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Effect of Spices and Salt on the Overall Acceptability and Preservation of Tomato Cubes

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Abstract

Wastage of tomato during peak season and the consumers increasing trend toward natural and nutritional diet have led the food industries to develop new and quality tomato product containing natural ingredients. Accordingly, the present research was conducted to prepare tomato cubes with incorporated salt and spices at various levels and to study the influence of these selected spices (garlic, onion, ginger, red pepper, turmeric, coriander, cumin) & salt on the quality characteristics of tomato cubes stored at room temperature for 90 days. The treatments were LS0, LS1, LS2, LS3, LS4, and LS5. Physico-chemical (total soluble solids, titratable acidity, ash and moisture), and sensory properties (color, taste, flavor and overall acceptability) of tomato cubes were analyzed at 15 days' interval. The means of TSS, titratable acidity, moisture and ash of tomato cubes were ranged from 26.81 (LS3) -31.33 (LS5), 1.41 (LS0) -3.04 (LS5), 21.44 (LS3) -23.35 (LS1) and 10.57 (LS1) -34.53 (LS2) respectively, during storage period. The result observed in case of color, taste, flavor and overall acceptability ranged from 5.90 (LS0) to 7.56 (LS3), 6.34 (LS0) to 7.50 (LS4), 6.44 (LS0) to 7.47 (LS3), 5.89 (LS0) to 7.77 (LS3), respectively. The present findings showed that moisture content, and sensory properties were decreased however, total soluble solids, titratable acidity and ash content of cubes increased with storage. The results further showed that treatments LS3 followed by LS4 were found most acceptable in term of physicochemical and sensory acceptability of product.

Keywords: Physicochemical analysis; Sensory analysis; Storage period; Tomato cubes

Introduction

Tomato (*Lycopersicum esculentum*) belongs to a family solanaceae [1]. Tomatoes are fruits but referred to as vegetables [2]. Tomatoes are one of the most cultivated and commercialized vegetable crop in the world [3-5]. The crop duration is relatively short, high yielding and is economically attractive. Its cultivation (area wise) is increased substantially in the recent past [6]. Tomatoes are mainly of three types; cultivars for industrial use, cultivars for fresh usage and cherry tomatoes [7]. It provides healthful and necessary nutrients in the human diet and is consumed either fresh as in salad or used as an ingredient in different food products [8-10].

Tomato contains 94-95% water and 5-6% organic compounds, of which almost one percent is seeds and skin [11,12]. The composition of tomatoes reveals that it contains substantial amount of vitamins, minerals, sugars, essential amino acids and dietary fibers. It is a rich source of iron, phosphorus, vitamin B and C [13-15]. It is very rich source of lycopene in the human diet, and among all dietary carotenoids, it has the highest anti-oxidative properties [6,16,17]. Tomatoes and products made from tomatoes are also the rich sources of quercetin and kaempferol, which exist together in the form of conjugates [18,19]. It also contains chlorogenic acid and a flavanone (naringenin). Tomatoes are ranked first in case of the total consumption of phenols [18].

The beneficial aspects of tomatoes in the human diet is mostly attributed to it protections against prostate cancer, cardiovascular diseases and neurodegenerative diseases, which is provided by lycopene, antioxidant and phyto-chemicals in the fruit [20-23]. Lycopene and other compound present in the fruit acts as a radical scavenger [24]. Anti-oxidant destroys and neutralizes free radicals, which results in the oxidative damages of the biological molecules i.e. lipids, protein and nucleic acids [25,26]. The presence of phenolic compounds functions as anti-allergic, anti-thrombotic and anti-inflammatory and plays an important role against neurological and cardiovascular disease [27]. The processed products made from tomatoes include purees, pastes, ketchup and juices. Their shelf life has been increased to a great extent by canning and drying [6,28]. It is very important to extend the shelf life of the tomatoes for domestic market and exporting [29]. Dehydration of tomato is one the oldest process used to overcome the losses of tomato by extending the storage life [20]. It can be preserved by different methods such as canning, bottling and by using chemical preservatives [30].

