005, Islam *et al.,* 2009). From this Figure 4.1, it was also found that decreasing rate was slightly lower in tomato pulp of freezing temperature without KMS. There was no significant change of TSS of tomato pulp in freezing temperature with KMS; this may be due to temperature and preservative factor because both lower temperature and preservative prevent activity of micro-organisms during fermentation of reducing sugar during six months storage period. But decreasing rate was greater in tomato pulp with KMS in normal, in refrigeration (with or without KMS) temperature; this may be due temperature factor because higher temperature increase fermentation of reducing sugar present in tomato pulp (Mamun 2000, Begum 2002, Nwanekezi *et al.,* 2005, Islam *et al.,* 2009). The lowest value of TSS was 4.1^0 Brix, which are found in tomato pulp of refrigeration temperature (without KMS), where freezing temperature (with KMS) showed best result (4.5^0Brix) during six months storage period. The TSS of tomato pulp with KMS at freezing temperature was suddenly found 4.4 in 3rd month; it would be due to experimental error.

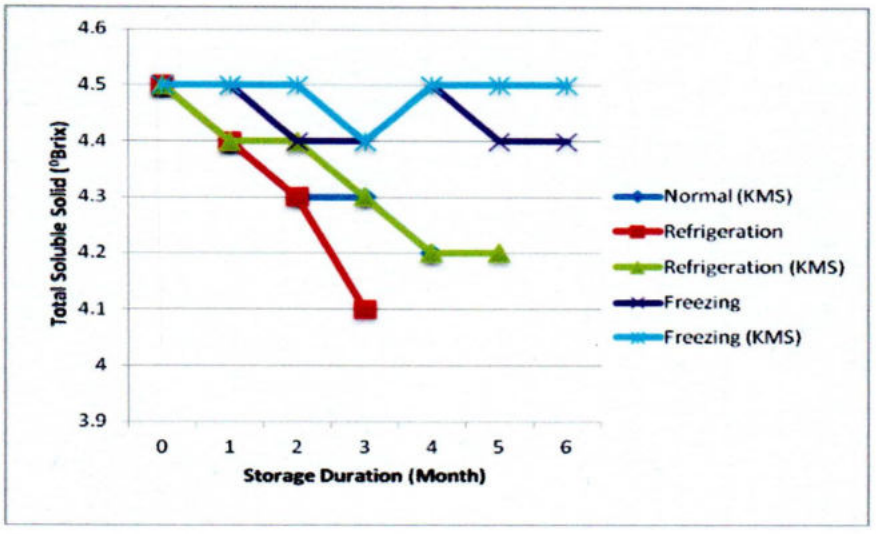


Figure 4.2: Change of TSS in different storage condition during different storage period (Month)

Tomato pulp (without KMS) at normal temperature was spoiled after 3 days only. Moreover keeping tomato pulp without KMS at refrigerant temperature was spoiled after 3 months. On the other hand the shelf life of tomato pulp keeping normal temperature (with KMS) and refrigeration temperature (with KMS) was 4 months and 5 months respectively. The study found keeping tomato pulp at freezing temperature (with or without KMS) gave the highest shelf life; it was not spoiled after six months. Figure 4.3, showed the TSS of tomato pulp at the end of shelf life (with KMS) at normal, refrigeration and freezing temperature. In this Figure 4.3, the TSS of tomato pulp at freezing temperature (with KMS) was significantly ($P<0.05$) higher than tomato pulp at normal temperature (with KMS) and tomato pulp at refrigeration temperature (with KMS). This may be due to temperature factor because higher temperature increases fermentation of sugar presents in tomato pulp (Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009).

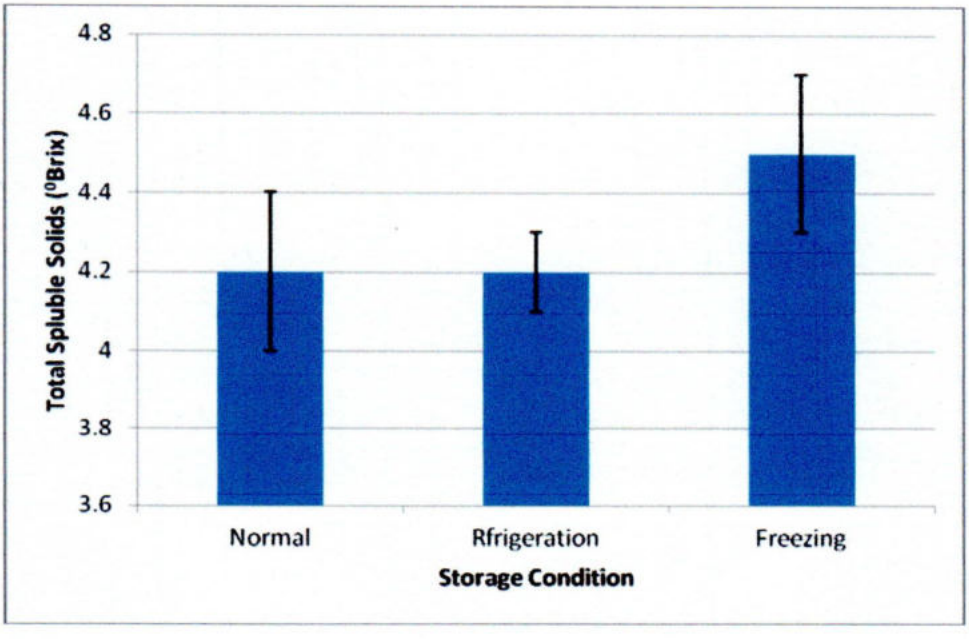


Figure 4.3: The TSS of tomato pulp with KMS in different temperature at end of storage period (month)

4.2 Effect of potassium metabisulfite (KMS) and temperature on acidity of tomato pulp during storage

Effect of potassium metabisulfite (KMS) and temperature on acidity of tomato pulp was determined during 1st four week at normal and refrigeration temperature and presented in Figure 4.4. At the beginning day acidity was 0.161% in all tomato pulp samples. The acidity of tomato pulp of without KMS at normal temperature did not determine because it destroyed within 3 days. From this Figure 4.4, it was found that after four weeks acidity was slightly decreased both in tomato pulp of normal (with KMS) and refrigeration (with or without KMS) temperature. This may be due to increased of pH and however it was measured that pH in normal (with KMS) and refrigeration (with or without KMS) temperature was increased during 1st four week (Mamun 2000, Begum 2002, Nwanekezi *et al.,* 2005, Islam *et al.,* 2009) which affect the acidity of tomato pulp. The temperature influences the acidity, change of acidity directly related to change in pH (Ahmed 1997). It was also found that decreasing rate of acidity slightly greater in tomato pulp of without KMS in refrigeration temperature after 3rd week, however preservatives (KMS) gives which SO_2 prevents the increasing rate of pH (Fluria, 1972, Mamun 2000, Begum 2002, Nwanekezi *et al.,* 2005, Islam *et al.,* 2009). But it was statistically found that there was no significant difference ($P<0.05$) in acidity of tomato pulp normal temperature with KMS, refrigeration temperature (with or without KMS) KMS during four weeks storage periods.

