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Research Article

Partial Substitute of Sugar with Date Concentrate in the Peach/Apple Juice and Study Physicochemical/Color Properties of Blend Fruit Juice

Nader Ghahremannejad, Mohammad Alizadeh and Sajad Pirsa
Department of Food Science and Technology, Faculty of Agriculture, Urmia University, P.O. Box 57561-51818, Urmia, Iran

Abstract: The main aim of this study is the substitution of sugar with date concentrate in the fruit juice and blend fruit juice, for this purpose date concentrate was used as a sugar substitute in the blend of peach and apple juice. The effect of five factors including; sugar syrup (%w/w), date concentrate (%w/w), apple concentrate (%w/w), peach puree (%w/w) and storage time (day) on the physicochemical/color properties of juice samples were investigated. An experimental design based on a D-Optimal Combine Design (DOCD) was used to study the different factors affecting (in 5 levels) on the physicochemical/color properties of provided mixed fruit juices. Different quality indices, including acidity, vitamin C content, total phenolic content, antioxidant capacity, None Enzymatic Browning Index (NEBI), Hydroxyl Methyl Furfural (HMF), turbidity, color index and formalin index were measured and modeled. The obtained responses were analyzed and studied by Design-Expert software. Results showed that 1- The sugar in fruit juice blend can be easily replaced by date concentrate, 2- The blend fruit juice contains date concentrate has more HMF, vitamin C and NEBI indices than blend fruit juice contains sugar that is so important for human health, 3- Storage time don't have a significant effect on the turbidity, color parameters (L^*, a^* and b^*) and antioxidant properties of fruit juices.

Keywords: Apple juice, date concentrate substitute, d-optimal combine design, qualitative factors

INTRODUCTION

Consumption of fresh fruit is often replaced by the intake of fruit juices, due to their convenience and ability to quench thirst. It is expected that fresh fruits will be exempt from health and nutritional claims, it is therefore important to evaluate their chemical composition and biological value (Tamuno and Onyedikachi, 2015; Akazome, 2004; Nweze *et al*., 2015). Peaches include one of the most favorable fruits thanks to the delicious taste and the richness of nutrients. The texture of the skin is smooth and the fruit is sweet and watery. Peaches are rich in antioxidant, minerals and fiber (Sentanin and Rodriguez-Amaya, 2007; Toralles *et al*., 2006). That is why many people love to consume the fruits either at fresh or make it to be juices. Peaches contain high vitamin A which is good to reduce the risk of cancer on the glands and other tissues. The phosphor is beneficial to get rid of toxin in the kidney. Thanks to the beta carotene, this fruit can protect your eyes from any free radicals. Peaches are also full of fiber, which is good for the digestive system. Consuming peaches every day can increase your teeth and bones healthy since it is rich of minerals like fluoride and iron. With the fire, you can rely on these fruits to help you losing weight and getting rid of any helminth. The high amount of vitamin C has a big role to enhance your skin healthy as well (Sentanin and Rodriguez-Amaya, 2007; Toralles *et al*., 2006). Apple juice is a fruit juice made from the maceration and pressing of apple. The resulting expelled juice may be further treated by enzymatic and centrifugal clarification to remove the starch and pectin, which holds fine particulate in suspension and then pasteurized for packaging in glass, metal or aseptic processing system containers, or further treated by dehydration processes to a concentrate (Brillouet *et al*., 1996; Eisele and Drake, 2005; Wu *et al*., 2007). Due to the complex and costly equipment required to extract and clarify the juice from apples in large volume, apple juice is normally produced commercially. Apple juice has a significant concentration of natural phenols of low molecular weight (including chlorogenic acid, flavan-3-ols and flavonols) and procyanidins. Apple juice has been shown to reduce oxidative stress in the brains of aging lab mice. Research suggests that apple juice increases acetylcholine in the brain, possibly resulting in improved memory (Brillouet *et al*., 1996; Eisele and

Corresponding Author: Sajad Pirsa, Department of Food Science and Technology, Faculty of Agriculture, Urmia University, P.O. Box 57561-51818, Urmia, Iran

