IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Tomato Products are Potential source of Lycopene in the Management of Cardiovascular Diseases

Vijaya jyothi S; and Srilatha D department of food and nutritional sciences, S.P.Mahila University, Tirupathi

Abstract

We aimed to verify the beneficial effects of processed tomato ketchup prepared in the laboratory on hypolipidemic subjects with hyperlipidemia condition. Using purposive sampling technique, 90 CVD subjects between 35-55 years of age group, BMI levels falls between 18.5-34.9 (kg/m2) were selected for the study and the total sample is divided under two experimental groups with 30 subjects under each group, supplemented with pure lycopene gel capsule and tomato ketchup, respectively, and the remaining 30 subjects placed under control group without any intervention and the study was carried out for a period of 3 months. The parameters like physic-chemical analysis shows that the samples were superior safe during storage and nutrient analysis shows that the tomato ketchup was nutritionally rich and lycopene content was very high. The hypolipidemic effects of tomato products showed that the TC, TG, LDL, VLDL and HDL levels studied were found to be decreased at 1% level and 5% level significantly after supplementation.

Key words: tomato ketchup, tomato products, lycopene capsule, TC, TG, LDL, VLDL, HDL CVD subjects, lipid profile

Introduction

Tomato is a globally famous food and contains several phytonutrients including lycopene, β-carotene, anthocyanin, and flavonoids (Lee HS, et al. 2013). The increased temperature used to produce tomato juice, ketchup, tomato paste and canned tomato enhances the bioactive composition. Lycopene is a naturally occurring chemical that gives fruits and vegetables a red color is due to the pigments called carotenoids (Schweiggert RM, et al. 2014). Lycopene is found in watermelons, pink grapefruits, apricots, and pink guavas. It is found in particularly high amounts in tomatoes and tomato products (Seifi M, et al. 2013). In North America, 85% of dietary lycopene comes from tomato products such as tomato juice or paste. One cup (240 ml) of tomato juice provides about 23 mg of lycopene. Processing raw tomatoes using heat (in the making of tomato juice, tomato paste or ketchup, for

example) actually change the lycopene in the raw product into a form that is easier for the body to use (Friedman M; 2013).

Lycopene is also used for treating the heart disease, for preventing of "hardening of the arteries" (atherosclerosis); and cancer of the prostate, breast, lung, bladder, ovaries, colon, and pancreas (Datta M**,** et al., (2013). Lycopene is also used for treating the human papilloma virus (HPV) infection, which is a major cause of uterine cancer.

Methodology

General information

Sample distribution according to age

Table 1 Percentage distribution of sample according to age

Age (Years)	**Group**			**Total (n=90)**
	Control (n=30)	**Experiment-I (n=30)**	**Experiment-II (n=30)**	
26-35	0 (0)	2 (6.7)	4 (13)	6 (6.7)
36-45	11 (36.7)	5 (16.7)	14 (46.7)	30 (33.3)
46-55	19 (63.3)	14 (46.7)	11 (36.7)	44 (48.9)
Above 55	0 (0)	9 (30)	1 (3.3)	10 (11.1)

Figure in ( ) indicates percentage.

The percentage distribution of the sample according to age presented in Table 1 shown that in control group a majority of 63.3 percent of patients were in between 46 to 55 years and next higher 36.7 percent were between 36-45 years; whereas in experimental group-I 46.7 percent of patients were between 46-55 years and next higher 30 percent of patients above55 years, whereas in experimental group-II 46.7 percent of patients were between 36-45 years and next higher 36.7 percent of patients above 46-55 years. This table revealed that cardiovascular disease highly prevalent in the age middle adulthood due to the unhealthy lifestyle, faulty food habits and sedentary activities.

Sample distribution according to gender

Table 2 Percentage distribution of sample according to gender

Gender	Group			Total (n=90)
	Control (n=30)	Experiment-I (n=30)	Experiment-II (n=30)	
Male	19 (63.3)	23 (76.7)	22 (73.3)	64 (71.0)
Female	11 (36.7)	7 (23.3)	8 (26.7)	26 (28.9)

Figure in ( ) indicates percentage.

The percentage distribution of the sample according to gender presented in Table 2 shown that in control group a majority of 63.3 percent of patients were males and 36.7 percent of patients were female; whereas in experimental group-I majority 76.7 percent of patients were males and 23.3 percentile patients were female; whereas in experimental group-II higher 73.3 percent of patients were male and 26.7 percent were female. This table revealed that cardiovascular disease is highly prevalent in the males rather than females.