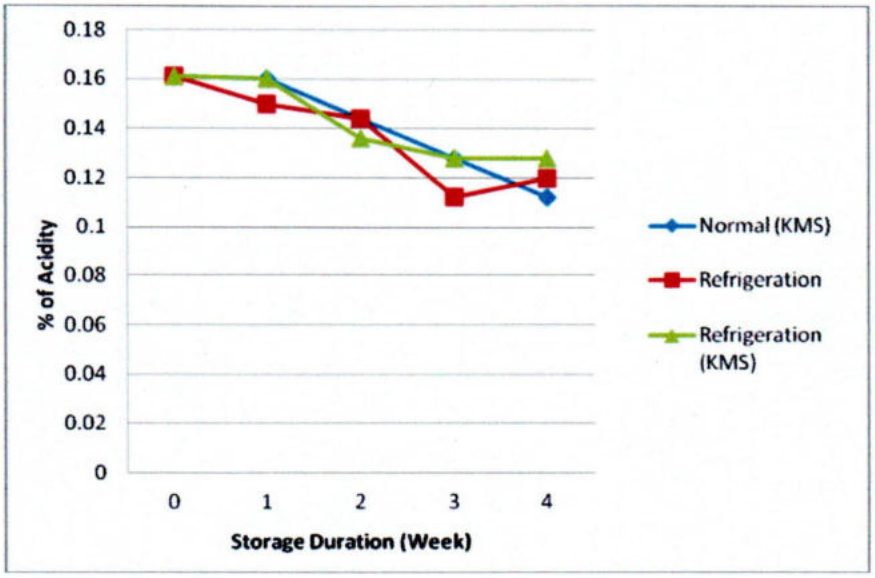


Figure 4.4: Change of acidity in different storage condition during different storage period (week)

Again, the effect of potassium metabisulfite (KMS) and temperature on acidity of tomato pulp was determined during six months storage periods and presented in Figure 4.5. At the beginning day acidity was 0.161% in all tomato pulp samples. The acidity of tomato pulp of without KMS at normal temperature was not determined because it was destroyed within 3 days. From this Figure 4.5, it was found that acidity is slightly increased after 1st month. But during six months storage period acidity of tomato pulp (with or with KMS) was deceased in all temperature, this may be due to increased of pH and it was measured that pH in all storage condition was increased during six months storage period (Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009) which affect the acidity of tomato pulp during six months storage periods. However temperature and storage time influences the acidity, change of acidity directly related to change in pH (Ahmed 1997). However it was statistically found that acidity of tomato pulp in normal temperature with KMS, refrigeration temperature (with or without KMS), freezing temperature (with or without KMS) during six months storage period was significantly ($P<0.05$) different.

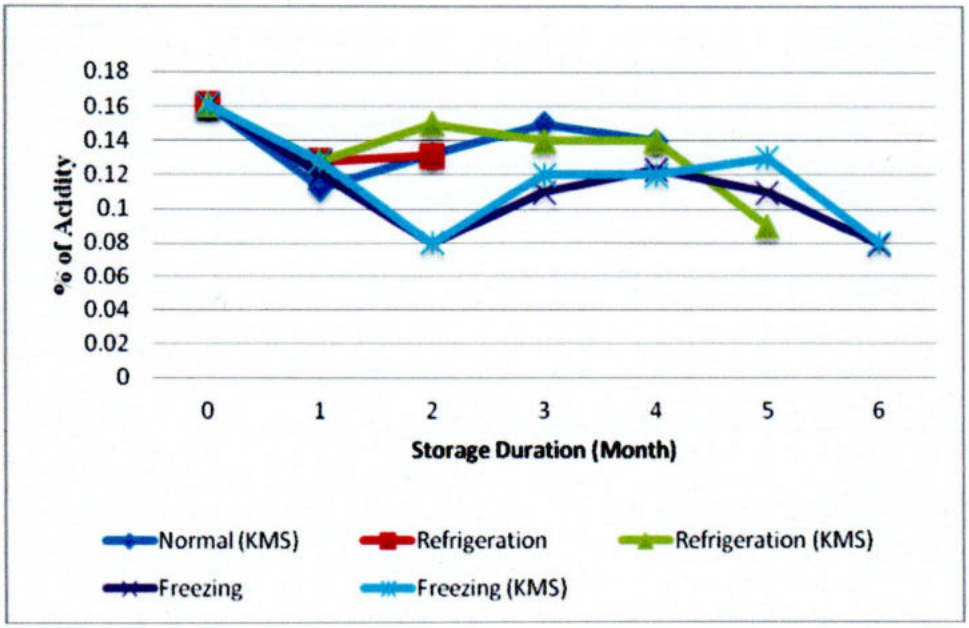


Figure 4.5: Change of acidity in different storage condition during different storage period (Month)

Figure 4.6, showed the acidity of tomato pulp at the end of shelf life (with KMS) at normal, refrigeration and freezing temperature. In this Figure 4.6, the acidity of tomato pulp at normal temperature (with KMS) is significantly ($P<0.05$) higher than tomato pulp at refrigeration temperature (with KMS) and tomato pulp at freezing temperature (with KMS). This is due to increase of pH during storage periods because temperature and storage time influences the pH, where lower temperature and preservative reduced the increasing rate of pH of tomato pulp (Fluria, 1972, Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009).

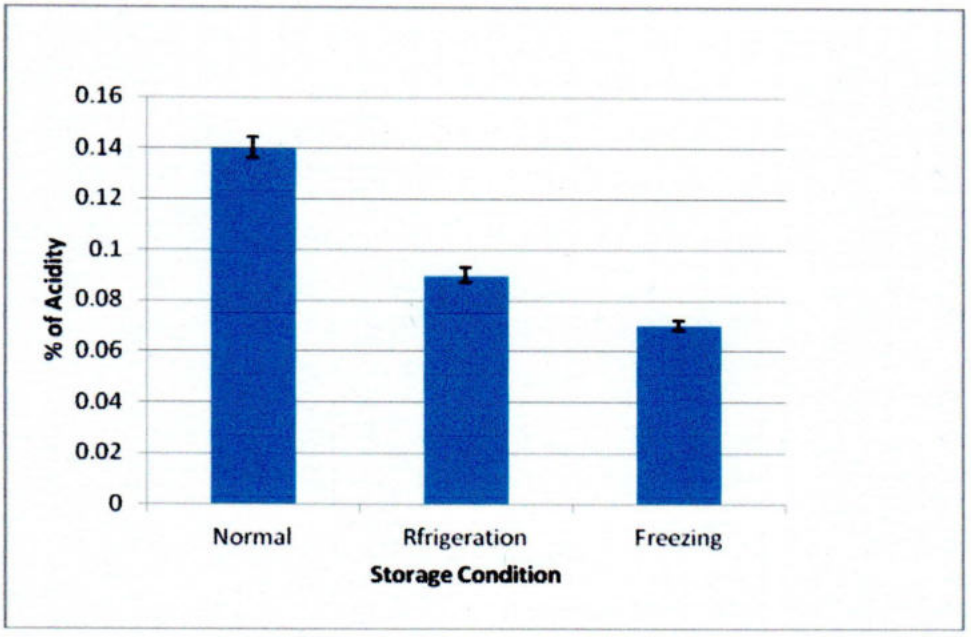


Figure 4.6: The acidity of tomato pulp with KMS in different temperature at end of storage period (month)