Drake, 2005; Wu *et al*., 2007). Consuming fruits, including peaches in juice form could help the colon to absorb the nutrient more easily and quickly. Despite having some health benefits, apple juice is high in sugar. Fruit juices, smoothies and fruit drinks marketed to children and their parents contain "unacceptably high" levels of sugar, often as much in one small carton or bottle as a child should consume in a day, according to research. The researchers say tough action is needed to reduce the amount of sugar children consume in fruit drinks that are bought and sold on the assumption that they are healthy. The revelations of the high sugar levels in fruit juices and smoothies will dismay parents who may have turned to what they see as a healthier option than sugar-sweetened fizzy drinks such as colas and lemonades (Gibson, 1998; Schulze *et al*., 2004; St-Onge *et al*., 2004). Dates are among the sweetest of fruits, with up to 70% of their weight coming from sugar. Because of their sugar content, dates are higher in calories than most fruit. One Medjool date contains about 66 calories (Drake and Eisele, 1994; Farahnaky *et al*., 2016). The affluent presence of fibers in date concentrate helps to prevent constipation, intestinal disorders, heart problems and even, abdominal cancer. Prepared from the crown of sweets-dates, it is a powerhouse of energy and ideal for pregnant women to maintain their iron levels. Freshly squeezed concentrate, made by soaking dates in water overnight, contains fiber in surplus amounts, which enables proper bowel movements. Thus, people who are suffering from constipation can make use of this concentrate to obtain relief (Drake and Eisele, 1994; Farahnaky *et al*., 2016). The nicotine present in it is a known cure for intestinal disorders. Along with keeping a check on the production of harmful organisms, nicotine makes a fertile space for the growth of intestine-friendly bacteria. The concentrate when consumed as a part of healthy, balanced, nutrient rich diet aids in gaining weight. The natural presence of fats and sugars, along with proteins and vitamins enable the body to maintain its weight. Studies suggest intake of date concentrate with milk or with a cucumber paste to prevent over-slimming (Abbès*et al*., 2013; Al-Farsi and Lee, 2008; El-Sharnouby *et al*., 2009).

Concentrated dates syrup is rich in soluble fiber, making it easily digestible. Hence, it is ideal in controlling the loose bowels experienced in cases of diarrhea. The natural presence of sugars aids in getting rid of the tiredness experienced due to excessive defecation. Studies suggest that the concentrate can offer relief from abdominal cancer. It does wonders in healing cancer without any side effects (Drake and Eisele, 1994; Farahnaky *et al*., 2016; Abbès*et al*., 2013; Al-Farsi and Lee, 2008; El-Sharnouby *et al*., 2009). The fact that it contains sugars naturally enables it to supply extra energy essential to overcome the tiredness experienced due to chemotherapy. The presence of fluorine enables it to shield the teeth from cavities. However, due to the presence of natural sugars in excess, it is suggested to use it up calmly.

In this study the date concentrate was used as a sugar substitute in the blend fruit juice. The effect of five factors including; sugar syrup (%w/w), date concentrates (%w/w), apple concentrate (%w/w), peach puree (%w/w) and storage time (day) on the physicochemical/color properties of juice samples were investigated.

EXPERIMENTAL

Reagents and chemicals: The date and apple concentrate and peach puree was provided from urum-Marian and shahdbab-pars company, Urmia, Iran and were stored in refrigerator in front of using. All organic compounds were purchased from Merck.

Fruit juice preparation: After the standardization of apple and date concentrate and peach puree, these three different juices were diluted with deionized water to Brix 13 then mixed with each other and sugar syrup in the different percent according to the experimental design (Table 1).

Analysis methods:

Acidity determination: Measuring acidity was performed with titration of 10 g fruit juice sample (5 g

Table 1: List of experiments in the DOCD and the responses including vitamin C, acidity, formalin index and antioxidant activity

	Factors				
Run order	F1: Sugar (w/w %)	F2: Date (w/w %)	F3: Apple (w/w %)	F4: Peach (w/w %)	F5: Storage time (day)
1	0.083	0.248	0.168	0.503	23
2	0	0.33	0.335	0.335	1
3	0	0.33	0	0.67	1
4	0	0.33	0	0.67	89
5	0.165	0.165	0	0.67	45
6	0.165	0.165	0.335	0.335	45
7	0	0.33	0.335	0.335	45
8	0	0.33	0	0.67	45
9	0.33	0	0.67	0	45
10	0.33	0	0.67	0	1
11	0.248	0.083	0.168	0.503	67

Table 1: Continue

	Factors				
Run order	F1: Sugar (w/w %)	F2: Date (w/w %)	F3: Apple (w/w %)	F4: Peach (w/w %)	F5: Storage time (day)
13	0.165	0.165	0	0.67	89
14	0.165	0.165	0.67	0	45
15	0.083	0.248	0.503	0.168	67
16	0.33	0	0.335	0.335	1
17	0.33	0	0.335	0.335	89
18	0	0.33	0.335	0.335	89
19	0	0.33	0.67	0	89
20	0	0.33	0.67	0	1
21	0.33	0	0	0.67	1
22	0.33	0	0.335	0.335	45
23	0	0.33	0	0.67	1
24	0.165	0.165	0	0.67	1
25	0.165	0.165	0.67	0	1
26	0.33	0	0	0.67	89
27	0.165	0.165	0.335	0.335	1
28	0.165	0.165	0.67	0	89
29	0	0.33	0.67	0	1
30	0.248	0.083	0.503	0.168	67
31	0.248	0.083	0.168	0.503	23
32	0	0.33	0.67	0	89
33	0.083	0.248	0.503	0.168	23
34	0.33	0	0	0.67	89
35	0.165	0.165	0.335	0.335	89
36	0.083	0.248	0.168	0.503	67
37	0.33	0	0	0.67	1
38	0.33	0	0.67	0	89
39	0	0.33	0.67	0	45
40	0.33	0	0	0.67	45