The usage of spices has increased significantly in the recent years because of its preservative role. Some studies provide information on their inhibitory role against microbial contamination [31-33]. Over all spices cannot help in the preservation of food. Some provide only flavor to food like vinegar, some act as an anti-microbial which help the food to preserve it for long time like salts and garlic. The usage of herbs in large quantity leads to high flavor, texture, when used in the commodities like soups; whereas when exposed to high quantity of salts no detrimental changes were observed [34]. Spices are used in tomato ketchup along with salt, sugar and vinegar with other optional ingredients (starches, onions, garlic etc.), where the proportion of tomato solids must not be less than 12% and is the most highly consumed products [35]. The current study is designed keeping in view the effect of natural additives i.e. spices and salt on the physicochemical, microbial and sensory attributes of tomato cubes during storage period.

Material and Methods

Tomato, garlic, onion, salt, ginger, red pepper, turmeric powder, coriander powder and cumin powder were purchased from the local market at Peshawar, and were brought to the laboratory of Pakistan Council of Scientific and Industrial Research (PCSIR), Peshawar for research work.

Preparation of Tomato Cubes

Tomatoes were washed and the unwanted portions as well as diseased tomatoes were removed. The tomatoes were slashed into four equal halves and the pulp was extracted through Pulper machine. Garlic, onion and ginger were first peeled and cut into small pieces and the pulp were extracted through Pulper machine. Garlic, onion and ginger pulp as well as salt, red pepper, turmeric powder, coriander powder and cumin powder were mixed with the tomato pulp. The mixtures were then heated until the moisture content reduced to 22 percent. After heating, the mixtures were put in a cube shaped plastic mould. Then the cubes were placed in an oven at a temperature of 60 ^{0}C to avoid moisture absorption. The standard protocol of Amankwah et al. (2006) [36] was used by modifying the time for heat treatment and the amount of additives.

Physicochemical Analysis

Physicochemical properties such as total soluble solids, titratable acidity, moisture and ash contents were determined following the standard method of AOAC (2012) [37].

Sensory Evaluation

The 9-point hedonic scale of Larmond (1977) [38] was used for sensory evaluation. On the basis of experience in sensory analysis, 15 judges were selected. The quality characteristics including taste, color, flavor and overall acceptability were estimated by taking the mean value of final decision of the panelists. The panelist expresses the results in term of hedonic scale (1-9), where 9 exhibit strong liking and 1 express strong disliking.

Statistical Analysis

The data were analyzed statistically by using 2-factorial Completely Randomized Design (CRD) and means were separated by LSD test at 0.05% significant level [39].

Results and Discussion

Total Soluble Solids of Cubes

The effect of storage and treatments on total soluble solids of tomato cubes stored at room temperature is presented in Table 1, 2. Statistically analyzed data showed that storage and treatments had significant ($p < 0.05$) effect on TSS of tomato cubes. The results showed that total soluble solids were significantly increased during storage. At initial day of storage of tomato cubes, total soluble solids were found in the range of 27.0 to 30.0. But on the other hand, after 90 days' interval storage, total soluble solids raised (27.8-33.0). The results are similar to the findings of (Rohani et al. 1979) [40], who studied TSS of tomato paste in the range of 25.5 to 31.3. Total soluble solids fluctuate during storage due to different factors. Temperature is one of the main factors which affect total soluble solids during storage [41]. Similarly, total soluble solids are also related to moisture content i.e. increase in moisture content cause dilution effect of solids [42].

Treatments	Salt (g)	Tomato Pulp (kg)	Garlic (g)	Onion (bulb)	Ginger (g)	Red pepper (g)	Turmeric powder (g)	Coriander powder (g)	Cumin powder (g)
LS0	Nil	1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
LS1	4	1	Nil	Nil	Nil	Nil	Nil	Nil	Nil
LS2	4	1	10	1	10	Nil	Nil	Nil	Nil
LS3	4	1	10	1	10	8	5	5	2
LS4	5	1	15	1	15	8	8	8	4
LS5	6	1	15	1	15	10	10	10	5

Table 1: Proposed plan of study.