4.3 Effect of potassium metabisulfite and temperature on Vitamin C

Effect of potassium metabisulfite (KMS) and temperature on vitamin C of tomato pulp (with or without KMS) was determined during 1st four week in normal and refrigeration temperature and presented in Figure 4.7. At the beginning day vitamin C was 18.98 (mg/100 gm) in all tomato pulp samples. The vitamin C of tomato pulp of without KMS at normal temperature was not determined as it destroyed within 3 days. From this Figure 4.7, it was revealed that vitamin C content was reduced after four weeks in each observation but the decreasing rate was not same, and significantly ($P<0.05$) different from each other. Because vitamin C is heat liable and the concentration of vitamin C

follows first order kinetics and thus storage time and temperature affects vitamin C content (Heldman, 1974). Decreasing rate was slightly greater in tomato pulp with KMS in normal temperature and without KMS in refrigeration temperature during four weeks. On the other hand, vitamin C content of refrigeration temperature with KMS preferred the best result and significantly ($P<0.05$) different from tomato pulp of normal temperature with KMS, refrigeration temperature without KMS during 1st four week, this may be due to preservative and temperature factor. Because vitamin C (ascorbic acid) more susceptible to oxidation at higher temperature (Words and Anrand, 1977, Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009)) and temperature and SO_2 prevent the reduction ascorbic acid (Fluria, 1972, Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009).

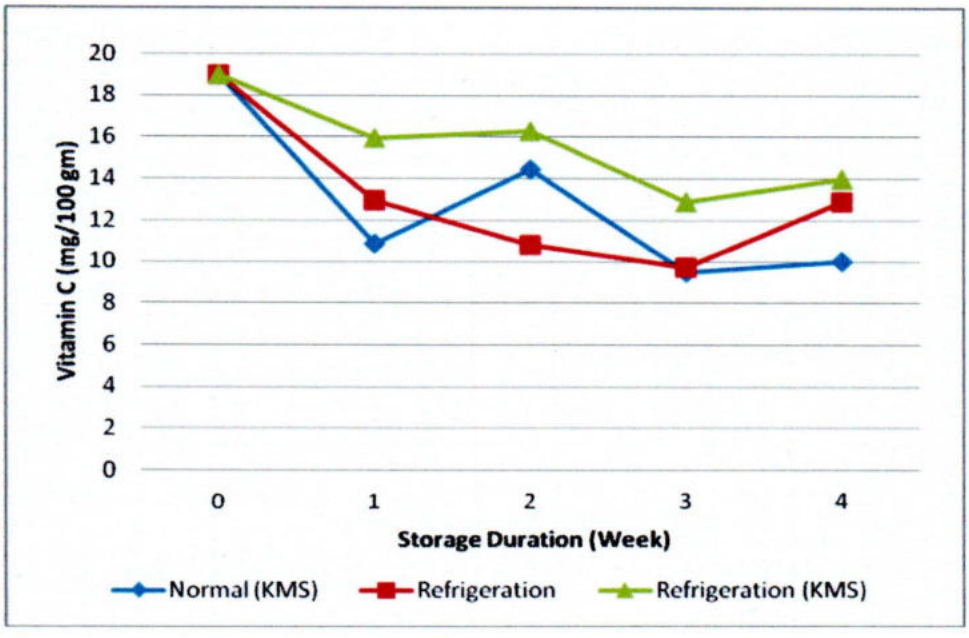


Figure 4.7: Change of vitamin C in different storage condition during different storage period (week)

Again, the effect of potassium metabisulfite (KMS) and temperature on vitamin C of tomato pulp was determined during six months storage period and presented in Figure 4.8. The vitamin C of tomato pulp of without KMS at normal temperature was not determined because it destroyed within 3 days. At the beginning day vitamin C content was 18.98 (mg/100 gm) in all tomato pulp samples. From this Figure 4.8, it was revealed that vitamin C content was reduced after six months in each observation, but the

decreasing rates are not same and significantly ($P<0.05$) different from each other. Vitamin C is heat liable and the concentration of vitamin C follows first order kinetics and storage time affects vitamin C content (Heldman, 1974) and for this reason vitamin C was reduced six months storage period. The decreasing rate was slightly greater in tomato pulp with KMS in normal temperature, without KMS in refrigeration temperature and without KMS in freezing temperature during six months storage period. The highest vitamin C content (18.93 mg/100gm) found in tomato pulp with KMS in freezing temperature and preferred the best result. On the other hand, second highest vitamin C content (17.71 mg/100gm) found in tomato pulp with KMS in refrigeration temperature. This is may be preservative and temperature factor, because vitamin C (ascorbic acid) more susceptible to oxidation at higher temperature (Words and Anrand, 1977, Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009)), lower temperature and SO_2 prevent the reduction ascorbic acid (Fluria, 1972, Mamun 2000, Begum 2002, Nwanekezi *et al.*, 2005, Islam *et al.*, 2009).

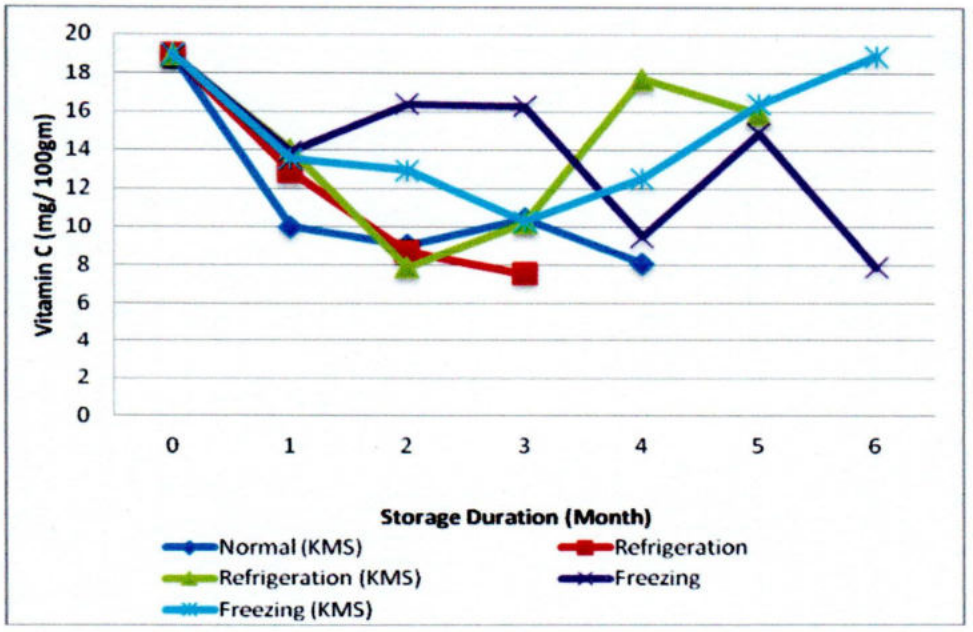


Figure 4.8: Change of vitamin C in different storage condition during different storage period (Month)