	Responses (Physicochemical property)			
Run order	Vitamin C (g/100 g)	Acidity (g/100 g)	Formalin index(g/100 g)	Antioxidant activity (%)
1	0.487	0.43	12.5	24
2	0.857	0.42	16.5	61
3	0.52	0.53	23.5	74
4	0.274	0.59	22.5	-
5	0.7	0.48	20.5	34
6	0.624	0.39	13.4	5
7	0.787	0.32	12.85	56
8	0.563	0.5	21.6	53
9	0.404	0.19	5.2	86
10	0.46	0.21	5.5	34
11	0.242	0.48	9.7	82
12	0.487	0.31	5.55	89
13	0.375	0.59	12	91
14	0.476	0.28	2.55	84
15	0.342	0.39	8.6	93
16	0.732	0.36	14.5	67
17	0.316	0.39	5.8	40
18	0.26	0.43	9	36
19	0.559	0.31	4.2	55
20	0.7	0.23	5.65	20
21	0.714	0.49	19	57
22	0.364	0.36	11.15	61
23	0.734	0.55	19.5	51
24	0.61	0.54	19	49
25	0.826	0.21	20.5	55
26	0.27	0.63	13.4	89
27	0.56	0.36	13.5	78
28	0.35	0.29	4.1	26
29	0.593	0.19	8.75	40
30	0.263	0.28	6.15	89
31	0.75	0.41	11.5	12
32	0.693	0.31	4.8	31
33	1.16	0.25	6.75	62
34	0.489	0.26	15	33
35	0.331	0.7	8.4	76
36	0.249	0.45	14.4	88
37	0.494	0.53	17.5	46
38	0.241	0.25	2.9	33
39	0.654	0.25	6.7	78
40	0.391	0.54	16.5	72

sample and 5 g of distilled water) by NaOH solution (0.1 N) in the presence of phenolphthalein.

Total phenol determination: The total phenolic content of the juice samples was determined by the Folin-Ciocalteu method (Eisele and Drake, 2005). Briefly, 1 mL juice samples mixed with 5 mL of Folin-Ciocalteu reagent (0.2 Mol/L) for 3 min, followed by the addition of 4 mL of 7.5% (w/v) sodium carbonate. The mixture was allowed to stand for a further 120 min in the dark and absorbance was measured at 765 nm. The total phenolic content was calculated from the calibration curve based on Gallic acid concentration (10-1000 mg/L) and the results were expressed as mg of Gallic acid equivalent per liter of juice samples.

Formalin index: The formalin index of the juice samples was determined by the potentiometric titration method as the following: Briefly, NaOH (0.1 M) was added to 25 mL juice sample to reach pH = 8.1, followed by the addition 10 mL formaldehyde and stirred well. Finally the NaOH (0.1 M) gradually was added to the mix to pH = 8. 1 and the volume of consuming NaOH was recorded. The formalin index was calculated:

$$F = \frac{V \times N \times 10}{V_0} \times 100 \qquad (1)$$

where,

V : NaOH volume

V_0 : Juice sample volume

N : Normality of NaOH

Vitamin C content determination: The vitamin C content of juice samples was determined by titration method of samples by 2, 6-dichloro phenyl indophenols indicator. For this purpose three solutions were provided:

- Extraction solution (Oxalic acid 2% W/W)
- 2, 6-dichloro phenyl indophenols indicator solution
- Standard ascorbic acid solution. Briefly, 15 g of juice sample was mixed with an extraction solution (to 50 mL), this mixed solution was filtered and the solution volume was recorded. The filtered solution was titrated with the indicator solution to appear pink color and the indicator volume was recorded. The vitamin C content of juice samples was calculated:

$$Ascorbicacid\left(\frac{mg}{100g}\right) = \frac{\frac{\frac{V1 \times 5}{V2 \times A}}{B}}{sampleweight} \times 100 \qquad (2)$$

where,

V_1 : Indicator solution volume consumed for juice sample titration

V_2 : Indicator solution volume consumed for standard ascorbic acid titration

A : The initial volume of mixed solution (50 mL)

B : The volume of filtered solution

Determination of NEB and HMF indexes:

Nonenzymatic Browning Index (NEBI): Ethyl alcohol (5 mL; 95% w/w), was added to 5 mL of juice sample, centrifuged (10 min) and the absorbance of the supernaant was read at 420 nm. The value obtained was considered as the Nonenzymatic Browning Index (NEBI).