Treatments	Storage Intervals							% Increase	Means
	0	15	30	45	60	75	90		
LS0	27	27.6	28.3	28.9	29.6	30.3	31.1	13.18	28.97c
LS1	29	29.7	30.4	31	31.6	32.3	33	12.12	31.00a
LS2	26	26.5	26.9	27.2	27.8	28.4	29.2	10.96	27.43d
LS3	26	26.3	26.5	26.7	27	27.4	27.8	6.47	26.81e
LS4	29	29.5	29.9	30.3	30.7	31.1	31.8	8.81	30.33b
LS5	30	30.4	30.8	31.2	31.7	32.3	32.9	8.81	31.33a
Mean	27.40g	27.92f	28.40e	28.82d	29.34e	29.90b	30.58a		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 2: Influence of storage period and treatments on total soluble solids of tomato cubes.

Titratable Acidity of Cubes

Titratable acidity of tomato cubes had significantly ($p<0.05$) different from each other. The results showed that higher acidity was found in LS0 (3.04 %) whereas lower total acidity (1.41%) was observed in LS5 at initial day of storage (Table 3). It was observed from the results that titratable acidity increased with the storage intervals in the range of 1.80 % to 5 %. Titratable acidity may be affected by the temperature and presence of sugar content in fruits and also influenced by the conversion of starch into sugar [43,44]. It might be increased by the influence of spoilage organisms which can secrete some substance into the samples [45].

Treatments	Storage Intervals							% Increase	Means
	0	15	30	45	60	75	90		
LS0	0.81	1.23	2.74	3.37	3.98	4.12	5	83.8	3.04a
LS1	0.69	1.73	2.54	2.68	2.77	2.81	2.93	76.45	2.31b
LS2	0.77	0.97	1.43	2.17	2.29	2.35	2.46	68.7	1.78bc
LS3	0.87	1.13	1.45	1.58	1.67	1.73	1.83	52.46	1.47c
LS4	0.73	1.41	1.48	1.55	1.63	1.72	1.81	59.67	1.48c
LS5	0.72	1.14	1.32	1.47	1.63	1.78	1.8	60	1.41c
Mean	0.77d	1.29cd	1.93bc	2.27ab	2.47ab	2.55a	2.81a		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 3: Influence of storage period and treatments on titratable acidity of tomato cubes.

Moisture (%) of Cubes

Statistical results indicate that treatments and storage period had significant ($p<0.05$) influence on moisture content of tomato cubes (Table 4). The moisture content was observed in the range of 21.44 % (LS3) to 23.35 % (LS1) at the storage of tomato cubes after 90 days. But at initial day of storage the moisture content was found in the range of 22.87 to 21.9%. The results indicated that moisture content decreased significantly during storage. The results are similar with the findings of the article by [46]. They observed moisture content of 16-27 % in tomato cubes. Moisture content of any food product during storage depends on the processing time and storage temperature [47]. Lodge and Whalley (1981) [48] concluded that moisture content and water activity are directly proportional to each other. The higher the moisture content the higher the water activity and vice versa.

Treatments	Storage Intervals							% Decrease	Means
	0	15	30	45	60	75	90		
LS0	23.1	22.83	22.58	22.39	22.12	21.77	21.49	6.97	22.33c
LS1	22.92	22.75	22.59	22.38	22.14	21.94	21.73	5.19	23.35c
LS2	22.82	22.78	22.74	22.13	21.95	21.93	21.87	4.16	22.32c
LS3	21.7	21.63	21.52	21.47	21.35	21.24	21.17	2.44	21.44d
LS4	23.52	23.47	23.33	23.28	23.15	22.93	22.85	2.85	23.22a
LS5	23.21	23.17	22.82	22.74	22.65	22.56	22.43	3.36	22.80b
Mean	22.87a	22.78ab	22.60b	22.40c	22.24cd	22.09de	21.96e		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 4: Influence of storage period and treatments on percent moisture of tomato cubes.

Sensory Evaluation of Tomato Cubes

Color Measurement

The results of stored treatments of tomato cubes are presented in Table 5. Statistically both storage and treatments had significant ($p<0.05$) effect on color of tomato cubes. Maximum score of 7.56 was given to LS3, whereas minimum score of 5.90 was given to LS0 by the panelists. Maximum rating of 8.20 was observed at day one, while minimum rating of 5.55 was observed at 90 days' storage interval. Throughout the storage, the highest fall in color was recorded in LS0 (48.72%), while lowest fall was observed in LS3 (20.24%). Lycopene is the color pigment of tomato, which is affected by the addition of sodium chloride and heat treatment [20]. It was also observed that the color of tomato product might also be influenced by drying time [49,50].