Figure 4.9, showed the vitamin C content of tomato pulp (with KMS) at the end of shelf life at normal, refrigeration and freezing temperature. In this Figure 4.3, the vitamin C content of tomato pulp at freezing temperature (with KMS) was significantly ($P<0.05$)

higher than tomato pulp at normal temperature (with KMS) and refrigeration temperature (with KMS). From this Figure 4.9, it was revealed that highest vitamin C content was in freezing temperature with KMS and lowest vitamin C content in normal temperature with KMS, so vitamin C is more oxidized in room temperature. Because vitamin C (ascorbic acid) destroyed by oxidation and more susceptible to oxidation at higher temperature (Words and Anrand, 1977) and stability is greatly influenced by temperature, oxygen and metal ion content. Vitamin C is also most liable of the nutrients, so its degradation is used as an indicator of quality (Smith and Hui 2004). The losses of ascorbic acid is probably attributable to oxidation of ascorbic acid to dehydroascorbic acid followed by hydrolysis of latter to 2,3-diketogluconic acid, which then undergoes polymerization to other nutritionally inactive products (Dewanto *et al.*, 2002).

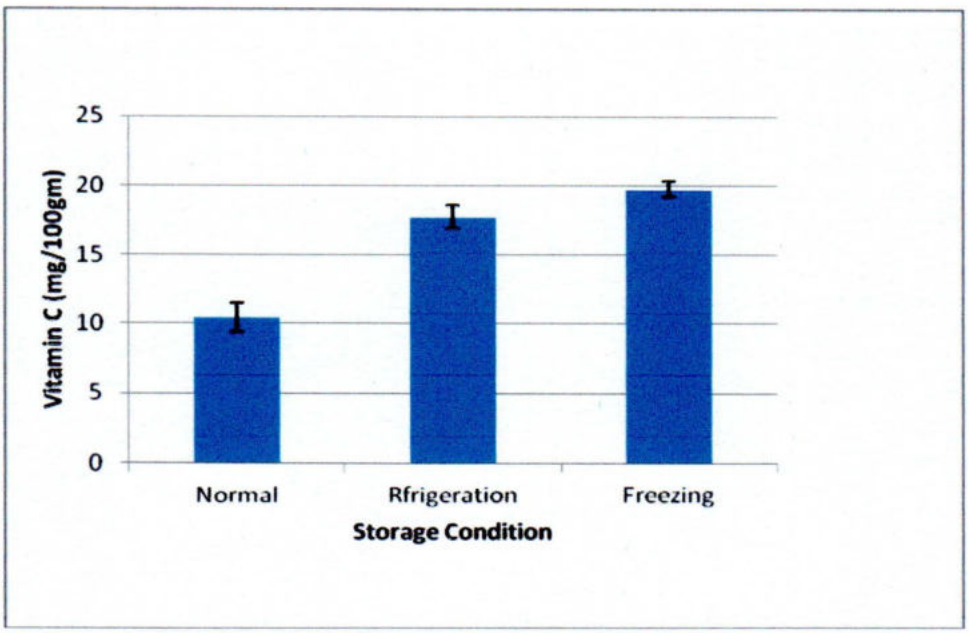


Figure 4.9: The vitamin C content of tomato pulp with KMS in different temperature at end of storage period (month)

4.4 Effect of potassium metabisulfite (KMS) and temperature on Lycopene

Effect of potassium metabisulfite (KMS) and temperature on lycopene content of tomato pulp was determined during six months and presented in Figure 4.10. At the beginning day lycopene content was 11.00 (mg/100 gm) in all tomato pulp samples. The lycopene content of tomato pulp without KMS at normal temperature was not determined because

it destroyed within 3 days. From this Figure 4.10, it was revealed that lycopene content was reduced after six months in each observation and significantly ($P<0.05$) different from each other during six month storage periods. The decreasing rate was slightly greater in tomato pulp with KMS in normal temperature, this may be due to temperature factor during six months storage periods. Because Sharma and Maguer (1996), Rukhsana (2002) found that in tomato pulp lycopene loss was increasesd at high storage temperature. The decreasing rate was also slightly greater in tomato pulp without KMS in refrigeration temperature during six months storage periods, this may be due to preservative factor, it was also found that lycopene content decreased remarkably in tomato pulp without preservatives, because temperature and SO_2 prevent the reduction lycopene content (Fluria, 1972, Rukhsana 2002). Furia (1972) stated that, SO_2 helped preserving colour and retention of carotene. The highest lycopene content found in tomato pulp in freezing temperature (with KMS) and showed best the result (7.57mg/100gm) during six months storage period. On the other hand, second highest lycopene content found in tomato pulp without KMS in freezing temperature. Tomato pulp in normal temperature (with KMS) showed the lowest value (4.30mg/100gm).

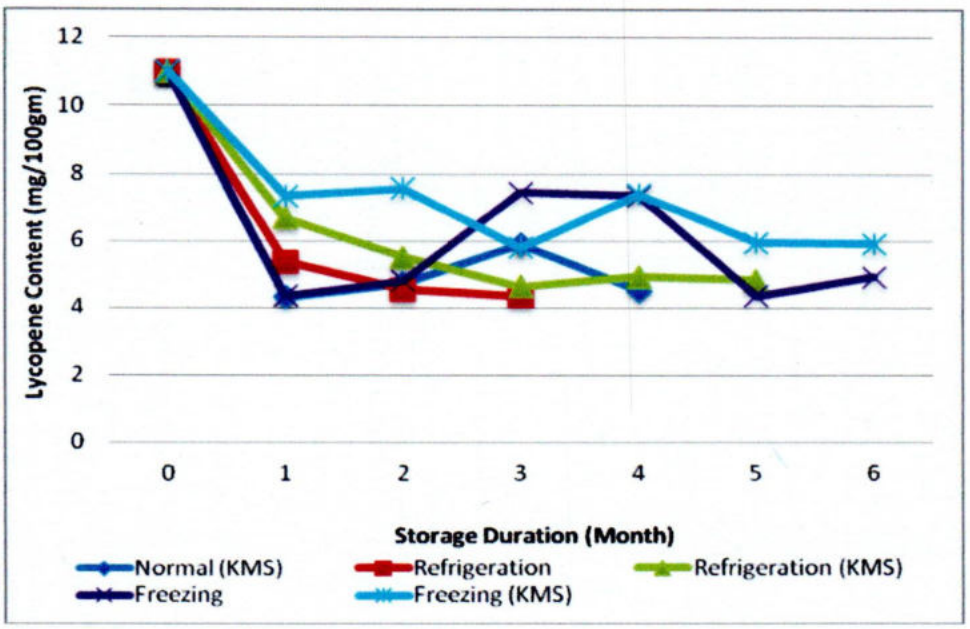


Figure 4.10: Change of lycopene content in different storage condition during different storage period (Month)

Figure 4.11, showed the lycopene content of tomato pulp (with KMS) at the end of shelf life at normal, refrigeration and freezing temperature. In this Figure 4.11, the lycopene content of tomato pulp at freezing temperature (with KMS) was significantly ($P<0.05$) higher than tomato pulp at normal temperature (with KMS) and tomato pulp at refrigeration temperature (with KMS). From this figure 4.11, it was revealed that highest lycopene content was in freezing temperature with KMS and lowest lycopene content in normal temperature with KMS at the end of shelf life. So, lycopene content of tomato pulp with preservatives decreased remarkably with the increased of storage temperature. Sharma and Maguer (1996), Begum (2002) are also found that lycopene loss in tomato pulp was increased at high storage temperature.

