ACTA SCIENTIFIC NUTRITIONAL HEALTH (ISSN:2582-1423)

Volume 4 Issue 11 November 2020

Research Article

Comparative Study on Antioxidant Activity and Microbial Loads of Dried Tomatoes Treated with Local Spices (*Aframomum danielli* and *Syzygium aromaticum*)

Mapamile AD[1], Osunbade OA[2]*, Ani CP[1] and Oyewo IO[2]

[1]*Department of Food Science and Technology, Federal Polytechnic Oko, Anambra State, Nigeria*

[2]*Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria*

***Corresponding Author:** Osunbade OA, Department of Food Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Received: August 18, 2020

Published: October 28, 2020

Abstract

The worldwide usage of tomato (*Solanum lycopersicum* L.) cannot be underestimated therefore, spoilage and postharvest losses must be controlled through processing and preservation. Two spices (*Aframomum danielli* and *Syzygium aromaticum*) aqueous extract were separately formulated into 5 and 10% concentrations. The aqueous extract preparations were used to pre-treat tomatoes (var. UTC) prior to drying. Two drying methods (sun drying and oven drying at 60°C) were employed to effect drying. Dried tomato samples treated with 0% spice served as control for dried samples treated with 5 and 10% spice concentrations. The activity of each spice used was evaluated and compared based on their concentrations in terms of ascorbic acid, total carotenoid, lycopene and total viable and fungal count using standard methods. The results of antioxidants revealed that ascorbic acid and lycopene value were reduced in sun-dried samples when treated with varying concentrations of *A. danielli* and *S. aromaticum* compared to the control sample. However, in spice-treated oven-dried samples when compared to the control sample, the ascorbic acid values were better retained with increasing concentrations of spice from 5 to 10% concentrations. The values of total carotenoid were best retained in sun dried samples treated with 5% concentrations of *S. aromaticum* and 5% concentrations of *A. danielli* in oven dried sample. There were also considerable reductions in the values of both total viable and fungal count of spice-treated dried tomato samples over the control samples. Evidently, the findings revealed the effectiveness of *A. danielli* to exact a more preservative effect in oven dried sample better than *S. aromaticum*. This was evident in its better antioxidant retention ability as well as reduction in total viable and fungi count of the oven dried samples treated with both spices.

Keywords: Carotenoid; *Aframomum danielli*; *Syzygium aromaticum; Solanum lycopersicum;* Ascorbic Acid; Lycopene

Introduction

In recent years, increasing research interest had developed in processing tomatoes for both commercial and home use while focusing on retaining the quality and prevents postharvest losses. Tomato (*Lycopersicon esculentum* L.) in its fresh state is a highly perishable agricultural product and starts to lose its quality immediately after harvesting and storage over a few days. Considering the enormous global production totalling 170.8 million tons [1], it become imperative to address spoilage and avoid quality loss while enhancing the shelf life. Although some processing methods like concentration and drying the tomatoes either to fruit or to powder in order to enhance the keeping quality will no doubt lead to quality loss. This has made drying in particular not a popular means of processing tomatoes. However, the search for new improvement on tomato qualities after drying is increasing. This is due to the possibility of using them in Pizza toppings, snacks and other savoury dishes [2].

Consumers demand that processed products retained many of their original characteristics and for tomatoes; this means retaining the nutritional qualities, antioxidant compounds and reduce microbial proliferation. The antioxidant compounds in tomato include vitamins A, C, E and carotenoid such as beta-carotene and lycopene, a compound that reduces the risk of cancer and coronary heart diseases. The use of preservatives will however impact quality retention while also enhancing the keeping quality. However, the use of chemical preservatives in food industry is under increasing scrutiny and re-appraisal due to its subsequent effect on human health mostly from accumulative consumptions. Some chemical preservatives have been reported to have carcinogenic and mutagenic activities [3]. Hence, the research focus is therefore shifted to the use of natural preservatives.