Sample distribution according to occupation

Table 3 Percentage distribution of sample according to occupation

Occupation	Group			Total (n=90)
	Control (n=30)	Experiment-I (n=30)	Experiment-II (n=30)	
Employee	9 (30.0)	16 (53.3)	18 (60.0)	43 (47.8)
Unemployee	21 (70.0)	14 (46.7)	12 (40.0)	47 (52.2)

Figure in ( ) indicates percentage.

The percentage distribution of the sample according to occupation presented in Table 3 shown that in control group a majority of 70 percent of patients were unemployed and 30.0 percent of patients were employed; whereas in experimental group-I majority 53.3 percent of patients were employees and 46.7 percentile patients were unemployed; whereas in experimental group-II higher 60.0 percent of patients were employed and next higher 40 percent were unemployed. This table result revealed that the no occupation may cause of reduction in physical activity which may change in lifestyle and cause heart disease.

Using purposive sampling technique, 90 CVD subjects were selected for the study and the total sample is divided under two experimental groups with 30 subjects under each group, supplemented with pure lycopene capsule and tomato ketchup, respectively, and the remaining 30 subjects placed under control group without any intervention.

Sample distribution according to Body Mass Index

Table 4 Percentage distribution of sample according to Body Mass Index

BMI levels (kg/m2)	Group			Total (n=90)
	Control (n=30)	Experiment-I (n=30)	Experiment-II (n=30)	
<18.4 (Underweight)	0 (0)	1 (3.3)	0 (0.0)	1 (1.1)
18.5-24.9 (Normal)	12 (40.0)	17 (56.7)	20 (66.7)	49 (54.4)
25-29.9 (Overweight)	14 (46.7)	9 (30.0)	6 (20.0)	29 (32.2)
30-34.9 (Obesity Grade-I)	4 (13.3)	3 (10.0)	4 (13.3)	11 (12.2)

Figure in ( ) indicates percentage.

The percentage distribution of the sample according to height presented in Table 4 results shown that in the control group majority 46.7 percent of patients were overweight their BMI was in between 25-29.9 kg/m2 and next higher 40 percent of patients were normal nutritional status their BMI in between 18.5-24.9 kg/m2 and only 13.3 percent of patients were in grade-I obesity and their BMI was in between 30-34.9kg/m2; whereas in experimental group-I majority 56.7 percent of patients were in normal nutritional status and their BMI was in between 18.5-24.9 kg/m2 and next higher 30 percent of patients were overweight and their BMI was in between 25-29.9 kg/m3; whereas in experimental group-II majority 66.7 percent of patients were in normal nutritional status and their BMI was in between 18.5-24.9 kg/m2 and next higher 20 percent of patients were overweight and there BMI was in between 25-29.9 kg/m3; This data revealed that higher body mass index, which increases the more deposition of adipose fat in the body which may alters the lipid profile level cause of metabolic complications like cardiovascular disease.

Dietary intervention

Food product standardization

1. **Tomato ketchup**

Among tomato products, tomato ketchup was decided to prepared as it is a concentrated source of tomato pulp, using standard procedure (suryaprakasa rao, 2011)

Tomato pulp preparation: 1. Select clean red ripe tomatoes free from rots and pests and removal of raw green core portion wash thoroughly and cut them into pieces of convenient size 2. Crush them in a stainless steel vessel and cook well until they are soft to facilitate easy extraction of pulp 3. Extract the pulp by rubbing the cooked material on wire mesh screen or sieve collecting the same into a stainless steel vessel 4. Heat the pulp quickly raising it to boiling point and continue boiling until the material is concentrated and reduced to nearly one third of its volume by constant stirring to prevent charring of the product 5. Tomato pulp is obtained

Tomato ketchup preparation: 1. Add one fourth of sugar to the pulp prepared and mix and cook thoroughly. Then add remaining three fourth sugars and cook it until it is completely dissolved and mix thoroughly 2. Add dry chili powder onion and garlic extracts and mix it 3. Remove from stove and then add salt, vinegar and ketchup masala extract and mix thoroughly. 4. Fill the hot ketchup into thoroughly cleaned bottles and cap them air tight.

