JEB®
Journal of Environmental Biology
p-ISSN: 0254-8704 • e-ISSN: 2394-0379 • CODEN: JEBIDP
Journal website : www.jeb.co.in ★ **E-mail :** editor@jeb.co.in

Triveni Enterprises
(Educational Services Set-up)

Original Research

DOI : http://doi.org/10.22438/jeb/43/6/MRN-5013

Combined effect of *Emblica officinalis* juice in the prevention of enzymatic browning in *Solanum anguivi* L.

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Received: 14.02.2022 *Revised*: 20.06.2022 *Accepted*: 16.08.2022

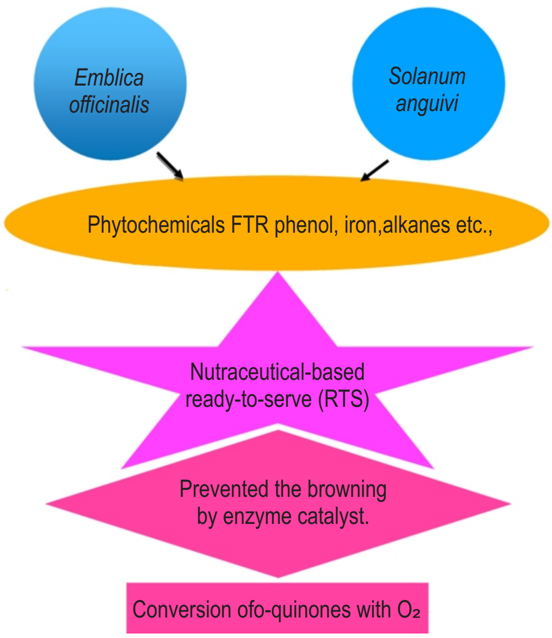
Abstract

Aim: The present study aimed to investigate the impact of *Emblica officinalis* juice as an antibrowning agent on *Solanum anguivi* L. juice where enzymatic browning reaction occurs naturally.

Methodology: The fresh fruits of *S. anguivi* (S) and *E. officinalis* (E) were weighted at five different proportions such as S1-100g:E0-0g; S0-0g:E1-100g; S1-25g:E3-75g; S1-50g:E1-50g and S3-75g:E1-25g. Each combination was ground using a domestic mixer to extract the juice without adding water and analyzed for its characteristics such as color value, browning index, and acceptance level through a sensory evaluation which was recorded at two different intervals (0 and 90 min).

Results: Overall color analysis (DE*) indicates that *E. officinalis* juice significantly reduced the enzymatic browning reaction by its concentration and postponed the brown color development in all three combinations of extracted fruit juices during the storage period. Although, the browning index was high in all the combinations of juices at 0 and 90 mins, except S1-25g:E3-75g, since it had a higher concentration of *E. officinalis*. The sensory evaluation opted that S1-25g:E3-75g was accepted by all panel members. The FTIR spectral peak revealed the presence of various functional compounds such as carbohydrates, phenol, iron, alkanes, primary amines, esters, aromatics, phosphorous compounds, aliphatic amines, ketones, bromo and halo compounds.

Interpretation: The present study demonstrated that the enrichment of *S.anguivi* juice with *E. officinalis* concentration had prevented the browning that often occurred due to enzyme catalyst where the reaction of conversion of o-quinones in the presence of oxygen, and o-quinones polymerise into undesirable brown color compound. The developed juice could be used in the formulation of nutraceutical-based ready-to-serve (RTS) beverages that might be the solution for preventing several diseases.



Key words: Browning index, Color profile, FTIR spectra, Natural inhibitor, Oxidation, *Solanum anguivi*

How to cite : Karthika, P., T.P. Vijayakumar and K. Baskar: Combined effect of *Emblica officinalis* juice in the prevention of enzymatic browning in *Solanum anguivi* L. *J. Environ. Biol.*, **43**, 818-825 (2022).