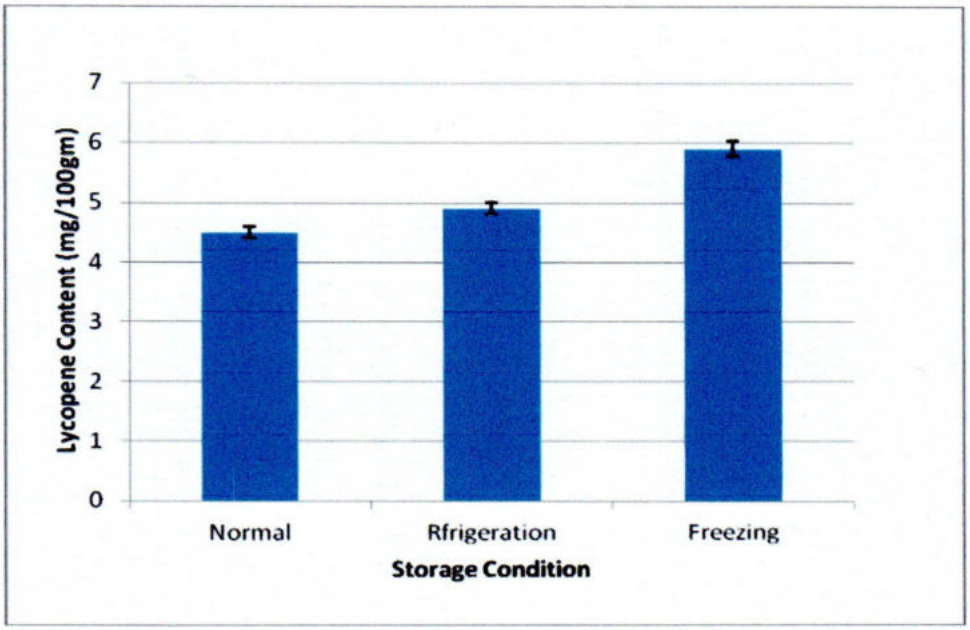
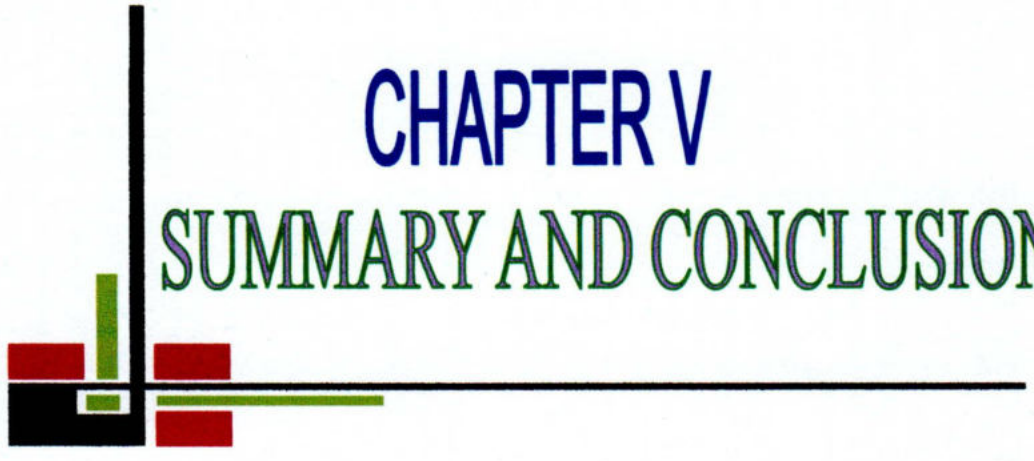


Figure 4.11: The lycopene content of tomato pulp with KMS in different temperature at end of storage period (month)



CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSIONS

This research work was carried out in the laboratories of the Department of Food Processing and Preservation and Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, during November 2012 to May 2013. In order to observed the nutritional changes of tomato pulp (summer) treated with potassium metabisulphite (0.1% KMS) among different storage temperature (normal/room, refrigeration and freezing) this study was conducted.

Fully ripe and fresh tomatoes were collected soaked, rinsed and washed with water thoroughly. Then tomatoes were boiled by steam heat (water vapuor) in rice cooker at 100-105^{0}C for 5-10 min. After that boiled tomotes were blended by blender and thus made tomato pulp. By adding preservatives potassium metabisulphite (0.1% KMS) tomato pulp was bottled and preserved tomato pulp (with/without KMS) at normal/room (28-30^{0}C), refrigeration (4^{0}C) and freezing (<-10^{0}C) temperature.

Chemical analysis (TSS, acidity, vitamin C) of tomato pulp (with or without KMS) was done at an interval of 7 days during 1st month in normal and refrigeration temperature. Again chemical analysis (TSS, acidity, vitamin C and lycopene) of tomato pulp (with or without KMS) was also done at an interval of 30 days during six months storage periods in normal, refrigeration and freezing temperature. Tomato pulp of without KMS at normal temperature was spoiled after 3 days, with KMS at normal temperature was spoiled after 4 months, without KMS at refrigeration temperature was spoiled after 3 months, with KMS at refrigeration temperature was spoiled after 5 months and tomato pulp (with or without KMS) at freezing temperature was not spoiled after six months.

Total soluble solid (TSS) of tomato pulp (with or without KMS) was slightly decreased in all storage temperature during six months storage periods. There is no significant difference ($P<0.05$) in TSS of tomato pulp in normal temperature with KMS, refrigeration temperature (with or without KMS) during 1st four weeks storage period and TSS of tomato pulp (with or without KMS) in all storage temperature during six month storage periods. TSS of tomato pulp at freezing temperature with KMS preferred the best result during six month storage periods.

Again it was found that acidity of tomato pulp (with or without KMS) was also slightly decreased in all storage temperature. There was no significant difference ($P<0.05$) in acidity of tomato pulp normal temperature with KMS, refrigeration temperature (with or without KMS) during 1st four weeks storage period. But acidity of tomato pulp (with or without KMS) in all storage temperature during six month storage periods was significantly different ($P<0.05$) and acidity of freezing temperature with KMS preferred the best result.