2. **Pure lycopene capsules**

Lycopene Capsules (tomato source) containing 20 mg lycopene per each capsule was obtained from piping Rock.com company.

Capsules Per Container : 120

Serving size : 1 Soft gel

Lycopene Amount per Serving : 20 mg

Experimental design

In Experimental group-I

20 mg of lycopene soft gel capsule has been supplemented to 30 patients twice in a day, i.e., 2 capsules per day with meals for 3 months

In Experimental group-II

30 g of tomato ketchup sachets (Consist 20 mg of lycopene) has been supplemented to 30 patients twice in a day, i.e., 2 sachets per day with meals and advise them to have with their toasted bread, sandwich, or chapathi for 3 months

Control group 30 patients were recruited for the study. They were neither supplemented tomato ketchup sachets nor lycopene capsules. They were asked to follow their own household diets.

Nutrient analysis of Tomato ketchup

The primary nutrients such as proteins, fat, carbohydrates, ash content were analyzed according to standard procedures Suzanne Nielson (2010). The lycopene content was estimated in the samples according to the procedures given by Ranganna S (2001).

Table 5 Nutrient analysis of Tomato ketchup

Nutrients	Tomato ketchup
Lycopene (mg/100 g)	67.9
Protein (g/100g)	8.5
Fat (g/100 g)	2.1
Carbohydrates (g/100g)	37.8
Energy (kcal/100 g)	204
Ash (g/100g)	3.7

The Table 5 shown that 100 g of developed tomato ketchup in the laboratory contained 67.9 mg of lycopene, 8.5 g of proteins, 2.1 g of fat, 37.8 g of carbohydrates, 204 kcal of energy and 3.7 g of ash and Friedman M. (2013) studied on anti-carcinogenic, cardio protective, and other health benefits of tomato compounds lycopene, α-tomatine, and tomatidine in pure form and in fresh and processed tomatoes.

Shelf life analysis of the product

The Shelf life analysis of the product was carried out by assessing microbial analysis, moisture content pH and rancidity of tomato ketchup according to standard procedures given in Suzanne Nielson (2010).

Microbiological analysis of Tomato ketchup

The microbial analysis was done using dilution plate technique as per the methods specified by American Public Health Association (2012) Dilution plate technique is the most frequently used technique for determining the number of viable microbial present in samples. The technique is based upon the assumption that when a known weight of the sample is agitated in the suitable liquid, the microorganisms before detached from the sample and each of the detached cells gives rise to discrete colonies when plate on a nutrient medium in a Petri dish. These colonies are counted and the number of cells in the original sample estimated, since the number of cells present is large even in a small sample. The suspension of cells must be diluted using dilution plate technique so that a small number of well separated colonies develop on each Petri dish.

Table 6 Microbiological analysis of Tomato ketchup

Sample	**Tomato ketchup**	
	24 hours' incubation (Cfu/g)	**48 hours' incubation (Cfu/g)**
Fresh sample	8	9
15 days old	12	16
30 days old	34	36

The Table 6 shown that the microbiological analysis of fresh supplement products for 24 hours' incubation was 8 Cfu/g, on the 15 th day 12 Cfu/g and on 30 th day 34 Cfu/g; whereas after 48 hours' incubation of fresh supplemented product 9 Cfu/g, on the 15 th day 16 Cfu/g and on the 30 th day 36 Cfu/g.

The limit range for microbial growth on food sample is 20-25 colonies. If the number of colonies is more than that, the food sample is not consumable. If 15 days old food sample the microbial growth was seen, but it was less than 20 colonies which implies that it is consumed. At 30 days old samples, the food sample shown dense growth of colonies which indicates, it is deteriorated keeping the shelf life in view the investigator supplemented the freshly prepared the samples once in every 10-15 days and advise them to keep ketchup sachets in general refrigeration temperature.

Table 7 Analysis of Moisture contents, pH and rancidity of the Tomato ketchup

Samples	Moisture content %	pH	Rancidity
Fresh sample	47.9	3.94	1.04
15 days old	49	3.94	1.03
30 days old	49	3.95	1.03

The Table 7 shown the chemical analysis of supplemented product tomato ketchup and the moisture content of fresh sample was 47.9% at 15 and 30 days of storage moisture content was 49%. Similarly the pH values of fresh and 15 and 30 was ranges from 3.94 -3.95 and rancidity values were decreased from 1.04 to 1.03.