Introduction

Solanum anguivi L. is considered as a medicinal plant that belongs to family Solanaceae. The ethnobotanical and clinical investigations suggest that *S. anguivi* berries are used in one of many diseases such as diabetes mellitus, high blood pressure and anemia which are of public health concern (Jayanthy *et al.,* 2016; Nakitto *et al.,* 2021). *S. anguivi* has been suggested as a dietary supplement for all age groups since it is considered a remedy for an anemic condition in females (Elekofehinti *et al.,* 2012). The berries of *S. anguivi* had bitterness attributed to various phenolic components (N'Dri *et al.,* 2010). Therefore, *S. anguivi* is a wild vegetable consumed in India and all over the world, due to its tremendous medicinal value with low cost. In recent years, an increase in the demand for fresh-cut fruits due to their high nutrition such as bananas, apples, pears, etc. Enzymatic browning is one of the most important deterioration factors that occurs in many fruits and vegetables, where phenolic compounds are oxidized which is termed as polyphenol oxidation (PPO). Polyphenol oxidase catalyzes phenols to finally form polymeric pigment compounds (Terefe *et al.,* 2015; Yu *et al.,* 2021; Teribia *et al.,* 2021).

This reaction not only affects the sensory characters but also shows a negative impact on shelf-life quality (Koukounaras *et al.,* 2008). Traditional synthetic additives are deemed to be the most common and effective PPO inhibitors, although they are generally regarded as insufficiently safe and can be used excessively. Natural plant extracts, on the other hand, with numerous browning inhibitors such as phenols, steroids, and alkaloids, are environmentally benign, safe for humans, and advantageous to product sensory and nutritional characteristics (Tinello and Lante, 2018).Several studies have been done on plants such as onion (Kim *et al.,* 2005), honey (Jeon and Zhao, 2005), aloe vera gel (Supapvanich *et al.,* 2016), green tea (Klimczak and Gliszczynska-Swigło, 2016) and rice bran extract (Sukhontha *et al.,* 2016) which showed a strong effect in the prevention of browning reaction. Besides that, ascorbic acid has been used as an antibrowning agent to maintain the quality and prevent the enzymatic browning reaction by its reducing action (Tan *et al.,* 2015). Remorini *et al.* (2015) and Sikora *et al.* (2021) proved that ascorbic acid effectively inhibits the enzymatic browning of red apple and mung bean sprouts. *Emblica officinalis* fruit has a high amount of ascorbic acid (600-700 mg $100g^{-1}$) (Jain and Purshottam, 2013).

Amla (*E. officinalis*) or Indian gooseberry is found abundantly in the Indian sub-continent. *E. officinalis* comprise high antimicrobial properties which reduce microbial contamination (Gautam and Shukla, 2017) and antidiabetic activity (Shukla *et al.,* 2011; Srinivasan *et al.,* 2018), it also possesses more potential cytotoxic activity against HT-29 cells lines (Sumalatha, 2013), antibrowning agent (Prajapaty *et al.,* 2011). Therefore, the present research is focused to prevent the enzymatic browning which occurs in *S. anguivi L.* using *E. officinalis* as a natural anti-browning agent, especially at three different proportions.

Materials and Methods

Samples: Fresh *S. anguivi* and *E. officinalis* were obtained from the local orchards of Salem, India, and both the fruits were authenticated at the Institute of Herbal Science, Plant Anatomy Research Centre, Chennai (PARC/2016/3297, PARC/2016/3296). The color profile and bioactive compounds were identified using Hunter Lab Colorimeter and Fourier Transform Infrared Spectroscopy.

Preparation of juice extract: The pilot study was carried out (Karthika and Poongodi, 2017) for the juice extraction of *S. anguivi* (S) and *E. officinalis* (E) fruits. The color profile, browning index and organoleptic characteristics of developed fruit juices were analyzed in fresh and stored conditions (90 min intervals) at ambient temperature (25°C).

Color profile: The hunter colorimeter was used to measure the color of all five developed juices (different combinations) during the storage period. The results were determined in terms of Hunter Color values of L* (lightness), a* (positive – redness; negative – greenness) and b* (positive – yellowness; negative –blueness).To measure the color of different juices upon storage, the extracted juice was placed in a glass bottle, labeled and kept at room temperature for 0 and 90 min, respectively. The juice samples were decanted into a small beaker after each storage time and the color was measured using the spectrophotometer.

Browning index: All five developed juices were centrifuged at 800 x g for 25 min at 4ºC and filtered through Whatman No 4-filter paper and thereafter the absorbance was read at 420 nm on a UV/Vis spectrophotometer.

Testing of organoleptic evaluation: In the present study, organoleptic parameters were observed for its color, flavor, taste and overall acceptance by 15 trained panelists. The hedonic score ranged between 1 and 5. The complete assessment scores and organoleptic quality test schemes are present in Table 1.