The potent sources of natural preservatives are spices and herbs [4]. Spices have been noted over the years to impact flavour but research had spanned its functions beyond fulfilling this one purpose. Research report suggested that certain spices prolong the shelf life of foods by their bacteriostatic activity. Jalosinska and Wilczak [5] reported the preservatives effect of spice and herbs on foods due to their bacteriostatic and anti-oxidative activities. The preservative effect of lemon juice was reported in the research conducted by Onyimba and Dishon (2019) on the shelf life enhancement of kunun zaki. Similarly, Babarinde., *et al.* [6] reported the inhibition of microbial growth from two formulation of African black pepper to mention a few. Generally, when natural antioxidants are compared with synthetic one, they are readily acceptable by consumers because they are safer with no safety test required by legislation for they belong to the component of food regarded as safe [3]. This research therefore, studied the antioxidant and antimicrobial effect *of S. aromaticum* and *A. danielli* on dried tomatoes. Also, the effectiveness of the spices were evaluated and compared.

Materials and Methods

Materials

The raw materials used in this research work are freshly harvested tomatoes (UTC variety), *S. aromaticum* and *A. danielli*. The freshly harvested tomatoes were purchased at Wazobia market, Ogbomoso, Oyo State, Nigeria while *A. danielli* and *S. aromaticum* were purchased at Oja Oba market, Ibadan, Oyo State, Nigeria.

Methods

Preparation of raw materials

Red tomatoes (UTC variety) with diameter of 45 - 55 mm were used in this research work. The tomatoes were sorted to remove rotten, unripe, infected tomatoes and tomatoes that did not conform to require diameter. The tomato fruits were washed to remove contaminants and then sliced into 10mm using knife and vernier caliper for the measurement. It was then stored at 25^0C.

A. danielli and *S. aromaticum* purchased in its dried form were cleaned of dirts and contaminants. *A. danielli* seeds were separated from the pod. Clean spices were made into its powdery form using hammer mill. The powder was sieved with a mesh to obtain fine powder. 5 and 10g of fine powder was dissolved into 100ml of distilled water to obtain 5 and 10% concentrations of spices aqueous extract. The suspension was kept in the refrigerator for 4 days followed by centrifugation as described by Ashaye., *et al.* [7] and the supernatant was obtained as spice aqueous extract (*A. danielli* and *S. aromaticum*).

Procedures of pre-treatment operation for dried tomato

600g each of tomatoes slices was immersed into 800 ml of the designed 5 and 10% concentrations of each spice and allowed to stand for 5 minutes to achieve effective pre-treatment operations. The pre-treated tomatoes were removed and dried accordingly. For the oven drying method, the tomatoes were dried at 60^0C for 10 hour [8].

Qualitative analysis

The following analyses were carried out on fresh and spice-treated dried tomato samples: ascorbic acid, lycopene, total carotenoid, total viable and fungi count. Analysis was done in triplicate.

Ascorbic acid determination

20g sample was weighed and ground with a little glacial acetic acid in a mortar. The extract was transferred quantitatively with distilled water into a 50 ml volumetric flask and made up to mark with more water and filtered rapidly. 10ml of the filtrate was taken into a conical flask with one drop dilute acetic acid. It was titrated against the redox dye 2, 6-dichlorophenol solution in the burette. The volume of the dye required to decolorize the 10ml of the sample was noted. Titration was repeated using a standard ascorbic acid solution (1 mg. pure vit/100 ml) in a place of the tomato extract. The calculation of ascorbic acid per 100g of tomato was made thus:

$$\text{Mg Vit. C/100g} = \frac{w_1 + w_2 \times v_1}{w_{1x} w_3} \times \frac{100\ (v \times f)}{v_2}$$

Where w_1 = Weight of sample (g)

w_2 = Weight of extracting acid (g)

w_3 = Weight of slurry taken for analysis (g)

$v_{1=}$ Volume to which slurry sample is diluted (ml)

v_2 = Volume of filtrate taken for filtration (ml)

v = Volume of dye solution used for titration

f = Ascorbic acid equivalent of dye (mg/ml) [9].

Total carotenoid determination

10g of homogenous sample was weighed. 50ml of cold acetone was added and homogenize for 1 minute. It was filtered through Whatman No 4.0 filter paper. Residue from homogenizer was washed with cold acetone until washing is colourless. The extract was poured into a separating funnel and 20 ml petroleum ether was added slowly, flowing along the wall of the separating funnel to avoid formation of an emulsion. It was allowed to stand for a few minutes until the 2 phases separated. The lower aqueous acetone phase was discarded. The petroleum ether phase was washed with water for 4 - 5 times to remove all traces of acetone. The petroleum ether phase was passed through cotton wool and anhydrous sodium sulphate in a glass funnel. It was collected in 25 ml volumetric flask and petroleum ether was added to make up to volume. Absorbance was then measured at 450 nm and total carotenoid was calculated as:

$$\text{ug/g} = \frac{A \times \text{vol.} \times 10^4}{A^{1\%/cm} \times \text{weight of sample}}$$

Where A = Absorbance

$A^{1\%/cm}$ = 2592

Vol. = 25 ml [9].