Hydroxymethylfurfural: The Keeney and Bassette (1959) method was utilized as follows: 2 mL of the supernatant (from the NEB test described above), 2 mL (120 g/kg) 3-chloroacetic acid (TCA) and 2 ml 0.025 mol/L Thiobarbituric Acid (TBA) were mixed in 16-mL screw-cap test tubes. The test tubes were placed in a water bath at 40±0.5°C, heated for 50 min and then cooled immediately with tap water to approximately 25°C. The absorbance measured at 443 nm was defined as the quality index utilized to quantify HMF. The actual HMF was read from a calibration curve of HMF ranging from 0 to 1000 mg/L.

Antioxidant activity determination by DPPH: The antioxidant activity of the juice samples was determined by the 1, 1-Diphenyl-2-Picryl-Hydrazyl (DPPH) assay. Briefly, 2 mL methanol solution (include 100 μl/L of juice sample) were mixed with 2 mL methanol solution (include 0.002% DPPH) and incubated in the dark at room temperature for 1 h. The absorbance of the mixture was then measured at 517 nm. Ascorbic acid was used as a positive control. The ability of the sample to scavenge DPPH radical was determined from:

$$Antioxidantactivity = \frac{A-B}{A} \times 100 \qquad (3)$$

where,

A = Control sample absorbance

B = Juice sample absorbance

Turbidity determination: The turbidity of apple concentrates samples was determined by turbidimeter (N2100, HACH, United State). Firstly the turbidimeter instrument was calibrated in the 0 degrees (100% transmission) by deionized water, then fruit juice sample was put in the cell and the shown number as turbidity was recorded. In the fruit juice samples, high color and clarity (near to 100) and low turbidity (near to 0) show the high quality of samples.

Color determination: The apparent color of juice samples was determined by a Hunter lab system (Colorflex, United State) based on a color system (L^*, b^* a^*). In addition to the hue angle and chroma were analyzed as the following:

$$\text{Chroma (magnitude)} = [a^* + b^*]^{1/2} \quad (4)$$

$$\text{Hue (angle)} = \tan^{-1}(b^*/a^*) \quad (5)$$

Experimental design: Substitution of sugar by date concentrate in blend juice of apple and peach juices can affect the physicochemical and color of the products. So the apple, peach and date concentrate and sugar percent (% w/w) and storage time of juice samples as five factors that affect physicochemical/color properties of mix fruit juice were studied. The studied physicochemical/color properties include acidity, formalin index, total phenolic compounds, HMF, NEBI, Vitamin C content, antioxidant activity, turbidity and color properties (L*, b* a*, Hue angle, chroma and b_i). To study the effect of these factors on the responses a D-Optimal Combine Design (DOCD) was used. Five variables, including apple, peach and date concentrate and sugar percent (% W/W) and storage time of juice samples (all in five levels) were investigated. In Table 1 and 2, the 5 processing variables as factors, levels and experimental design are given. These tables also present the evaluated responses including, vitamin C, acidity, formalin index and antioxidant activity (Table 1) and NEBI, HMF, turbidity and total phenol (Table 2). Table 3 shows the list of juice sample color properties including L*, a*, b*, chroma and Hue angle for each experimental run. The Design-Expert software (version 7) was used to perform statistical analysis. Initially, the full term second order polynomial response surface models were fitted to each of the response variables, according to the following equation:

Table 2: List of experiments in the DOCD and the responses including NEBI, HMF, turbidity and total phenol