Fourier Transforms Infrared (FTIR) Technology: All the five fresh juice extracts were investigated using FTIR spectroscopy. FTIR transmission spectra were recorded on a Perkin Elmer FTIR Spectrometer. The fresh juice extracts were mixed with potassium bromide and compressed into a thin KBr disc under 7845 kPa pressure for 2 min and the samples were run between the scan range of 400 and 4000 cm^{-1} (resolution, 16 cm^{-1}; scanner velocity, 7.5 kHz; background 32 scans; sample 32 scans) at controlled temperature (23 ± 1°C) in the transmittance mode. As per the obtained frequencies, relative intensity corresponding to absorption of light was calculated. The functional groups were identified according to the absorbance band.

Statistical analyses: The experiments were conducted in triplicate and their data were expressed as mean ± SD. Statistically significant differences among variations were obtained using the Statistical Package for Social Sciences.

Results and Discussion

Enzymatic browning (polyphenol oxidation) is the main cause of deprivation of color in fruit juice that can be easily accessed by measuring CIELab parameters, especially the decrease in brightness with L* (Falguera *et al.,* 2012). The color profile of five developed juices (Table 2) noticed that there is a significant difference in color properties. L* value of all five developed juices was determined in fresh, and after 90^{th} min color stability and implication of browning reaction was determined. L* values of all five juices declined significantly ($p<0.01$) after 90 min of extraction which reflected the low stability of original color; the color changed into brown followed by blackish in S1-100 g:E0-0 g. But in the case of S0-0 g:E1-100 g and S1-25 g:E3-75 g fruit juices L* value was found to be significantly ($p<0.05$) higher than other fruit juices which indicates a higher index of lightness. These obtained levels were higher than the level reported by Falguera *et al.* (2012), although similar results were observed in Mangosteen and Julo fruits at 0 min and 90^{th} min, respectively.

Initially (0 mins) the redness (a*) value of an individual fruit juices such as S1-100g:E0-0g and S0-0g:E1-100g was found to be significantly higher, but after 90 mins it was lower. In the case of three combined fresh fruit juices, the redness (a*) value was noticed contradictory behavior in S1-25g:E3-75g, S1-50g:E150g and S3-75g:E1-25g(2.01± 0.01; 1.50± 0.01& 1.84± 0.02) at 0 mins and (3.53±0.03; 2.52±0.03& 3.01±0.02) at 90 mins. It indicated that more red color in combined fruit juices than the individual. On the other hand, yellow (b*) values were observed as significantly higher at 90 min compared to 0 min, the highest value was procured by S1-25g:E3-75g (30.41±0.02 and 44.75±0.04) fresh fruit juice, which could be due to high polyphenol content and strong antioxidant activities as reported by Hussein *et al.* (2017) and closure values were also noticed in different formulations of natural juice blends. According to Christofi *et al.* (2021), the chroma index indicates the color intensity, as the value of chroma increases a color becomes more intense; it decreases, and the color becomes duller. The chroma value of fresh fruit juice of S0-0g:E1-100g indicates that it was more intense than S1-100g:E0-0g juice; a similar trend was noticed in all fruit juices during the storage period (after 90 min) which revealed the instability of color (Table 2).

This could be explained by oxidation of polyphenols or non-enzymatic browning reaction in the developed juices. A similar observation was noted by Kishor *et al.* (2017) in different apple strains; Yenrina *et al.* (2016) in Asian java plum rind (16.25±0.05) and melastome (18.50±0.03). Hue is the most familiar color representing six-color tone such as red, orange, yellow, green, blue, and violet or purple. The H0 values are stepped from 0 to 360°C (red to blue color). The hue angle range was closer to 0° indicating reddish yellow color (Kheng *et al.,* 2012).In the present study, the hue value was in the range between 1.49±0.00 and 1.52±0.00 in all five fruit juices (Table 2) revealing the red zone. Yildiz and Baysal (2007) stated that hue angle values also indicate the degree of browning that increasing yellowness and/or decreasing greenness result in high hue angles. Saturation is widely used as a generic term for chromatic intensity/ purity of color. It was observed that S0-0g:E1-100g juice had strong color than S1-100g:E0-0g juice during the period of 0 and 90 min. A similar rising trend was noticed in all three combined juices; the intensity varied with concentration of *E. officinalis* juice. For instance, S1-25 g:E3-75 g had a greater value at 90 min compared to 0 min.