Lycopene determination

Lycopene standard was prepared by weighing 1g of lycopene powder into 100ml of hexane-acetone mixture. This was allowed to stand for 1 hr before filtration. Then 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9ml of the stock were measured into test tubes and these were made up to 10 ml each with hexane-acetone mixture. About 10 ml of acetonic hexane mixture was used as blank. This mixture was allowed to stand for another 30 minutes before measuring there absorbance with UV-Spectrophotometer at 475 wavelengths and a standard curve were obtained. About 3g of tomato sample was grinded with pestle and mortal and 1g of each sample was added to 100 ml of hexane and acetone for 1hr with vigorous shaking. From the stock, 1ml of each sample were made up to 10 ml with hexane and acetone mixture and absorbance read on the spectrophotometer at 475 [10].

Microbial count

The total viable and fungal counts were estimated. Serial dilution method was employed in the analysis. Nutrient agar was used for the estimation of total viable count while acidified potatoes dextrose agar (PDA) was used for fungal count [11].

Statistical analysis

Data was analyzed using analysis of variance (ANOVA) with the aid of SAS (statistical analysis system) software package and means that was significantly different was separated at 5% probability level.

Results and Discussion

Antioxidants property of fresh and dried Tomato samples treated with 5 and 10% Concentrations of spices (*A. danielli* and *S. aromaticum*)

Ascorbic acid

As shown in table 1, the ascorbic acid of fresh tomato sample was 61.30 mg/100g. When comparing this value with the dried samples treated with 0, 5 and 10% concentrations of spices (Table 2 and 3), it is numerically higher. Font [12] reported that the presence of vitamin C in a fresh tomato solution decline after it was heated. It was also confirmed by Marfil., *et al.* (2006); Santos., *et al.* (2008); Babarinde., *et al.* [13] that drying reduces the vitamin C content. The ascorbic acid content of control sample (0% spice) in table 2 was 45.67 mg/100g and sun-dried tomato samples treated with varying concentration of spices (5 and 10% conc.) ranged between 30.00 mg/100g and 37.67 mg/100g. This result showed a significantly higher ($p < 0.05$) vitamin C content in control sample (Table 2) when compared to sun-dried tomato samples treated with 5 and 10% concentrations of each spice (*A. danielli* and *S. aromaticum*). The reason(s) for reduction in ascorbic acid content of treated samples (5 and 10% spice conc.) when sun-dried cannot be established since it is thought that spices have antioxidant properties as reported by Milda [4]. However, when comparing the control sample (0% spice) of table 3 with treated oven-dried samples (5 and 10% conc.), the control sample was significantly lower in ascorbic acid content ($P < 0.05$). This is in line with Milda [4] affirmation. Adegoke and Idowu [14] reported that certain spice has been found to have preservative properties on some food systems. As evident in table 2 and 3 when comparing the effectiveness of the

two spices used (*A. danielli* and *S. aromaticum*), it is clearly noted that *A. danielli* exacted more ascorbic acid retention ability over *S. aromaticum* and with increased concentration from 5 to 10%, significant improvement ($P < 0.05$) was observed.

Attributes	Fresh tomato
Ascorbic acid (mg/100g)	61.3
Total carotenoid (mg/100g)	2.90
Lycopene (mg/100g)	1.50
Bacterial counts (cfu/ml)	2.05×10^5
Fungal counts (cfu/ml)	2.45×10^5

Table 1: Evaluation of selected attributes of fresh tomato.

Samples	AA (Mg/100g)	TC (Mg/100g)	Lyc (Mg/100g)
0% spice	45.67^a	3.37^c	2.83^a
5% *S. aromaticum*	30.00^e	3.50^a	2.50^d
5% *A. danielli*	34.67^c	3.23^e	2.73^b
10% *S. aromaticum*	31.67^d	3.46^{ab}	2.63^c
10% *A. Danielli*	37.67^b	3.43^b	2.53^d

Table 2: Evaluation of antioxidant property of sun-dried tomato samples treated with 5 and 10% concentrations of spices (*A. danielli* and *S. aromaticum*)

Values are mean of three replicates determination. Samples with the same superscript along the column are not significantly different at 5% probability.