Lycopene is a natural carotenoid pigment found in tomato and possess health benefits, such as cardiovascular preventative properties. The molecular mechanisms of lycopene is revealed that, this molecule possess a very potential therapeutic properties (Palozza P, et al. 2010).

Shukla SK (2010) stated the role of dietary nutritional supplements such as lycopene from tomato and tomato products, flavonoids (citrus fruits, pulses, red wine, tea and cocoa), olive oil, omega-3 (omega-3) fatty acids (fish oil and fish-based products), resveratrol (grapes and red wine), coffee, and soy was very effective in the prevention and treatment of cardiovascular disorders

Biochemical parameters:

Table 8 Comparison of paired t-test Blood cholesterol changes before, intermittently, and after intervention in control group, experimental group- I and II

Type of Group	Blood cholesterol	N	Mean	Std. Deviation	t-test	p value
Control group	Pre-Test	30	174.270	16.884	4.938**	0.000
	Post-Test	30	198.970	35.843		
Experimental –I group	Pre-Test	30	170.080	53.989	14.230**	0.000
	Post-Test	30	145.880	51.034		
Experimental –II group	Pre-Test	30	175.850	46.190	16.422**	0.000
	Post-Test	30	140.670	45.431		

**= Indicates significant at 1% level

* = Indicates significant at 5% level

NS=Indicates not significant

The comparison paired-t-test of Blood cholesterol, pre and post of the study in three groups presented in Table 8 shown that in control group mean and SD values raised from 174.270±16.884 mg/dl to 198.970±35.843mg/dl, with the mean difference of 24.7 mg/dl, t-value was 4.938**and p-value was 0.000. This data revealed that the rise of blood cholesterol was statistically significant at the 1% level; whereas in experimental group-I after intervention mean and SD values changed from 170.080 ±53.989mg/dl to 145.880 ± 51.034mg/dl, with the mean difference of 24.2 mg/dl, t-value was 14.230** and p-value was 0.000. This data revealed that reduction was statistically significant at the 1% level; whereas in experimental group-II after intervention mean and SD values changed from 175.850±46.190mg/dl to 140.670±45.431mg/dl, with the mean difference of 35.18 mg/dl, t-value was 16.422** and p-value was 0.000. This data revealed that reduction was statistically significant at 1% and the blood cholesterol level in the control group was raised whereas in experimental group–I and II blood cholesterol reduction was due to lycopene had an impact on lipid metabolism.

Table 9 Comparison of paired t-test Triglycerides changes before, intermittently, and after the intervention in the control group, experimental group- I and II

Type of Group	Triglycerides	N	Mean	Std. Deviation	t-test	p value
Control group	Pre-Test	30	181.930	33.673	4.804**	0.000
	Post-Test	30	192.500	36.083		
Experimental –I group	Pre-Test	30	136.810	54.934	3.144*	0.004
	Post-Test	30	133.710	51.938		
Experimental –II group	Pre-Test	30	131.830	51.449	1.975 NS	0.058
	Post-Test	30	130.270	52.228		

**=Indicates significant at 1% level

* =Indicates significant at 5% level

NS=Indicates not significant

The comparison paired-t-test of Triglycerides in pre and post of the study in three groups presented in Table 9 shown that in control group mean and SD values raised from 181.930 ±33.673mg/dl to 192.500±36.083mg/dl, with the mean difference of 10.57 mg/dl, t-value was 4.804** and p-value was 0.000. This data revealed that race was statistically significant at the 1% level; whereas in experimental group-I after intervention mean and SD values changed from 136.810±54.934mg/dl to 133.710±51.938mg/dl, with the mean difference of 3.1 mg/dl, t-value was 3.144* and p-value was 0.004. This data revealed that reduction was statistically significant at the 5% level; whereas in experimental group-II after intervention mean and SD values changed from 131.830±51.449mg/dl to 130.270±52.228mg/dl, with the mean difference of 1.56 mg/dl, t-value was 1.975 NS and p-value was 0.058. the triglycerides levels in the control group was raised, whereas in experimental group–I triglycerides, cholesterol was significantly reduced due to lycopene capsule supplementation has a better effect on lipid metabolism than tomato ketchup.