The least yellow index and maximum whiteness index were noticed in all five developed juices at 0 min, however, after 90 min, the yellow and white index was in reverse trend similarly, Kotwaliwale *et al.* (2007) reported that the whiteness index increased whilst the yellowness index decreased as rehydration progressed (oyster mushroom). Lin *et al.* (2009) found that rising whiteness index and falling yellowness index indicates lesser amount of flavonoids and carotenoids in buckwheat. This is in agreement with the reports of Sousa *et al.* (2009) on passion fruit. It indicates the magnitude of color difference between the control and the studied samples (Patras *et al.,* 2011). ΔE^* value between 0 and 90 min period of fresh juice was significantly different and it increased in all the fresh juices, except S3-75 g:E1-25 g which could be related to vitamin C content. This trend was reported by Agustini (2018) in mango and found that a low level of vitamin C may be the reason for low level of total color difference. The lowest total color difference of S1-100g:E0-0g (16.31±0.60) and

Table 1: Hedonic rating scale for sensory evaluation

Sensory parameters	Scores		Sensory parameters	Scores	
Color	Green	1	Taste	Very bitter	1
	Thick green	2		Light bitter	2
	Greenish brown	3		Astringent	3
	Brown	4		Sour	4
	Dark brown	5		Pungent	5
	Very Poor	1		Very poor	1
	Poor	2		Poor	2
Flavor	Fair	3	Overall acceptance	Medium	3
	Better	4		Fair	4
	Excellent	5		excellent	5

Table 2: Color profile of *S. anguivi* and *E. officinalis* fruit juices and its combinations

Name of the samples	S1-100g:E0-0g		S0-0g:E1-100g		S1-25g:E3-75g		S1-50g:E1-50g		S3-75g:E1-25g	
	Duration (0th and 90th min)									
Color value	0	90	0	90	0	90	0	90	0	90
	68.00± 0.02^{a}	62.02± 0.02^{a*}	98.24± 0.02^{e}	84.36± 0.03^{e*}	92.77± 0.02^{d}	83.36± 0.01^{d*}	86.24± 0.04^{c}	74.03± 0.03^{c*}	78.54± 0.02^{b}	69.93± 0.03^{b*}
a*	1.35± 0.03^{a}	0.85± 0.03^{a*}	3.06± 0.02^{e}	2.03± 0.01^{b*}	2.01± 0.01^{d}	3.53± 0.03^{e*}	1.50± 0.01^{b}	2.52± 0.03^{c*}	1.84± 0.02^{c}	3.01± 0.02^{d*}
b*	16.40± 0.01^{a}	18.00± 0.05^{a*}	29.75± 0.03^{d}	37.99± 0.04^{d*}	30.41± 0.02^{e}	44.75± 0.04^{e*}	20.54± 0.04^{c}	29.93± 0.02^{c*}	19.38± 0.02^{b}	24.98± 0.03^{b*}
Chroma	16.46± 0.01^{a}	18.02± 0.05^{a*}	29.91± 0.03^{d}	38.05± 0.04^{d*}	30.47± 0.02^{e}	44.89± 0.04^{e*}	20.59± 0.04^{c}	30.03± 0.02^{c*}	19.47± 0.02^{b}	25.16± 0.03^{b*}
Hue0	1.49± 0.00^{c}	1.52± 0.00^{e*}	1.47± 0.00^{a}	1.52± 0.00^{d*}	1.50± 0.00^{d}	1.49± 0.00^{c*}	1.50± 0.00^{d}	1.49± 0.00^{b*}	1.48± 0.00^{b}	1.45± 0.00^{a*}
Saturation	0.16± 0.00^{a}	0.27± 0.00^{a*}	0.38± 0.00^{e}	0.44± 0.00^{d*}	0.31± 0.00^{c}	0.53± 0.00^{e*}	0.28± 0.00^{b}	0.43± 0.00^{c*}	0.31± 0.00^{d}	0.30± 0.00^{b*}
Yellow index	22.80± 0.01^{a}	37.83± 0.09^{a*}	54.11± 0.04^{e}	62.94± 0.04^{d*}	44.22± 0.01^{c}	75.79± 0.03^{e*}	39.64± 0.06^{b}	61.14± 0.01^{c*}	44.65± 0.04^{d}	42.80± 0.04^{b*}
White index	103.59± 0.02^{e}	69.63± 0.03^{a*}	83.44± 0.03^{c}	93.73± 0.05^{d*}	102.37± 0.02^{d}	95.03± 0.04^{e*}	76.18± 0.04^{b}	75.45± 0.03^{b*}	64.23± 0.03^{a}	86.50± 0.02^{c*}
Total color difference	16.31± 0.60^{a}	35.79± 0.01^{b*}	35.79± 1.09^{d}	39.65± 0.05^{c*}	29.91± 0.99^{b}	46.67± 0.03^{d*}	32.16± 0.86^{c}	41.48± 0.00^{d*}	41.68± 0.84^{e}	16.03± 0.01^{a*}