The major loss was found in case vitamin C, it was found that vitamin C of tomato pulp (with or without KMS) was decreased in all storage temperature. Vitamin C content of tomato pulp of refrigeration temperature with KMS preferred the best result during four 1st weeks storage period and significantly different ($P<0.05$) from normal temperature with KMS, refrigeration temperature without KMS. Again, vitamin C content of tomato pulp (with or without KMS) in all storage temperature are significantly different ($P<0.05$) during six months storage periods and vitamin C content of freezing temperature with KMS preferred the best result.

Lycopene content of tomato pulp (with or without KMS) was also gradually decreased in all storage temperature and lycopene content of tomato pulp in normal temperature with KMS, refrigeration temperature (with or without KMS), freezing temperature (with or without KMS) are significantly different ($P<0.05$) during six months storage period. Lycopene content of freezing temperature with KMS preferred the best result.

The findings of present study may help developing in commercial processing technology for effective utilization of tomato (summer) pulp especially tomato based processed products and thus growers, producers and finally country will be benefited. Therefore this study showed that to prolong the shelf life by at least 5 months, the tomato pulp (with KMS) can be preserved at 4^0C but for longer shelf life it should be preserve at below $<-10^0$C. More research would be needed to extent shelf life of tomato pulp at normal and refrigeration temperature and minimize the loss of vitamin C and lycopene content during storage period.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APPENDICES

APPENDICES

APPENDIX I

Here, Factor A means storage condition (normal, refrigeration & freezing temperature) and Factor B means treatment (with or without KMS) of tomato pulp.

1.1 Analysis of variance (ANOVA) for TSS of tomato pulp for 1st four week

Table 1.1.1 ANOVA (Analysis of variance) for TSS (1st Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	10.125	10.125	88.0435
Factor B	1	60.750	30.375	264.1304
AB	2	20.250	10.125	88.0435
Error	12	1.380	0.115	
Total	17	92505		
Coefficient of Variation: 15.07%				

Table 1.1.2 ANOVA (Analysis of variance) for TSS of Tomato Pulp (2nd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	10.125	10.125	88.0435
Factor B	1	60.750	30.375	264.1304
AB	2	20.250	10.125	88.0435
Error	12	1.380	0.115	
Total	17	92.505		
Coefficient of Variation: 15.07%				

Table 1.1.3 ANOVA (Analysis of variance) for TSS of Tomato Pulp (3rd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	10.580	10.580	88.1667
Factor B	1	59.410	29.705	247.5416
AB	2	19.810	9.905	82.5417
Error	12	1.440	0.120	
Total	17	91.240		
Coefficient of Variation: 15.51%				

Table 1.1.4 ANOVA (Analysis of variance) for TSS of Tomato Pulp (4th Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	9.680	9.680	138.2857
Factor B	1	58.080	29.040	414.8572
AB	2	19.360	9.680	138.2857
Error	12	0.840	0.070	
Total	17	87.044		
Coefficient of Variation: 12.03%				

1.2 Analysis of variance (ANOVA) for TSS of tomato pulp for six months Table

1.2.1 ANOVA (Analysis of variance) for TSS of Tomato Pulp (1st Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	20.2801	10.140	70.7442
Factor B	1	9.680	9.680	67.5349
AB	2	19.360	9.680	67.5349
Error	12	1.720	0.143	
Total	17	51.040		
Coefficient of Variation: 8.34%				

Table 1.2.2 ANOVA (Analysis of variance) for TSS of Tomato Pulp (2nd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	20.280	10.140	60.2376
Factor B	1	10.125	10.125	60.1485
AB	2	17.640	8.820	52.3960
Error	12	2.020	0.168	
Total	17	50.065		
Coefficient of Variation: 11.24%				

Table 1.2.3 ANOVA (Analysis of variance) for TSS of Tomato Pulp (3rd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	18.610	9.305	35.7885
Factor B	1	10.125	10.125	38.9423
AB	2	17.610	8.835	33.9808
Error	12	3.120	0.260	
Total	17	49.525		
Coefficient of Variation: 14.23%				

Table 1.2.4 ANOVA (Analysis of variance) for TSS of Tomato Pulp (4th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	23.040	11.520	90.9474
Factor B	1	35.280	35.280	278.5263
AB	2	17.640	8.820	69.6316
Error	12	1.520	0.127	
Total	17	77.480		
Coefficient of Variation: 12.27%				

Table 1.2.5 ANOVA (Analysis of variance) for TSS of Tomato Pulp (5th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	59.470	29.735	228.7308
Factor B	1	9.245	9.245	71.1154
AB	2	17.230	8.615	66.2692
Error	12	1.560	0.130	
Total	17	87.505		
Coefficient of Variation: 16.51%				

Table 1.2.6 ANOVA (Analysis of variance) for TSS of Tomato Pulp (6th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	79.210	39.605	240.0303
Factor B	1	0.005	0.005	0.0303
AB	2	0.010	0.005	0.0303
Error	12	1.980	0.165	
Total	17	81.205		
Coefficient of Variation: 27.38%				

Table 1.3 Effect of KMS and temperature on the TSS of tomato pulp during four week

Sample		**1st week**	**2nd week**	**3rd week**	**4th week**
without KMS	Normal	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
	Refrigeration	4.500^{a}	4.500^{a}	4.400^{a}	4.400^{a}
	Freezing	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
with KMS	Normal	4.500^{a}	4.500^{a}	4.500^{a}	4.400^{a}
	Refrigeration	4.500^{a}	4.500^{a}	4.500^{a}	4.400^{a}
	Freezing	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
LSD at 5% level		0.771	0.6033	0.6163	0.5792
CV %		18.13	15.07	15.51	14.48

*Means with same superscripts within a column are not significantly different at 5% level by DMRT

Table 1.4 Effect of KMS and temperature on the TSS of tomato pulp during six month

Sample		1st month	2nd month	3rd month	4th month	5th month	6th month
without KMS	Normal	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
	Refrigeration	4.400^{a}	4.300^{a}	4.100^{a}	0.000^{b}	0.000^{b}	0.000^{b}
	Freezing	4.500^{a}	4.400^{a}	4.400^{a}	4.500^{a}	4.400^{a}	4.400^{a}
with KMS	Normal	4.400^{a}	4.300^{a}	4.300^{a}	4.200^{a}	0.000^{b}	0.000^{b}
	Refrigeration	4.400^{a}	4.400^{a}	4.300^{a}	4.200^{a}	4.200^{a}	0.000^{b}
	Freezing	4.500^{a}	4.500^{a}	4.400^{a}	4.500^{a}	4.500^{a}	4.500^{a}
LSD at 5% level		0.673	0.729	0.907	0.634	0.641	0.723
CV %		10.23	11.24	14.23	12.27	16.51	27.38

*Means with same superscripts within a column are not significantly different at 5% level by DMRT

APPENDIX II

Here, Factor A means storage condition (normal, refrigeration & freezing temperature) and Factor B means treatment (with or without KMS) of tomato pulp.