Table 10 Comparison of paired t-test HDL-Cholesterol changes before, intermittently, and after intervention in control group, experimental group- I and II

Type of Group	HDL level	N	Mean	Std. Deviation	t-test	p value
Control group	Pre-Test	30	37.600	5.308	3.529**	0.000
	Post-Test	30	35.870	6.447		
Experimental –I group	Pre-Test	30	40.970	14.618	11.266**	0.000
	Post-Test	30	47.210	14.989		
Experimental –II group	Pre-Test	30	42.170	12.943	8.872**	0.000
	Post-Test	30	48.250	12.755		

**=Indicates significant at 1% level

* =Indicates significant at 5% level

NS=Indicates not significant

The comparison paired-t-test of High density lipoprotein (HDL)-Cholesterol in pre and post of the study in three groups presented in Table 10 shown that in control group mean and SD values decreased from 37.600±5.308 mg/dl to 35.870±6.447 mg/dl, with the mean difference of 1.73 mg/dl, t-value was 3.529** and p-value was 0.000. This data revealed that HDL level reduction was statistically significant at the 1% level; whereas in experimental group-I after intervention mean and SD values changed from 40.970±14.618 mg/dl to 47.210±14.989 mg/dl, with the mean difference of 6.24 mg/dl, t-value was 11.266** and p-value was 0.000. This data revealed that HDL increased was statistically significant at the 1% level; whereas in experimental group-II after intervention mean and SD values changed from 42.170±12.943mg/dl to 48.250±12.755 mg/dl, with the mean difference of 6.08 mg/dl, t-value was 8.872** and p-value was 0.000. This data revealed that HDL-Cholesterol increased was statistically significant at 1%.and in the control group was decreased, whereas in experimental group–I and II, HDL- Cholesterol was increased significantly.

Table 11 Comparison of paired t-test LDL changes before, intermittently, and after the intervention in the control group, experimental group- I and II

Type of Group	LDL level	N	Mean	Std. Deviation	t-test	p value
Control group	Pre-Test	30	100.300	17.011	4.639**	0.000
	Post-Test	30	124.230	37.580		
Experimental –I group	Pre-Test	30	101.300	34.427	15.286**	0.000
	Post-Test	30	72.770	32.040		
Experimental –II group	Pre-Test	30	107.470	30.504	14.105**	0.000
	Post-Test	30	67.270	32.366		

**=Indicates significant at 1% level

* =Indicates significant at 5% level

NS=Indicates not significant

The comparison paired-t-test of Low density lipoprotein (LDL)-Cholesterol in pre and post of the study in three groups presented in Table 11 shown that in control group mean and SD values raised from 100.300±17.011 mg/dl to 124.230±37.580mg/dl, with the mean difference of 23.93 mg/dl, t-value was 4.639** and p-value was 0.000. This data revealed that the race was statistically significant at the 1% level; whereas in experimental group-I after intervention mean and SD values changed from 101.300±34.427mg/dl to 72.770±32.040mg/dl, with the mean difference of 28.53 mg/dl, t-value was 15.286** and p-value was 0.000. This data revealed that reduction was statistically significant at the 1% level; Whereas in experimental group-II after intervention mean and SD values changed from 107.470±30.504mg/dl to 67.270±32.366mg/dl, with the mean difference of 40.2 mg/dl, t-value was 14.105** and p-value was 0.000. This data revealed that reduction was statistically significant at the 1% level, and in the control group the LDL cholesterol was raised, whereas in experimental group–I and II, LDL cholesterol reduced was due to lycopene supplementation had an impact on lipid metabolism and per oxidation because based on the intriguing results of various studies, Shukla SK (2010) proposed the prophylactic and therapeutic potential of tomato products and other natural plant products is due to the compound B-carotene (lycopene) occur from natural fruits and vegetables resources. Hence the supplementation of cardiovascular friendly natural products needs to be considered in all populations who have a high prevalence of CVD.

Table 12 Comparison of paired t-test VLDL changes before, intermittently, and after the intervention in the control group, experimental group- I and II

Type of Group	VLDL level	N	Mean	Std. Deviation	t-test	p value
Control group	Pre-Test	30	36.370	6.770	4.509**	0.000
	Post-Test	30	38.870	7.454		
Experimental group –I	Pre-Test	30	27.770	11.057	3.137*	0.004
	Post-Test	30	26.500	10.421		
Experimental group–II	Pre-Test	30	26.230	10.274	0.403 NS	0.690
	Post-Test	30	26.170	10.455		