Mean ±SD values are average of five determinants. The same alphabets indicate no significant difference between the groups by LSD test. *Indicates significant difference ($p<0.05$).

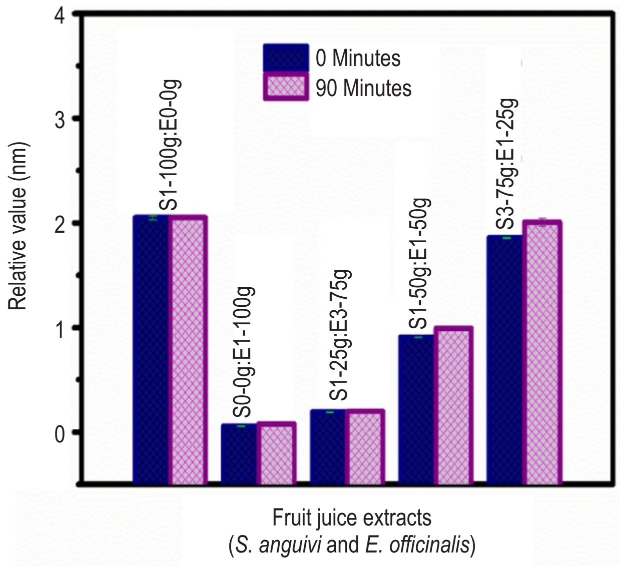
Table 3: Organoleptic evaluation of *S. anguivi* and *E. officinalis* fruit juices and its combinations at 0 and 90 min intervals

Parameters	0 min					90 min				
	S1-100g: E0-0g	S0-0g: E1-100g	S1-25g: E3-75g	S1-50g: E1-50g	S3-75g: E1-25g	S1-100g: E0-0g	S0-0g: E1-100g	S1-25g: E3-75g	S1-50g: E1-50g	S3-75g: E1-25g
Color	1.357± 0.49	1.071± 0.26	1.643± 0.49	2.143± 0.53	3.00± 0.67	2.786 ±0.42	1.143± 0.36	2.214± 0.42	3.214± 0.42	3.143± 0.36
Taste	1.87± 0.35	2.93± 0.25	2.87± 0.35	3.07± 0.25	2.8± 0.56	1.87± 0.35	2.93± 0.25	3±0.37	3.93± 0.25	3.87± 0.35
Flavor	4.47± 0.52	4.87± 0.35	4.93± 0.26	4.73± 0.46**	4.33± 0.9	4.13± 0.52	4.8± 0.41	4.87± 0.35	4±0.53 **	3.87± 0.35
Overall acceptance	1.37± 0.80	2.938± 0.25	4.688± 0.60	3.688± 0.60	1.938± 0.44	1±0.0	3.063± 0.44	4.188± 1.10	3.625± 0.88	1.813± 0.54

**Not significant at $p>0.05$ level and suggested by Pairded 't' test; Values are average of fifteen determinants

S3-75g:E1-25g (16.03±0.01) of fresh fruit juices reflected the lowest level of vitamin C than other fruit juices.