	Factors				
Run order	F1: Sugar (W/W %)	F2: Date (W/W %)	F3: Apple (W/W %)	F4: Peach (W/W %)	F5: Storage time (day)
1	0.083	0.248	0.168	0.503	23
2	0	0.33	0.335	0.335	1
3	0	0.33	0	0.67	1
4	0	0.33	0	0.67	89
5	0.165	0.165	0	0.67	45
6	0.165	0.165	0.335	0.335	45
7	0	0.33	0.335	0.335	45
8	0	0.33	0	0.67	45
9	0.33	0	0.67	0	45
10	0.33	0	0.67	0	1
11	0.248	0.083	0.168	0.503	67
12	0.248	0.083	0.503	0.168	23
13	0.165	0.165	0	0.67	89
14	0.165	0.165	0.67	0	45
15	0.083	0.248	0.503	0.168	67
16	0.33	0	0.335	0.335	1
17	0.33	0	0.335	0.335	89
18	0	0.33	0.335	0.335	89
19	0	0.33	0.67	0	89
20	0	0.33	0.67	0	1
21	0.33	0	0	0.67	1
22	0.33	0	0.335	0.335	45
23	0	0.33	0	0.67	1
24	0.165	0.165	0	0.67	1
25	0.165	0.165	0.67	0	1
26	0.33	0	0	0.67	89
27	0.165	0.165	0.335	0.335	1
28	0.165	0.165	0.67	0	89
29	0	0.33	0.67	0	1
30	0.248	0.083	0.503	0.168	67
31	0.248	0.083	0.168	0.503	23
32	0	0.33	0.67	0	89
33	0.083	0.248	0.503	0.168	23
34	0.33	0	0	0.67	89
35	0.165	0.165	0.335	0.335	89
36	0.083	0.248	0.168	0.503	67
37	0.33	0	0	0.67	1
38	0.33	0	0.67	0	89
39	0	0.33	0.67	0	45
40	0.33	0	0	0.67	45

Table 2:Continue

	Responses (Physicochemical) property			
Run order	NEBI	HMF (mg/L)	Turbidity (NTU)	Total phenol (mg/L)
1	0.528	84.5	3086	0.039
2	0.544	121.87	3366	0.014
3	0.119	7.236	3339	0.039
4	0.132	8.412	3236	0.042
5	0.364	57.96	3389	0.037
6	0.49	68.05	2713	0.018
7	0.837	88.98	2354	0.018
8	0.825	79.87	3270	0.035
9	0.276	16.78	21.9	0.012
10	0.188	13.42	50.5	0.006
11	0.508	19.14	3164	0.027
12	0.44	48.6	1636	0.056
13	0.542	31.05	3363	0.046
14	0.478	72.87	29	0.010
15	0.538	77.69	1795	0.011
16	501	6.145	2947	0.019
17	0.214	17.6	2834	0.025
18	0.515	105.42	2689	0.025
19	0.654	118.14	21.6	0.005
20	0.553	94.05	173	0.005
21	0.221	24.32	3327	0.035
22	0.628	34.96	2771	0.038
23	0.519	82.23	3382	0.034
24	0.241	49.05	2611	0.058
25	0.207	29.05	85.4	0.006
26	0.582	19.05	3301	0.047
27	0.239	50.32	2872	0.023
28	0.502	74.32	43.8	0.004
29	0.554	121.87	139	0.007
30	0.293	41.05	1620	0.014
31	0.35	61.87	3254	0.029
32	0.704	124.5	56.6	0.005
33	0.73	48.5	9588	0.010
34	0.328	24.51	3328	0.042
35	0.614	67.23	2694	0.067
36	0.428	82.69	3167	0.030
37	0.75	10.145	3448	0.025
38	0.285	12.69	7.24	0.004
39	0.911	101.69	26.2	0.009
40	0.272	27.23	3459	0.036

Table 3: List of juic samples color properties include L*, a*, b*, chroma and Hue angle for each experiment run

	Color properties				
Run order	L*	a*	b*	chroma	Hue angle
1	30.32	6.29	15.8	17.006	68.29244
2	27.01	4.5	12.95	13.70958	70.83815
3	30.38	6.63	16.7	17.96794	68.34663
4	28.9	7.41	15.66	17.32466	64.67742
5	30.43	6.93	16.69	18.07155	67.45086
6	27.36	4.81	13.07	13.92699	69.79546
7	25.55	4.42	11.7	12.50705	69.30455
8	28.9	7.11	17.06	18.48231	67.37537
9	13.31	0.32	0.24	0.4	36.8699
10	14.41	0.3	0.49	0.574543	58.52316
11	29.99	6.02	15.59	16.71193	68.88618
12	24.7	2.98	9.28	9.746733	72.1971
13	29.88	7.16	16.81	18.27134	66.92905
14	15.31	0.61	0.69	0.920978	48.52145
15	23.09	2.82	8.8	9.240801	72.23171
16	25.91	3.99	12.55	13.169	72.36307
17	26.88	4.31	12.58	13.29784	71.08817
18	24.94	4.59	11.63	12.503	68.46239
19	14.85	0.79	1.15	1.395206	55.51263
20	15.73	0.63	0.61	0.876926	44.07595
21	26.65	4.27	13.03	13.71181	71.85576
22	27.89	5.04	13.93	14.81373	70.10942