2.1 Analysis of variance (ANOVA) for acidity of tomato pulp for 1st four week

Table 2.1.1 ANOVA (Analysis of variance) for Acidity (1st Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.072	0.036	65.5454
Factor B	1	0.014	0.014	26.2727
AB	2	0.024	0.024	21.9091
Error	12	0.007	0.001	
Total	17	0.117		
Coefficient of Variation: 29.94%				

Table 2.1.2 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (2nd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.059	0.029	1729.8801
Factor B	1	0.009	0.009	543.9993
AB	2	0.022	0.011	645.6462
Error	12	0.000	0.000	
Total	17	0.090		
Coefficient of Variation: 5.83%				

Table 2.1.3 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (3rd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.046	0.023	4614.4019
Factor B	1	0.012	0.012	2310.4007
AB	2	0.014	0.007	1388.8005
Error	12	0.000	0.000	
Total	17	0.072		
Coefficient of Variation: 3.57%				

Table 2.1.4 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (4th Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.046	0.023	195.5155
Factor B	1	0.007	0.007	60.8451
AB	2	0.012	0.006	49.4873
Error	12	0.001	0.000	
Total	17	0.067		
Coefficient of Variation: 18.13%				

2.2 Analysis of variance (ANOVA) for acidity of tomato pulp for six months

Table 2.2.1 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (1st Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.020	0.010	133.9637
Factor B	1	0.007	0.007	98.1818
AB	2	0.012	0.006	79.8546
Error	12	0.001	0.000	
Total	17	0.039		
Coefficient of Variation: 8.34%				

Table 2.2.2 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (2nd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.018	0.009	47.6508
Factor B	1	0.012	0.012	62.7407
AB	2	0.015	0.008	39.6931
Error	12	0.002	0.000	
Total	17	0.047		
Coefficient of Variation: 14.47%				

Table 2.2.3 ANOVA (Analysis of variance) for Acidity of Tomato Pulp (3rd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.013	0.007	30.3974
Factor B	1	0.016	0.016	74.4562
AB	2	0.018	0.009	42.8064
Error	12	0.003	0.000	
Total	17	0.050		
Coefficient of Variation: 13.31%				

Table 2.2.4 ANOVA (Analysis of variance) for acidity of Tomato Pulp (4th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.011	0.005	18.6232
Factor B	1	0.038	0.038	134.6910
AB	2	0.020	0.010	35.8964
Error	12	0.003	0.000	
Total	17	0.073		
Coefficient of Variation: 19.36%				

Table 2.2.5 ANOVA (Analysis of variance) for acidity of Tomato Pulp (5th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.046	0.023	80.6471
Factor B	1	0.004	0.004	14.2941
AB	2	0.004	0.002	6.8825
Error	12	0.003	0.000	
Total	17	0.057		
Coefficient of Variation: 32.58%				

Table 2.2.6 ANOVA (Analysis of variance) for acidity of Tomato Pulp (6th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	0.025	0.025	186.3464
Factor B	1	0.000	0.000	0.0074
AB	2	0.000	0.000	0.0074
Error	12	0.001	0.000	
Total	17	0.026		
Coefficient of Variation: 31.08%				

Table 2.4 Effect of KMS and temperature on the acidity of tomato pulp during 1st four Week

Sample		1st week	2nd week	3rd week	4th week
Without KMS	Normal	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
	Refrigeration	0.150^{a}	0.144^{a}	0.112^{a}	0.120^{a}
	Freezing	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
With KMS	Normal	0.160^{a}	0.144^{a}	0.128^{a}	0.112^{a}
	Refrigeration	0.160^{a}	0.136^{a}	0.136^{a}	0.128^{a}
	Freezing	0.000^{b}	0.000^{b}	0.000^{b}	0.000^{b}
LSD at 5% level		0.056	0.056	0.056	0.056
CV %		29.94	5.83	3.57	18.13

**Means with same superscripts within a column are not significantly different at 5% level by DMRT

Table 2.3 Effect of KMS and temperature on the acidity of tomato pulp during six month

Sample		1st month	2nd month	3rd month	4th month	5th month	6th month
without KMS	Normal	0.000^{b}	0.000^{c}	0.000^{d}	0.000^{c}	0.000^{c}	0.000^{b}
	Refrigeration	0.120^{a}	0.128^{ab}	0.131^{b}	0.000^{c}	0.000^{c}	0.000^{b}
	Freezing	0.128^{a}	0.080^{b}	0.110^{c}	0.123^{ab}	0.110^{ab}	0.079^{a}
with KMS	Normal	0.112^{a}	0.132^{ab}	0.150^{a}	0.140^{a}	0.000^{c}	0.000^{b}
	Refrigeration	0.128^{a}	0.150^{a}	0.150^{a}	0.140^{a}	0.070^{b}	0.000^{b}
	Freezing	0.128^{a}	0.080^{b}	0.120^{bc}	0.120^{b}	0.130^{a}	0.080^{a}
LSD at 5% level		0.056	0.056	0.018	0.018	0.056	0.056
CV %		8.34	14.47	19.36	32.58	32.58	31.08

*Means with different superscripts within a column are significantly different at 5% level by DMRT

APPENDIX III

Here, Factor A means storage condition (normal, refrigeration & freezing temperature) and Factor B means treatment (with or without KMS) of tomato pulp.

3.1 Analysis of variance (ANOVA) for vitamin C of tomato pulp for 1st four week

Table 3.1.1 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (1st Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	639.296	319.648	245.2133
Factor B	1	95.773	95.773	73.4707
AB	2	94.457	47.229	36.2307
Error	12	15.457	1.304	
Total	17	845.168		
Coefficient of Variation: 17.23%				

Table 3.1.2 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (2nd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	550.426	275.213	259.0564
Factor B	1	198.403	198.403	186.7558
AB	2	159.682	79.841	75.1538
Error	12	12.748	1.062	
Total	17	921.259		
Coefficient of Variation: 14.89%				

Table 3.1.3 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (3rd Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	389.890	194.945	140.1272
Factor B	1	80.899	80.899	58.1507
AB	2	70.028	35.014	25.1683
Error	12	16.694	1.391	
Total	17	557.512		
Coefficient of Variation: 21.98%				

Table 3.1.4 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (4th Week)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	557.242	278.621	207.2146
Factor B	1	60.941	60.941	45.3226
AB	2	90.682	45.341	33.7206
Error	12	16.135	1.345	
Total	17	724.999		
Coefficient of Variation: 18.82%				

3.2 Analysis of variance (ANOVA) for vitamin C of tomato pulp for six months

Table 3.2.1 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (1st Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	296.911	148.456	28.2282
Factor B	1	56.498	56.498	10.7429
AB	2	95.376	47.688	9.0677
Error	12	63.110	5.259	
Total	17	511.895		
Coefficient of Variation: 21.35%				

Table 3.2.2 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (2nd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	316.489	158.244	50.6847
Factor B	1	11.376	11.376	3.6438
AB	2	129.990	64.995	20.8174
Error	12	37.466	3.122	
Total	17	495.321		
Coefficient of Variation: 19.28%				