The browning index was determined in all five fresh fruit juices of *S. anguivi* (S1-100 g:E0-0 g), *E. officinalis* (S0-0g:E1-100g) and combined fruit juices (S1-25g:E3-75g; S1-50g:E1-50g and S3-75g:E1-25) by measuring the absorbance at 420 nm at two different periods (0 and 90 min) (Fig. 1). *S. anguivi* (S1-100g:E0-0g) fruit juice opted highest OD value at 0 and 90 min of extraction, which revealed a significantly highest index of browning compared to other four fruit juices. The higher browning index might be due to its enzymatic browning reaction on several phenolic compounds (polyphenol oxidized) and converted to o-quinones in the presence of oxygen and o-quinones polymerise into undesirable brown, red, or black pigments (Zhang *et al.,* 2015). These brown pig¬ments could also affect the sensory and nutritional quality of fruits and vegetables (Sun *et al.,* 2012). The *E. officinalis* (S0-0g:E1-100g) fruit juice obtained a less OD value (0.05±0.001) at 0 min and it was observed to be significantly increased up to 0.07±0.0005, which was similar to Pareek and



Samples	0 Min	90 Min
S1:E0	2.04 ± 0.018^{c}	3.16 ± 0.001^{c}
S0:E1	0.05 ± 0.001^{a}	$0.07 \pm 0.005^{a**}$
S1:E3	0.19 ± 0.001^{b}	0.198 ± 0.0005^{b}
S1:E1	0.90 ± 0.002^{c}	$0.99 \pm 0.005^{c**}$
S3:E1	1.85 ± 0.005^{d}	$2.00 \pm 0.038^{d**}$

Values are the average of two determinants. a,b,c,d,e alphabets indicates the significant mean difference between the samples and suggested by LSD as Posthoc test ** Significantly different at $p<0.05$ level

Fig. 1: Browning index of *S. anguivi* and *E. officinalis* fruit juices and its combinations assessed over 90 min.

Kaushik (2012) in *E. officinalis* fruit; Bull *et al.* (2004) in solar drier anola (0.07) and (0.09) in Valencia orange juice respectively. Subsequently, a lower browning index was acquired by S1-25g:E3-75g (0.19) fruit juice and it was found to be stable without significant difference even after 90 min due to maximum contribution of *E. officinalis* which is rich in vitamin C. The other combined fruit juices such as S1-50 g:E1-50 g (0.90 and 0.99) and S3-75 g:E1-25 g (1.85 and 2.00) exposed higher browning index during the period of 90 min, mainly due to enzymatic browning reaction.

A similar result was reported by Rocha and Morais (2002) in jonagored apple juice (0.99). Similar, by prevention of enzymatic browning was reported by Jeong *et al.* (2008) in Fuji apple on adding ascorbic acid and by Supapvanich *et al.* (2016) in *Aleo vera* wax applied on fresh-cut apple. An organoleptic property of fruit juice has great importance in evaluating consumer preference and more chance to accept the food item (Hussein *et al.,* 2017). Therefore, sensory evaluation and overall acceptability of fresh fruit juices were evaluated during the period of 0 and 90 min (Table 3). The panel score and statistical analysis revealed that comparatively S1-25g:E3-75g is characterized by its highest score in all the parameters (color, taste, flavor and overall acceptance) over a period of 90 min followed by S1-50 g:E1-50 g, S0-0 g:E1-100 g, S3-75 g:E1-25 g and the least score was recorded by S1-100 g:E0-0 g due to its physical appearance.

Color of fresh fruit juices such as S1-100 g:E0-0 g; S1-50g:E1-50g and S3-75g:E1-25g initially, appeared green but soon after turned into brownish color due to enzymatic browning reaction, therefore a significantly high score was obtained at the end of 90 min which indicates brown color, but in case of S0-0 g:E1-100 g and S1-25 g:E3-75 g fruit juices were creamy and green in color and remained same till the entire storage period (90 min). Significant differences were noticed among variations with respect to taste, color and flavor scores. However, the flavor of S1-50 g:E1-50 g fruit juice was acquired to not significant category at $p>0.05$ level. In the case of S0-0 g:E1-100 g; S1-25:E3-75 g and S3-75g:E1-25g, fruit juices were found to have be a little bitter taste initially; S1-100 g:E0-0 g and S1-50 g:E1-50 g had a high bitter and astringent taste, after the period of 90 min, the S1-100g:E0-0g; S0-0 g:E1-100 g; S1-25 g:E3-75 g and S3-75 g:E1-25 f25fruit juices were secured the same score but the S1-50g:E1-50g juice taste becomes astringent to sour when time increases. These bitter tastes could be attributed to formation of different compound in fruit juices (Adubofuor *et al.,* 2010) that may due to enzymatic browning reaction. However, the flavor of S0-0 g:E1-100 g and S1-25 g:E3-75g juices were most effective to hold its sensory property during the period of 90 min, other fruit juices showed better flavor. Of all fresh juices, S1-25 g:E3-75 g fruit juice (4.68 and 4.18) scored the highest values for overall acceptability, due to good color, taste and flavor obtained by the combination of *S. anguivi* and *E. officinalis* fruit juice in appropriate ratio. The least score was secured by S1-100g:E0-0g fruit juice because of enzymatic browning reaction, therefore it fails to meet acceptability and other organoleptic quality of the fruit.