Table 3: Continue

	Color properties				
Run order	L*	a*	b*	chroma	Hue angle
23	30.18	6.91	17.39	18.71257	68.32936
24	29.63	6.56	16.8	18.03534	68.67054
25	15.57	0.49	0.72	0.870919	55.76254
26	31.09	7.64	17.67	19.25094	66.61773
27	26.76	4.39	12.88	13.60759	71.17891
28	13.44	0.87	1.56	1.786197	60.85193
29	15.01	0.92	0.58	1.087566	32.22876
30	23.25	2.33	8.34	8.659359	74.39089
31	29.21	6.11	15.53	16.68871	68.52373
32	14.6	0.92	1.17	1.488388	51.82115
33	20.79	2.48	7.04	7.464047	70.59403
34	30.21	7.32	17.31	18.79411	67.07762
35	26.29	4.88	12.83	13.72674	69.17526
36	28.31	5.86	14.58	15.71356	68.1038
37	31.56	7.16	17.83	19.21391	68.12107
38	14.15	0.39	1.22	1.28082	72.27237
39	11.25	1.01	0.58	1.164689	29.86692
40	29.24	7.13	17.2	18.61926	67.48429

Table 4: Some characteristics of the constructed models for physicochemical properties

Response type	Regression equation	Model Summary
Vitamin C	Not suitable regression	R-sq = 0.534 R-sq(adj) = 0.491
Acidity (g/100 ml)	Acidity=0.22 * F1 * F3+0.55* F1 * F4 +0.26* F2* F3+0.46*F2*F4+0.053*F1*F4*F5+ 0.055+*F2*F3*F5+0.098*F2*F4*F5^2	R-sq = 0.959 R-sq(adj) = 0.951
Formalin index (g/100 ml)	FI= 16.9 * F1* F3 +84.6* F1 * F4 +32.7* F2* F3+92.6* F2* F4-0.32*F1*F4*F5-0.18*F2*F3*F5	R-sq = 0.883 R-sq(adj) = 0.866
Antioxidant activity (g/100 ml)	Not suitable regression	R-sq = 0.28 R-sq(adj) = 0.18
NEBI	Not suitable regression	R-sq = 0.326 R-sq(adj) = 0.290
HMF (g/100 ml)	HMF= 66.2 * F1 * F3 +117.1* F1 * F4+521.2* F2* F3+268.7* F2* F4	R-sq = 0.718 R-sq(adj) = 0.695
Turbidity (NTU)	Turbidity=118* F1 * F3+15425* F1 * F4 +654.9* F2* F3+ 14955*F2*F4-848.8*F1*F2*F3- 42420+*F1*F2*F4+31932*F1*F3*F4-4.12*F1*F4*F5+ 45103+*F2*F3*F4-6.13*F2*F3*F5+35060+*F1*F2*F3*F4+17.49*F1*F2*F3*F5 +1428*F1*F2*F4*F5- 28.06+*F1*F3*F4*F5-1027*F2*F3*F4*F5-693.1*F1*F2*F3*F4*F5 -10.45*F1*F2*F4*F5^2+9.37*F2*F3*F4 *F5^2	R-sq = 0.998 R-sq(adj) = 0.997
Total phenol (g/100 ml)	1.0/Sqrt(Total phenol)= 9.6* F3 +4.9* F4 +0.534* F3* F5-2.24*F3* F4 *F5+3.58* F3* F5^2-10.6*F3* F4 *F5^2	R-sq = 0.944 R-sq(adj) = 0.936

F1: Sugar (% w/w), F2: Date concentrate (% w/w), F3: Apple juice (% w/w), F4: peach juice (% w/w) and F5: Storage time (day)

Table 5: Some characteristics of the constructed models for color properties

Response type	Regression equation	Model Summary
L*	L*=21.6 * F3 +44.33* F4 +4.53* F3* F4	R-sq = 0.965 R-sq(adj) = 0.63
a*	a*=0.95 * F3 +10.2* F4 +5.95* F3* F4+0.0083*F4*F5	R-sq = 0.991 R-sq(adj) = 0.990
b*	b*= 4.08* F1 * F3+78.4* F1 * F4 +4.17* F2* F3+ 77.2*F2*F4+111.5*F1*F3*F4+96.2*F2*F3*F4 -0.068*F2*F4*F5	R-sq = 0.994 R-sq(adj) = 0.992
Chroma	chroma= 4.42* F1 * F3+84.9* F1 * F4 +5.82* F2* F3+ 83.07*F2*F4+111.3*F1*F3*F4+94.01*F2*F3*F4-0.052*F2*F4*F5	R-sq = 0.994 R-sq(adj) = 0.993
b_i	bi= 13.7 * F3 +15.4* F4 +199.16* F3* F4+185.8* F3* F4* (F3- F4)	R-sq = 0.992 R-sq(adj) = 0.992

F1: Sugar (% w/w), F2: Date concentrate (% w/w), F3: Apple juice (% w/w), F4: peach juice (% w/w) and F5: Storage time (day)