Table 3.2.3 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (3rd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	195.234	97.617	28.8690
Factor B	1	25.418	25.418	7.5172
AB	2	202.639	101.320	29.9640
Error	12	40.577	3.381	
Total	17	463.869		
Coefficient of Variation: 20.15%				

Table 3.2.4 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (4th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	152.712	76.356	28.1416
Factor B	1	416.161	416.161	153.3792
AB	2	166.582	83.291	30.6975
Error	12	32.559	2.713	
Total	17	768.015		
Coefficient of Variation: 20.65%				

Table 3.2.5 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (5th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	983.450	491.725	307.2768
Factor B	1	1.037	1.037	0.6479
AB	2	2.074	1.037	0.6479
Error	12	19.203	1.600	
Total	17	1005.763		
Coefficient of Variation: 24.20%				

Table 3.2.6 ANOVA (Analysis of variance) for vitamin C of Tomato Pulp (6th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	774.119	148.45	181.1384
Factor B	1	572.445	56.498	33.9031
AB	2	144.889	47.688	33.9031
Error	12	25.642	5.259	
Total	17	1017.095		
Coefficient of Variation: 31.52%				

Table 3.3 Effect of KMS and temperature on the vitamin C of tomato pulp during 1st four Week

Sample		1st week	2nd week	3rd week	4th week
Without KMS	Normal	0.000^{d}	0.000^{c}	0.000^{c}	0.000^{c}
	Refrigeration	12.96^{b}	10.80^{b}	9.740^{b}	12.96^{a}
	Freezing	0.000^{d}	0.000^{c}	0.000^{c}	0.000^{c}
With KMS	Normal	10.86^{c}	14.45^{a}	9.500^{b}	10.00^{b}
	Refrigeration	15.94^{a}	16.27^{a}	12.96^{a}	14.00^{a}
	Freezing	0.000^{d}	0.000^{c}	0.000^{c}	0.000^{c}
LSD at 5% level		2.031	1.833	2.098	2.063
CV %		17.23	14.89	21.98	18.82

*Means with different superscripts within a column are significantly different at 5% level by DMRT

Table 3.4 Effect of KMS and temperature on the vitamin C of tomato pulp during six month

Sample		1st month	2nd month	3rd month	4th month	5th month	6th month
without KMS	Normal	0.000 ^{b}	0.000 ^{d}	0.000 ^{c}	0.000 ^{d}	0.000 ^{b}	0.000 ^{c}
	Refrigeration	12.96 ^{a}	8.710 ^{c}	7.540 ^{b}	0.000 ^{d}	0.000 ^{b}	0.000 ^{c}
	Freezing	13.95 ^{a}	16.40 ^{a}	16.27 ^{a}	9.500 ^{c}	14.96 ^{a}	7.893 ^{b}
with KMS	Normal	10.00 ^{a}	9.040 ^{c}	10.45 ^{b}	8.100 ^{c}	0.000 ^{b}	0.000 ^{c}
	Refrigeration	14.00 ^{a}	7.880 ^{c}	10.20 ^{b}	17.71 ^{a}	15.90 ^{a}	0.000 ^{c}
	Freezing	13.54 ^{a}	12.96 ^{b}	10.29 ^{b}	12.54 ^{b}	16.40 ^{a}	18.93 ^{a}
LSD at 5% level		4.080	3.143	3.271	2.930	2.377	2.601
CV %		21.35	19.28	20.15	20.65	16.96	31.52

*Means with different superscripts within a column are significantly different at 5% level by DMRT

APPENDIX IV

Here, Factor A means storage condition (normal, refrigeration & freezing temperature) and Factor B means treatment (with or without KMS) of tomato pulp.

4.1 Analysis of variance (ANOVA) for lycopene content of tomato pulp for six month

Table 4.1.1 ANOVA (Analysis of variance) for lycopene content (1st Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	57.402	28.701	56.1628
Factor B	1	37.325	37.325	73.0379
AB	2	6.654	3.327	6.5100
Error	12	6.132	0.511	
Total	17	107.513		
Coefficient of Variation: 15.30%				

Table 4.1.2 ANOVA (Analysis of variance) for lycopene content (2nd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	45.838	22.919	56.5161
Factor B	1	35.955	35.955	88.6615
AB	2	10.550	5.275	13.0074
Error	12	4.866	0.406	
Total	17	97.210		
Coefficient of Variation: 14.11%				

Table 4.1.3 ANOVA (Analysis of variance) for lycopene content (3rd Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	40.895	20.448	41.0003
Factor B	1	10.125	10.125	20.3021
AB	2	46.156	23.078	46.2747
Error	12	5.985	0.499	
Total	17	103.161		
Coefficient of Variation: 15.09%				

Table 4.1.4 ANOVA (Analysis of variance) for lycopene content (4th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	111.423	55.711	105.8847
Factor B	1	40.051	40.051	76.1213
AB	2	26.642	13.321	25.3183
Error	12	6.314	0.526	
Total	17	184.430		
Coefficient of Variation: 17.66%				

Table 4.1.5 ANOVA (Analysis of variance) for lycopene content (5th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	79.374	39.687	127.3318
Factor B	1	20.480	20.480	65.7077
AB	2	17.920	8.960	28.7471
Error	12	3.740	0.312	
Total	17	121.515		
Coefficient of Variation: 22.21%				

Table 4.1.6 ANOVA (Analysis of variance) for lycopene content (6th Month)

Source of Variance	Degree of freedom	Sum of Squares	Means square	F Value
Factor A	2	116.424	58.212	323.1609
Factor B	1	0.490	0.490	2.7205
AB	2	0.980	0.490	2.7205
Error	12	2.162	0.180	
Total	17	120.056		
Coefficient of Variation: 23.60%				

Table 4.2 Effect of KMS and temperature on the lycopene content of tomato pulp during six month

Sample		1st month	2nd month	3rd month	4th month	5th month	6th month
without KMS	Normal	0.00^{c}	0.00^{c}	0.00^{d}	0.00^{c}	0.00^{c}	0.00^{c}
	Refrigeration	5.36^{b}	4.52^{b}	4.34^{c}	0.00^{c}	0.00^{c}	0.00^{c}
	Freezing	4.34^{b}	4.78^{b}	7.45^{a}	7.35^{a}	4.34^{b}	4.90^{b}
KMS	Normal	4.30^{b}	4.72^{b}	5.89^{b}	4.50^{b}	0.00^{c}	0.00^{c}
	Refrigeration	6.69^{a}	5.49^{b}	4.61^{bc}	4.90^{b}	4.80^{b}	0.00^{c}
	Freezing	7.35^{a}	7.57^{a}	5.79^{b}	7.50^{a}	5.94^{a}	5.90^{a}
LSD at 5% level		1.27	1.13	1.26	1.29	0.99	0.75
CV %		15.30	14.11	15.09	17.66	22.21	23.60

*Means with different superscripts within a column are significantly different at 5% level by DMRT