Treatments	Storage Intervals							% Decrease	Means
	0	15	30	45	60	75	90		
LS0	7.8	7.2	6.4	5.9	5.3	4.7	4	48.72	5.90d
LS1	8.3	7.6	7.2	6.7	6.2	5.7	5.1	38.55	6.69c
LS2	8.3	8	7.6	7.2	6.8	6.3	5.7	31.33	7.13b
LS3	8.4	8.1	7.8	7.6	7.3	7	6.7	20.24	7.56a
LS4	8.2	7.5	7.3	6.8	6.5	6.2	6	26.83	6.93bc
LS5	8.2	7.8	7.3	6.9	6.5	6.1	5.8	29.27	6.94bc
Mean	8.20a	7.70b	7.27c	6.85d	6.43e	6.00f	5.55g		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 5: Influence of storage period and treatments on color of tomato cubes.

Taste

The effect of storage duration and treatments on taste of tomato cubes stored at room temperature is presented in Table 6. Statistically both storage and treatments had significant ($p<0.05$) impact on taste of tomato cubes. Higher score of 7.50 were obtained by LS4, whereas lower score of 6.34 were obtained by LS0 of tomato cubes. Maximum taste score (8.53) was observed at day one, while lowest taste score (5.82) was observed at day 90 of storage interval. Throughout the storage period, the highest fall in taste was recorded in LS0 (46.34%) while lowest fall was observed in LS3 (26.44%). Among treatments, maximum mean score was observed in treatment having fewer spices (8.14), while minimum was recorded (2.29) in the treatment having maximum concentration of spices. The result of analyzed samples showed a linear decrease for taste among treatments during storage periods. Increase in the concentration of spices beyond optimum amounts may, however, reduce the taste ratings thus requiring optimization. However, dried tomato was shown to maintain acceptable sweetness ratings within a study period of two months [51].

Treatments	Storage Intervals							% Decrease	Means
	0	15	30	45	60	75	90		
LS0	8.2	7.6	7	6.4	5.7	5.1	4.4	46.34	6.34c
LS1	8.6	8.4	8.1	7.6	7.3	6	5.8	32.56	7.40ab
LS2	8.5	8	7.6	7.1	6.8	6.3	5.8	31.76	7.16b
LS3	8.7	8.1	7.8	7.3	7	6.7	6.4	26.44	7.43a
LS4	8.6	8.3	8	7.5	7.1	6.7	6.3	26.74	7.50a
LS5	8.6	8.2	7.8	7.3	7	6.6	6.2	27.91	7.39ab
Mean	8.53a	8.10b	7.72c	7.20d	6.82e	6.23f	5.82g		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 6: Influence of storage period and treatments on taste of tomato cubes.

Flavor

Table 7 shows the impact of flavor on tomato cubes. Statistically both storage and treatments had significant ($p<0.05$) influence on flavor. LS3 was given maximum score (7.47) for flavor, whereas LS0 was given minimum score (6.44) by the sensory panels. Higher score for flavor (8.38) was observed at day one while lower score (5.70) was observed at 90 days of storage interval. During the storage period, highest fall in flavor score was recorded in LS0 (41.98%) while lowest fall was observed in LS3 (23.53%). Among the various samples, maximum mean score was recorded (8.05) in treatments having maximum proportion of spices, while minimum mean score was observed in treatments having minimum proportion of spices (4.71). The results pertaining to the response of flavor on the storage interval of the candies prepared from tomato paste. The mean scores of judges for flavor significantly decreased from 8.25 to 4.92 during storage [52].

Treatments	Storage Intervals							% Decrease	Means
	0	15	30	45	60	75	90		
LS0	8.1	7.6	7	6.5	5.9	5.3	4.7	41.98	6.44d
LS1	8.5	8	7.5	7.1	6.6	6.1	5.7	32.94	7.07c
LS2	8.4	8	7.7	7.3	6.8	6.4	5.9	29.76	7.21bc
LS3	8.5	8.1	7.7	7.5	7.2	6.8	6.5	23.53	7.47a
LS4	8.4	8.1	7.7	7.4	7	6.6	6.4	23.81	7.37ab
LS5	8.4	8	7.6	7.2	6.9	6.5	6.1	27.38	7.24bc
Mean	8.38a	7.93b	7.48c	7.10d	6.63e	6.15f	5.70g		
Mean values followed by different letters are significantly (P<0.05) different from each other									

Table 7: Influence of storage period and treatments on flavor of tomato cubes.