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i x_i + \sum_{i=1}^{3} \sum_{j=i+1}^{3} \beta_{ij} x_i x_j + \sum_{i=1}^{3} \beta_{ii} x_{ii}^2 \quad (6)$$

Where Y is the responses (vitamin C, acidity, formalin index and antioxidant activity-NEBI, HMF, turbidity and total phenol-L*, a*, b*, chroma and Hue angle); Xi and Xj are variables (five factor) and β values are the coefficient values obtained through multiple linear regressions. Where possible, stepwise deletion of terms was appliedtoremove thestatistically non-significantterms, so simplifying the model. However, when the exclusion of such terms from the model decreases R^2(adjusted) and increases the estimator of the variance S, the term was included in the model. The statistically non-significant linear terms also remained in the model when the respective quadratic or interactive effects were statistically significant. The quadratic polynomial models for all responses accompanied by F values and corresponding R^2 was used, the estimated regression coefficients summarized in Table 4 and 5.

RESULTS AND DISCUSSION

Contour plots of juice physicochemical properties based on variables: The contour plots based on the model function were used to predict responses to survey influence of each variable on the analyzed physicochemical properties.

Figure 1 shows a contour plot of juice vitamin Cversus three factors (sugar percent, date concentrates percent and storage time). Results show that vitamin C content of blend juice samples is decreased by increasing storage time and increasing of date concentrate in the juice samples can increase vitamin C content that has a beneficial effect on the human health. Esteve *et al*. (2005) research showed that the vitamin C concentration in orange juice was decreased by increasing storage time that their results is according to the our results.

Figure 2 shows three dimensional plots of acidityversus five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the acidity and there are some interactions between variables. The storage time has a little effect on the acidity and increasing of date concentrate percent against sugar percent increases slightly the acidity. The peach percent of the blend juice strongly affects the acidity. The blend juice acidity is increased by increasing peach percent. In the similar researches the obtained results showed that increasing of storage time increases the acidity of fruit juice by microbial activity and fermentation process (Esteve *et al*., 2005).

Figure 3 shows three dimensional plot of formalin indexversus five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the formalin index and there are some interactions between variables. The formalin index of blend juice samples is increased by increasing of peach percent and increasing of date concentrate content of juice sample cause to increase formalin index. Increasing of storage time causes to decrease formalin index.