The FTIR spectrum was used to identify the functional groups of bioactive compounds present in all five developed fruit juices (Fig. 2). The maximum number of compounds was noticed in S1-25 g:E3-75 g and S1-50 g:E1-50 g juice samples. The identified compounds were pyroles, alcohol, phenol, amine, phosphorous, iron, pyrroles, alkanes, amino acids, quinones, and carbohydrates. Hydroperoxides formed during the oxidation

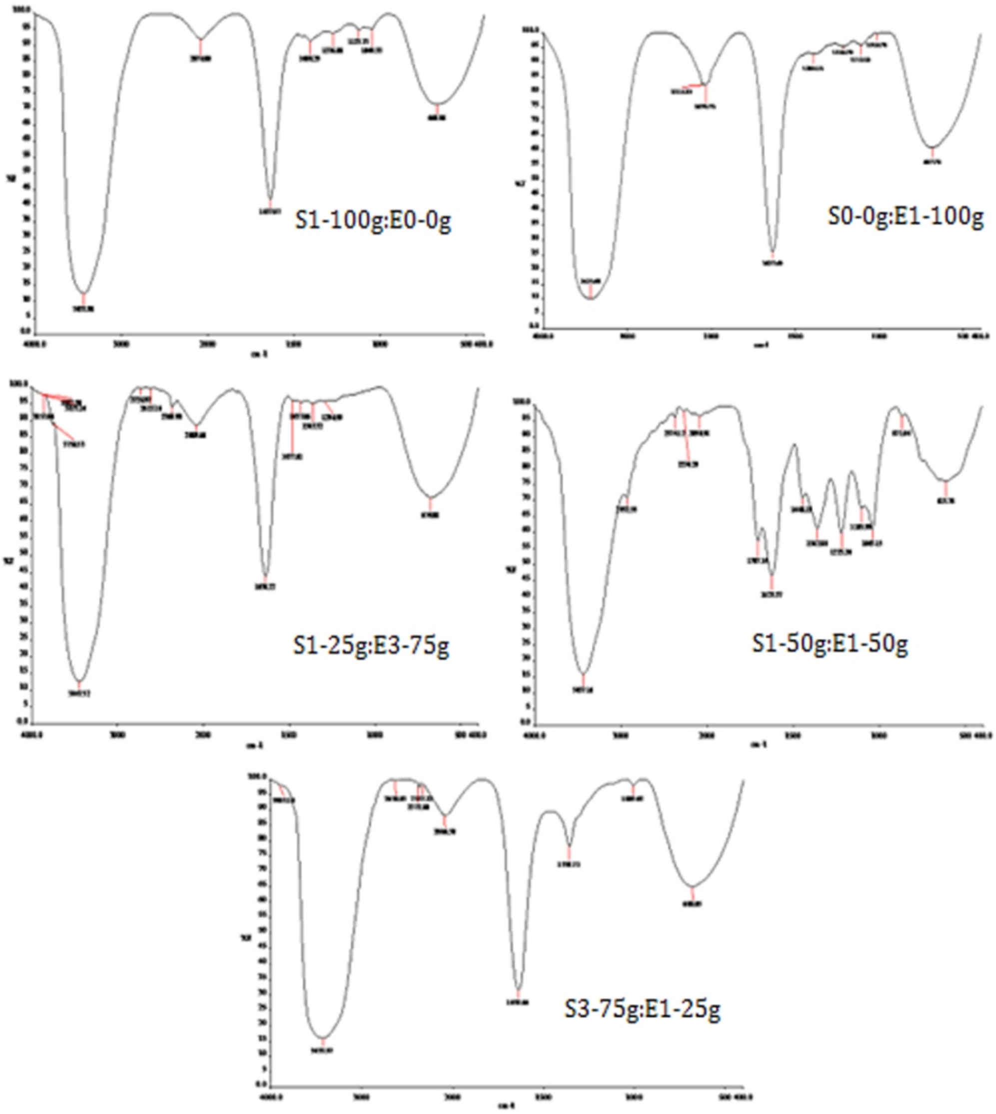


Fig. 2: Fourier Transform Infrared Spectrum of *S. anguivi* and *E. officinalis* fruit juices and its combinations.