Key: AA: Ascorbic Acid; TC: Total Carotenoid; Lyc: Lycopene.

Samples	AA (Mg/100g)	TC (Mg/100g)	Lyc (Mg/100g)
0% spice	31.67^e	3.27^c	2.47^c
5% *S. aromaticum*	32.33^d	3.23^c	2.43^c
5% *A. Danielli*	38.33^b	3.53^a	2.70^a
10% *S. aromaticum*	33.30^c	3.13^d	2.53^b
10% *A. Danielli*	39.33^a	3.40^b	2.57^b

Table 3: Evaluation of antioxidant property of oven-dried tomato samples treated with 5 and 10% concentrations of spices (*A. danielli* and *S. aromaticum*).

Values are mean of three replicates determination. Samples with the same superscript along the column are not significantly different at 5% probability.

Key: AA: Ascorbic Acid; TC: Total Carotenoid; Lyc: Lycopene.

Total carotenoid

The value for the total carotenoid of fresh tomato as shown in Table 1 was lower than the dried tomato samples as shown in table 2 and 3. McInerney., *et al.* [15] reported that due to processing, phytochemicals in certain vegetables may be more bio available. Increase in total carotenoid of dried tomatoes could be due to concentrations of pigments after considerable moisture was removed [16]. Sahlin., *et al.* [17] reported that bound antioxidants are released by processing and carotenoids become more bioavailable due to thermal treatment.

The increased in total carotenoid after drying was retained significantly when treated with 5 and 10 % concentrations of *S. aromaticum* in sundried samples of table 2. This further confirmed the antioxidant ability of spice as reported by Milda [4]. Similarly, at 10% concentration of *A. danielli* (Table 2), the carotenoid value was maintained significantly when compared with the control sample but significant decline was observed in *A. danielli* treatment of sun dried sample at 5% concentration. Chantaro., *et al.* [18] reported that thermal degradation during blanching and drying caused a decrease in the contents of carotene and phenolic compounds, hence leading to the loss of antioxidant activity. However, 5 and 10% concentration of *A. danielli* treatment of tomato samples exact better retention ability of total carotenoid as evident in table 3 of oven dried samples when compared with 0, 5 and 10% treatment of *S. aromaticum* with best retention capacity at 5% concentration of *A. danielli* treatment. On the other hand, a numerical decrease was recorded in oven dried samples treated with both 5 and 10% concentrations of S. aromaticum when compared to the control sample (Table 3). Decrease in total carotenoid could be due to variations in the distribution of heat in the oven.

Lycopene

The lycopene content for fresh tomato was 1.5 mg/100g (Table 1) which was numerically lower than dried tomato samples (Table 2 and 3). Roldan-Gutierrez and Luque de castro., *et al.* [19] reported that thermal treatment could increase the release of phytochemicals from the matrix tomatoes. Similarly, Chang., *et al.* [20] reported increase in lycopene content of hot-air-dried tomatoes and it was further confirmed in the work of Babarinde., *et al* (2009). Lycopene content of sun-dried tomato samples (Table 2) treated with 5 and 10% concentrations of spices had a means that were significantly lowered compared to control sample (0% spice). This could be due to initially low or dwindling sun drying temperature which enhanc-

es the growth of microorganism and enzymic activities responsible for the degradation of lycopene as reported by Kolawole., *et al.* [21] that if drying temperature is low at the beginning, microorganism may grow before the food is adequately dried. Meanwhile, at 5% concentrations of *A. danielli*, the lycopene value was better retained compared to other spice treated samples (Table 2). However, in oven dried samples (Table 3) at 5%, 10% *A. danielli* and 10% *S. aromaticum* concentrations, the lycopene values had a significantly higher means when compared to the control samples (0% spice). Comparing the lycopene retention ability of the two spices in oven dried sample (Table 3), it is evident that samples treated with *A. danielli* showed a better retention ability and best at 5% concentration compared to other treatment.