Overall Acceptability

The impact of storage and treatments on over all acceptability of tomato cubes stored at room temperature are presented in Table 8. Statistically, both storage and treatments had significant ($p<0.05$) effect on over all acceptability of tomato cubes. LS3 got the highest acceptance score (7.77), whereas LS0 obtained the lowest acceptance scores (5.89) among the tomato cube samples. Likewise, higher overall acceptability (8.28) was observed at day one, while lowest (5.37) was observed at day 90 of storage interval. In the whole period of the storage, the maximum decline in overall acceptability rating was recorded in LS0 (49.37%) while lowest decline was observed in LS3 (19.77%) followed by LS4 (25.88%). Overall acceptability generally related to all sensory attributes. It is reported that the acceptability of fruits and vegetables is influenced by their flavor and taste. The overall acceptability of intermediate moisture product decreased significantly during keeping period [53]. Maximum mean score was recorded in samples having maximum amount of spices, while minimum mean score was observed in the sample having minimum amount of spices.

Treatments	Storage Intervals							% Decrease	Means
	0	15	30	45	60	75	90		
LS0	7.9	7.2	6.5	5.8	5.2	4.6	4	49.37	5.89e
LS1	8.1	7.6	7	6.4	5.8	5.1	4.5	44.44	6.36d
LS2	8.2	7.7	7.1	6.6	6	5.4	4.8	41.46	6.54d
LS3	8.6	8.3	8	7.8	7.6	7.2	6.9	19.77	7.77a
LS4	8.5	8.1	7.7	7.4	7	6.6	6.3	25.88	7.37b
LS5	8.4	7.9	7.5	7	6.5	6.1	5.7	32.14	7.01c
Mean	8.28a	7.80b	7.30c	6.83d	6.35e	5.83f	5.37g		
Mean values followed by different letters are significantly ($P<0.05$) different from each other.									

Table 8: Influence of storage period and treatments on overall acceptability of tomato cubes.

Conclusion

Tomato cubes were prepared by the addition of various spices and salt due to their preservative role. It was concluded that the sample LS3 was found best, followed by LS4 on the basis of physicochemical analysis, and sensory analysis. During storage a decrease in moisture color, flavor, taste and over all acceptability were observed, while an increase in TSS, acidity and ash content were observed. All the formulations are acceptable considerably, but the formulation that is used in LS3 is recommended for the preparation of tomato cubes.