process were found in all samples at 3380 cm^{-1} peak due to OH stretching vibration, except for S1-25 g:E3-75 g where browning was prevented by *E.officinalis* inclusion at a greater level. According to Krasnov *et al.* (1968), the absorption band of Hydrogen Flouride centered at 3960 cm^{-1} was noticed as silicon tetrafluoride in S1-25 g:E3-75 g and S3-75 g:E1-25 g juices showing band width between 3600 cm^{-1} and 3900 cm^{-1}. A similar compound was noted in other studies by Armaroli *et al.* (2004) in exhaust gases and Chuprov *et al.* (2006) in impurity compositions of silicon tetrafluoride and silane.

According to Socrates (2004), the band position between 3450 cm^{-1} and 3300 cm^{-1} represents the presence of water and also revealed a band near 1650 cm^{-1}. A similar observation was also noted in all five developed juices. S3-75 g:E1-25 g juice could find any component at the triple bond region and S1-100 g:E0-0 g juice noticed the presence of isothiocyanates with-N=C=S stretching band at 2076 cm^{-1}. The presence of charged amines was noted only in S1-25 g:E3-75 g and S1-50 g:E1-50 g juices between 2700 cm^{-1} and 2330 cm^{-1} in the triple bond region. According to Carbonaro *et al.* (2008), the amide I band at 1635 to 1640 cm^{-1} closely resembles that of 7S globulin and revealed the most significant contribution of β sheet components. Some amino acid chains of globular proteins, especially arginine, glutamine, aspartic and glutamic acids, lysine, tyrosine, histidine and phenylalanine have intense absorption in the amide I spectral region (Freire *et al.,* 2017). Socrates (2004) revealed the presence of esters, ketones, amides, carboxylic acids and their salts, acid anhydrides, olefinic compounds and organic nitrite compounds compoundswhich was noted in all studied fruit juices.

In the fingerprint region, S1-100 g:E0-0 g and S0-0 g:E1-100 g juices revealed the presence of phenol, aromatic amines, ketones, esters, sulfites, sulfoxides, sulfonic acids, carbohydrates, primary and secondary alcohols; but iron and halo compounds were identified only in S1-100 g:E0-0 g and other components like phosphorus and substituted aromatics were identified in other four juices between 1400 cm^{-1} and 700 cm^{-1}. Socrates (2004) also confirmed the presence of sulphoxides, sulphates, sulphites, sulphinic acids or esters, sulphones, sulphonic acids, suiphonates, sulphonamides, sulphonyl halides Ethers (aromatic, olefinic or aliphatic), aliphatic unsaturation and substituted aromatics in this region. Hence, the FTIR result revealed that the addition of *E. officinal* with *S. anguivi* at different proportions had several compounds which were absent in the individual juices. Further advanced spectroscopic studies are required for the identification of specific active compounds.

The present study demonstrated that the enrichment of *S. anguivi* juice with *E. officinalis* concentration had prevented the browning that often occurred due to enzymes catalyst. It was observed through browning index, thorough conversion of o-quinones in the presence of oxygen, and o-quinones polymerise into the undesirable brown color compound. It could be used in the formulation of nutraceutical-based ready-to-serve beverages that might be the solution for preventing several diseases.

Acknowledgment

The authors wish to thank Periyar University for financial support through University Research Fellowship.

Add-on Information

Authors' contribution: T.P. Vijayakumar: Corresponding author of this present work. **P. Karthika:** All kind of analytical and manuscript was done; **K. Baskar:** Provided suggestions which are essential to work and guided through discussion.

Research content: The research content of manuscript is original and has not been published elsewhere.

Ethical approval: Not applicable.

Conflict of interest: The authors declare that there is no conflict of interest.

Data from other sources: Not applicable.

Consent to publish: All authors agree to publish the paper in *Journal of Environmental Biology.*

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