Microbial Analysis of fresh and dried tomatoes treated with *S. aromaticum*

The fungal and bacterial counts of fresh and dried tomato samples treated with 5 and 10% concentrations of spices (*A. danielli* and *S. aromaticum*) are presented in table 1 and 4. The bacterial and fungal counts of fresh tomatoes were 2.05 x 10^5 cfu/ml and 2.45 x 10^5 cfu/ml respectively. These values were higher than values recorded for both sun-dried and oven-dried tomato samples (Table 4). Babarinde., *et al.* [13] reported that microorganisms reduced with varying temperature and conditions. Reduction in microbial count could be due to destruction of microorganism by heat and substantial reduction in moisture content of tomatoes due to heat. Sun-dried and oven-dried tomatoes treated with spices (*S. aromaticum* and *A. danielli*) have a lower microbial count when compared to both sun-dried and oven-dried control samples (0% spices). Qinq., *et al.* [22] reported that many spice possessed antibacterial and antifungal activities against food spoilage thereby prolong the shelf life of foods by their bacteriostatic activity and also as an effective antibacterial agent. In table 4, it was noted that *A. danielli* impacted better antibacterial effect in both drying methods and also provided a better fungal inhibitory effect in oven dried samples. However, *S. aromaticum* showed a numerical promising effect of antifungal activities over *A. danielli* in sun dried samples although, with no significant effect at 5% probability [23-30].

	Sun-dried tomatoes treated with varying concentrations of spices		Oven-dried tomatoes treated with varying concentrations of spices	
Samples	**Bacteria (cfu/ml)**	**Fungi (cfu/ml)**	**Bacteria (cfu/ml)**	**Fungi (cfu/ml)**
0% spice	$3.0x10^{3a}$	$3.0x10^{4a}$	$3.2x10^{3a}$	$3.0x10^{4a}$
5% *S. aromaticum*	$2.0x10^{3b}$	$1.8x10^{3b}$	$0.9x10^{3c}$	$2.4x10^{3b}$
5% *A. danielli*	$1.7x10^{2c}$	$2.2x10^{3b}$	$1.1x10^{2b}$	$1.7x10^{3c}$
10% *S. aromaticum*	$1.7x10^{3b}$	$1.7x10^{3b}$	$1.3x10^{3c}$	$2.0x10^{3bc}$
10% *A. danielli*	$1.20x10^{2c}$	$2.1x10^{3b}$	$1.2x10^{2b}$	$1.2x10^{3cd}$

Table 4: Microbial evaluations of dried tomatoes treated with 5 and 10% concentrations of spices (*A. danielli* and *S. aromaticum*).

Samples of the same drying method with the same superscript along the column are not significantly different at 5% probability.

Note: cfu/ml means colony forming unit per millilitre.

Conclusion

The findings revealed that tomato samples treated with *A. danielli* had a higher average value of % ascorbic acid, total carotenoid, lycopene compared with tomato samples treated with *S. aromaticum.* The tomatoes samples treated with both *A. danielli* and *S. aromaticum* for oven-dried samples as well as sun-dried samples reduced both bacterial and fungal count of dried tomato samples compared to the control samples. However, the combined effect of heat with *A. danielli* on the average reduced the bacterial count better than *S. aromaticum*. Hence, *A. danielli* is a better natural preservative agent on tomato quality than *S. aromaticum.*

Bibliography

1. FAOSTAT (2017).

2. Lewicki PP., *et al*. "Effect of pre-treatment on convective drying of tomatoes". *Journal of Food Engineering* 54 (2002): 141-146.

3. Fasoyiro SB., *et al*. "The Antioxidants Property of Aframomum danielli Spice in oil". *The Journal of Food Technology in Africa* 6.4 (2001): 135-137.

4. Milda E Embuscado. "Spices and herbs: Natural sources of antioxidants- a mini review". *Journal of Functional Foods* 18 (2015): 811-819.

5. Jalosinska M and Wilczak J. "Influence of plant extracts on the microbiological shelf life of meat products". *Polish Journal of Food Nutrition and Science* 59.4 (2009): 303-308.

6. Babarinde GO., *et al*. "Quality characteristics of stored tomato fruit treated with two formulations of African black pepper". *Revista Brasileira de Gestao Ambiental e Sustentabilidade* 5.9 (2018): 249-259.

7. Ashaye O A., *et al*. "Effect of Local preservative (Aframomum danielli) on the Chemical and Sensory Properties of Stored Warakanshi". *African Journal of Agricultural Research* 1.1 (2006): 010-016.