References

1. Wang F, Smith AG, Brenner ML (1994) Temporal and spatial expression pattern of sucrose synthase during tomato fruit development. J Plant Physiol 104: 535-554.
2. Tyssandier V, Feillet-Coudray C, Caris-Veyrat C, Guilland JC, Coudray C, et al. (2004) Effect of tomato product consumption on the plasma status of antioxidant microconstituents and on the plasma total antioxidant capacity in healthy subjects. J Amer College Nutr 23: 148-156.
3. Amini F, Ehsanpour AA (2005) Soluble proteins, proline, carbohydrates and Na^+/K^+ changes in two tomato (*Lycopersiconesculentum* Mill.) cultivars *in vitro* salt stress. Amer J Biochem Biotechnol 4: 212-216.
4. Estañ MT, Martinez-Rodriguez MM, Perez-Alfocea F, Flowers TJ, Bolarin MC (2005) Grafting raises the salt tolerance of tomato through limiting the transport of sodium and chloride to the shoot. J Exp Bot 56: 703-712.
5. Primavesi L, Pravettoni V, Brenna OV, Farioli L, Pastorello EA, et al. (2011) Influence of technological processing on the allergenicity of tomato products. Eur Food Res Technol 32: 631-636.
6. Khokhar KM (2013) Present status and prospects of tomatoes in Pakistan. Agricultural corner- farmers to global market. Repot.
7. Rodriguez RG (2007) Effect of rice bran mulching on growth and yield of cherry tomato. Cien Inv Agr 23: 181-186.
8. GoP (2008) Government of Pakistan. Economic Survey. Economic Affairs Division. Ministry of Finance, Islamabad.
9. Rao AV, Agarwal S (1998) Bioavailability and *in vivo* antioxidant properties of lycopene from tomato products and their possible role in the prevention of cancer. Nutr Cancer 31: 199-203.
10. Thakur BR, Singh RK, Nelson PE (1996) Quality attributes of processed tomato products: A review. Food Res Int 12: 375-401.
11. Marschner H (1995) Mineral nutrition of higher plant. Ann Bot 78: 523-528.
12. Adedeji O, Taiwo KA, Akanbi CT, Ajani R (2006) Physicochemical properties of four tomato cultivars grown in Nigeria. J Food Process Preserv 30: 79-86.
13. Qureshi KM, Chughtai S, Qureshi US, Abbasi NA (2013) Impact of exogenous application of salt and growth regulators on growth and yield of strawberry. Pak J Bot 45: 1179-1186.
14. Giovanelli G, Paradiso A (2002) Stability of dried and intermediate moisture tomato pulp during storage. J Agric Food Chem 50: 7277-7281.
15. Adamse P, Peters JL, Jaspers PAPM, VAN Tuinen A, Koornneef M, et al. (1989) Photocontrol of anthocyanin synthesis in tomato seedling: a genetic approach. Photochem Photobiol 50: 107-111.
16. Miller NJ, Castelluccio C, Tijburg L, Rice-Evans C (1996) The antioxidant properties of theaflavins and their gallate esters-radical scavengers or metal chelators. FEBS Lett 392: 40-44.
17. Böhm V, Puspitasari-Nienaber NL, Ferruzzi MG, Schwartz SJ (2002) Trolox equivalent antioxidant capacity of different geometrical isomers of alpha-carotene, beta-carotene, lycopene, and zea-xanthin. J Agric Food Chem 50: 221-226.
18. Vinson JA, Hao Y, Xuehui S, Zubik L (1998) Phenol antioxidant quantity and quality in foods: Vegetables. J Agric Food Chem 46: 3630-3634.
19. Stewart AJ, Bozonnet S, Mullen W, Jenkins GI, Lean ME, et al. (2000) Occurrence of flavonols in tomatoes and tomato-based products. J Agric Food Chem 48: 2663-2669.
20. Abreu WC, Barcelos MFP, Silva EP, Boas EVBV (2011) Physical and chemical characteristics and lycopene retention of dried tomatoes subjected to different pre-treatments. Rev Inst Adolfo Lutz São Paulo 70: 168-174.

21. Rao AV, Rao LG (2007) Carotenoids and human health. J Pharmacol Res 55: 207-216.

22. Shi J, Le Maguer M (2000) Lycopene in tomatoes: chemical and physical properties affected by food processing. Crit Rev Biotechnol 20: 293-334.

23. Giovannucci E, Ascherio A, Rimm EB, Stampfer MJ, Colditz GA, et al. (1995) Intake of carotenoids and retinol in relation to risk of prostate cancer. J Natl Cancer Inst 87: 1767-1776.

24. Nguyen ML, Schwartz SJ (1999) Lycopene: chemical and biological properties. Food Technol 53: 38-45.

25. Nardini M, D'Aquino M, Tomassi G, Gentili V, Di Felice M, et al. (1995) Inhibition of human low-density lipoprotein oxidation by caffeic acid and other hydroxycinnamic acid derivatives. Free Radic Biol Med 19: 541-552.

26. Vinson JA, Jang J, Dabbagh YA, Serry MM, Cai S (1995a) Plant phenols exhibit lipoprotein-bound antioxidant activity using an *in vitro* model for heart disease. J Agric Food Chem 43: 2798-2799.

27. Kuskoski EM, Asuero AG, Troncoso AM, Mancini-Filho J, Fett R (2005) Aplicación de diverso sméto dos químicos para determiner activated antioxidante en pulpa de frutos. Ciencia y Tecnología Alimentaria 25: 726-732.

28. Opiyo MA, Ying TJ (2005) The effects of 1-methylcyclopropen treatment on the shelf life and quality of cherry tomato (Lycopersicon esculentum var. cerasiforme) fruit. Int J Food Sci Technol 40: 665-673.