**=Indicates significant at 1% level

* =Indicates significant at 5% level

NS=Indicates not significant

The comparison paired-t-test of Very low density lipoprotein (VLDL) in pre and post of the study in three groups presented in Table 12 shown that in control group mean and SD values raised from 36.370±6.770 mg/dl to 38.870±7.454 mg/dl, with the mean difference of 2.5 mg/dl, t-value was 4.509** and p-value was 0.000. This data revealed that the race was statistically significant at the 1% level; whereas in experimental group-I after intervention mean and SD values changed from 27.770±11.057 mg/dl to 26.500±10.421 mg/dl, with the mean difference of 1.27 mg/dl, t-value was 3.137* and p-value was 0.004. This data revealed that reduction was statistically significant at the 5% level; whereas in experimental group-II after intervention mean and SD values changed from 26.230±10.274mg/dl to 26.170±10.455mg/dl, with the mean difference of 0.06 mg/dl, t-value was 0.403 and p-value was 0.690. This data revealed that reduction was not significant.

This result revealed that in control group VLDL cholesterol raised, whereas in both experimental group-I VLDL cholesterol reduced lycopene capsule has a better effect on lipid metabolism than tomato ketchup.

Similar results were seen in Arranz S, et al., (2015) LDL cholesterol and total cholesterol decreased significantly 6h after the consumption of tomato juice with oil, which significantly correlated with an increase of trans-lycopene and 5-cis-lycopene, respectively. Hence, the consumption of lycopene rich foods is recommended for all the individuals who are reached 45 years of age for the best prevention of various inflammatory diseases.

Conclusions: The available evidence and the present research data on the effects of tomato products and lycopene supplementation on CV risk factors supports the view that increasing the intake of these tomatoes and tomato products and pure lycopene neutraceuticals has positive effects on blood lipids, blood pressure and endothelial function. These results support the development of promising individualized nutritional strategies involving tomatoes to tackle CVD.

Bibliography

1. Arranz S, Martínez-Huélamo M, Vallverdu-Queralt A, Valderas-Martinez P, Illán M, Sacanella E, Escribano E, Estruch R, Lamuela-Raventos RM. (2015) Influence of olive oil on carotenoid absorption from tomato juice and effects on postprandial lipemia. Food Chem. 2015 Feb 1; 168:203-10.

2. Datta M, Taylor ML, Frizzell B. (2013) Dietary and serum lycopene levels in prostate cancer patients undergoing intensity-modulated radiation therapy. J Med Food. 2013 Dec; 16(12):1131-7.

3. Lee HS, Cho YH, Park J, Shin HR, Sung MK.(2013) Dietary intake of phytonutrients in relation to fruit and vegetable consumption in Korea. J Acad Nutr Diet. 2013 Sep; 113(9):1194-9.

4. Seifi M, Seifi P, Hadizadeh F, Mohajeri SA. (2013) Extraction of lycopene from tomato paste by ursodeoxycholic acid using the selective inclusion complex method. J Food Sci. 2013 Nov; 78(11):C1680-5.

5. Schweiggert RM, Kopec RE, Villalobos-Gutierrez MG, Hogel J, Quesada S, Esquivel P, Schwartz SJ, Carle R. (2014) Carotenoids are more bioavailable from papaya than from tomato and carrot in humans: a randomised cross-over study. Br J Nutr. 2014 Feb; 111(3):490-8.

6. Shukla SK, Gupta S, Ojha SK, Sharma SB. (2010) cardiovascular friendly natural products: a promising approach in the management of CVD. Nat Prod Res. 2010 May; 24(9):873-98.

7. Friedman M. (2013) anti-carcinogenic, cardio protective, and other health benefits of tomato compounds lycopene, α-tomatine, and tomatidine in pure form and in fresh and processed tomatoes. J Agric Food Chem. 2013 Oct 9;61(40):9534-50.

8. Suzanne Nielsen (2010) "This second edition laboratory manual was written to accompany Food Analysis, Fourth Edition, ISBN 978-1-4419-1477-4, Springer Science & Business Media, 20-Mar-2010 -Technology & Engineering – 186-196 pages.

9. Ranganna S, 2001, Hand book of Analysis & Quality Control for fruit & vegetable products II Edition Tata Mc Graw Hill.

10. Surya prakasa rao, P.V; 2011 preparation preservation of fruit and vegetable products-Methods and Formulas. Panganamamula foundation. Pp 43-45Reprographic and printing services