8. Gisele AC., *et al*. "Quality of Dried Tomato Pre-treated by Osmotic Dehydration, Antioxidant Application and Addition of Tomato Concentrate". School of Engineering, Campinas, SP, Brazil (2004): 233-238.

9. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists, Washington D.C., U.S.A (2013).

10. Sharoba AM. "Producing and evaluation of red pepper pastes as new food product". *Annals of Agricultural Science Moshbohor* 47.2 (2009): 151-165.

11. Oyebanji AO., *et al*. "Moisture content, mouldiness, insect infestation, and acceptability of market samples of dried tatase pepper and tomato in Kano". *Nigeria Journal of Stored Products and Postharvest Research* 2.10 (2011): 200-207.

12. Fontes CR. The Effect of Heat on Vitamin C in Tomatoes. California State Science Fair 2009 Project Summary (2009).

13. Babarinde GO., *et al*. "Effects of Different Drying Methods on Physico-Chemical and Microbial Properties of Tomato (Lycopersicon esculentum Mill) var. Roma". Global Science Books.

14. Adegoke GO., *et al*. "Control of ochratoxin A in kunu zaki (a non-alcoholic beverage) using DaniellinTM". *African Journal of Agriculture Research* 2 (2007): 128-131.

15. McInerney JK., *et al*. "Effect of High Pressure Processing on Antioxidant Activity, and Total Carotenoid content and Availability, in Vegetables". *Innovative Food Science and Emerging Technologies* 8.4 (2007): 543-548.

16. Mozumder NHMR., *et al*. "Effects of Pre-drying Chemical Treatments on Quality of Cabinet Dried Tomato Powder". *Journal of Environmental Science and Natural Resources* 5.1 (2012): 253-265.

17. Sahlin E., *et al*. "Investigation of the Antioxidant Properties of Tomatoes after Processing". *Journal of Food Composition and Analysis* 17 (2004): 635-647.

18. Chantaro P., *et al*. "Production of Antioxidant High Dietary Fibre Powder from Carrot Peels". *LWT-Food Science and Technology* 41.10 (2008): 987-1994.

19. Roldan-Gutierrez JM and Luque de Castro MD. "Lycopene: The Need for Better Methods for Characterization and Determination". *Trends in Analytical Chemistry* 26.2 (2007): 163-170.

20. Chang CH., *et al*. "Comparisons on the Antioxidant Properties of Fresh, Freeze Dried and Hot-air-dried Tomatoes". *Journal of Food Engineering* 77 (2006): 478-485.

21. Kolawole OM., *et al*. "The Drying effect of Colour Light Frequencies on the Nutrient and Microbial Composition of Cassava". *African Journal of Agricultural Research* 4.3 (2009): 171-177.

22. Qing Liu., *et al*. "Antibacterial and antifungal activities of spices". *International Journal of Molecular Sciences* 18 (2017): 1283.

23. Abou Dahab TAM and Abd El-Aziz NG. "Physiological Effect of Diphenylamin and Tryptophan on the Growth and Chemical Constituents of Philodendron erubescens Plants". *World Journal of Agricultural Sciences* 2.1 (2006): 75-81.

24. Adeyemo SM and Popoola O. "A Digitally-Defined Analog Scheme to Aid Assessment of Food Colours". *Journal of Microbiology Research* 5.5 (2015): 157-160.

25. Alfaro-Olivera MDC., *et al*. "Hypolipidemic effects of tomato in rats fed a high-fat diet". *FASEB Journal* 30 (2016): 1016-1016.

26. Alshatwi AA., *et al*. "Tomato powder is more protective than lycopene supplement against lipid peroxidation in rats". *Nutrition Research* 30 (2010): 66-73.

27. FAO. Post-harvest management of tomato for quality and safety assurance Guidance for horticultural supply chain stakeholders. Food and Agriculture Organization of the United Nation Production Year Book, FAO, Rome (2018): 2-6.

28. FAO Report. Third mission report to project LTO under TCP/RAS/3310 – Capacity development to reduce post-harvest losses in horticultural chains in GMS countries, FAO RAP, Thailand (2012): 23-26.

29. Joseph HH and Norman NP. Food Science. CBS Publishers and Distributors. Daryaganj, New Delhi (2006).

30. Mahmoud IN., *et al*. "Chemical constituents of clove (Syzygium aromaticum, Fam. Myrtaceae) and their antioxidant activity". *Revista Latinoamericana de Química* 35.3 (2007): 49-54.