29. Mustafa A, Mughrabi AL (1994) Effect of packaging methods on the quality characteristics of tomato fruits produced in hydroponics. J King Saud University 6: 71-76.

30. Sethi V (1991) Effect of addition of spice extracts and flavor compounds on the keeping quality of tomato juice stored in different containers. Indian Food Packer 45: 17-18.

31. Sema A, Nursel D, Süleyman A (2007) Antimicrobial activity of some spices used in the meat industry. Bull Ve. I Pulawy 51: 53-57.

32. Souza EL, Montenegro-Stamford TL, Oliveira-Lima E (2006) Sensitivity of spoiling and pathogen food-related bacteria to *Origanum vulgare* L. (Lamiaceae) essential oil. Braz J Microb 37: 527-532.

33. Celikel N, Kavas G (2008) Antimicrobial properties of some essential oils against some pathogenic microorganisms. Czech J Food Sci 26: 174-181.

34. Sameer KG, Ian R, Lisa M (2014) Enhancing consumer liking of low salt tomato soup over repeated exposure by herb and spice seasonings. Appetite 81: 20-29.

35. Gupta RK (1998) SBP handbook of export oriented food processing projects. SBPPF Book Store, SBP Consultants and Engineers.

36. Amankwah EA, Ellis WO, Oldham JH (2006) Manufacture of tomato ketchup using the gravity method of concentration. J Ghana Sci Assoc 8: 63-64.

37. AOAC (2012) Association of official and analytical chemist. (15th Edition), Arlington, Virgina, USA.

38. Larmond E (1997) Lab methods of sensory evaluation of food. Canada, Dept. Agric. Ottawa.

39. Steel RGD, Torrie JH (1997) Principles and procedures of statistics with special reference to the biological sciences. J Biometr 4: 207-208.

40. Rohani MY, Zaipun MZ, Norhayati M (1997) Effect of modified atmosphere on the storage life and quality of Eksotika papaya. J Trop Agric Food Sci 25: 103-113.

41. Ajayi JK, Onayemi O (1979) Effect of steam blanching and chemical treatments on the quality characteristics of some common leafy vegetables grown in Nigeria. Nigerian Food Book, Van Nostrand Reinhold Co., New York.

42. Irwandi I, Vijaganand P, Cheman YB (1998) Durian leather: development properties and storage stability. J Food Qual 19: 479-489.

43. Lum MS (2011) Effects of hot water, submergence time and storage duration on quality of dragon fruit (*Hylocereus polyrhizus*). J Agric Sci 3: 146-152.

44. Clydesdale FM, Fleischmann DL, Francis FJ (1970) Maintenance of color in processed green vegetables. Food Product Development 4: 127-138.

45. Garangyo T, Thiombiano T, Werem A, Drawara B, Sawadogo L (1992) Etude de l'impact du sechagesolaire direct sur la teneurenvit c de la tomato. Sci Technol 20: 53-61.

46. Ashaye OA, Babalola SO, Babalola AO, Aina JO, Fasoyiro SB (2005) Chemical and organoleptic characterization of pawpaw and guava leathers. World J Agric Sci 1: 50-51.

47. Huang XG, Hsieh FH (2005) Physical properties, sensory attributes and consumer preference of pear fruit leather. J Food Sci 70: 177-186.

48. Lodge G, Whalley RDB (1981) Establishment of warm-and cool-season native perennial grasses on the north-west slopes of New South Wales. Dormancy and germination. Aust J Bot 29: 111-119.

49. Bauernfeind JC, Adams CR, Marisuch WL (1981) Carotenoids as colorants and vitamin A precursors. Academic press, N.Y.

50. Krokida MK, Tsami E, Maroulis ZB (1998) Kinetics on color changes during drying of some fruits and vegetables. Drying Technol 16: 667-685.

51. Babalola SO, Ashaye OA, Babalola AO, Aina JO (2002) Effect of cold temperature storage on the quality attributes of pawpaw and guava leathers. Afr J Biotech 1: 61-63.

52. Jain PK, Nema PK (2007) Processing of pulp of various cultivars of guava (Psidiumguajava L.) for leather production. Agric Eng Int 9: 1-9.

53. Karmas E, Harris RS (1988) Nutritional Evaluation of Food Processing. (3rd edition), Van Nostrand Reinhold Co., New York.