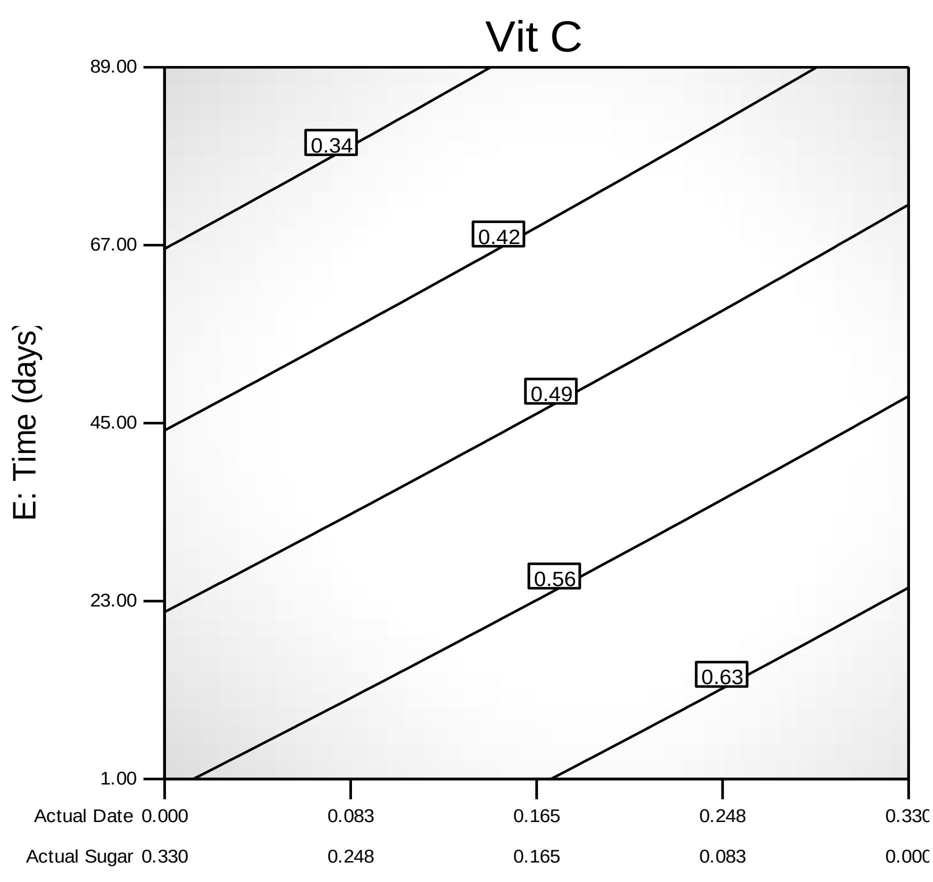


Fig. 1: Contour plots of vitamin C based on variables

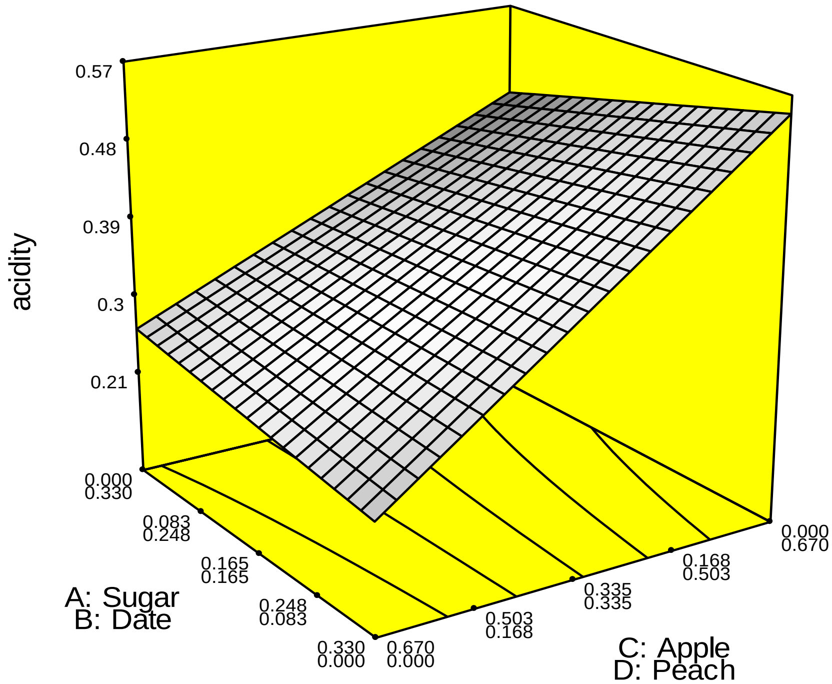


Fig. 2: Three dimensional plots of acidity based on variables

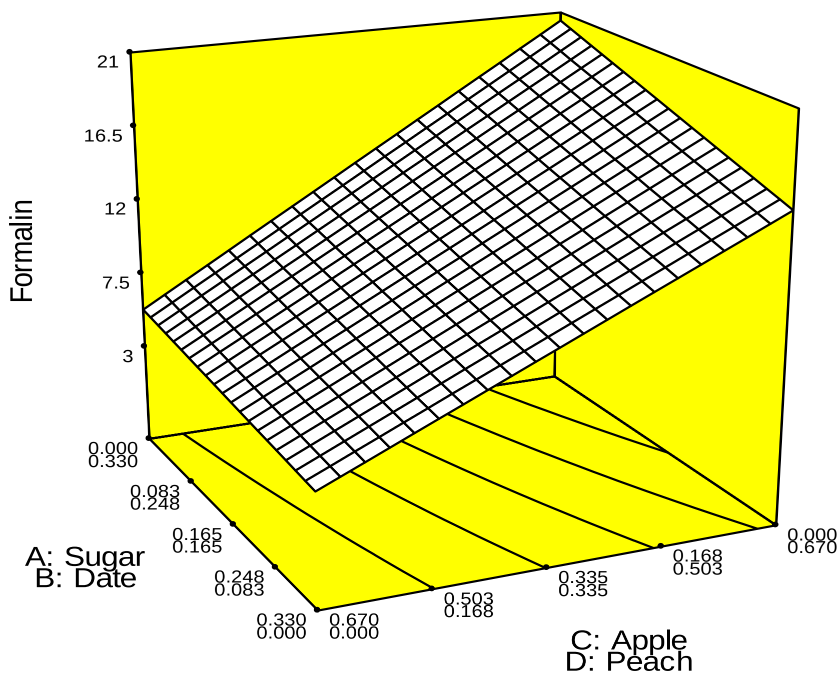


Fig. 3: Three dimensional plot of formalin index based on variables

Figure 4 shows a contour plot of antioxidantversus variables. Results show that there are not linear relations between variables and antioxidant activity. The antioxidant activity of blend juice is increased byincreasing of peach juice percent. According to the similar researches the antioxidant activity of fruit juices is decreased by increasing storage time (Tavarini *et al.*, 2008).

Figure 5 shows a contour plot NEBIversus variables. Results show that there are not linear relations between variables and antioxidant activity.The NEBI of blend juice is increased by increasing of

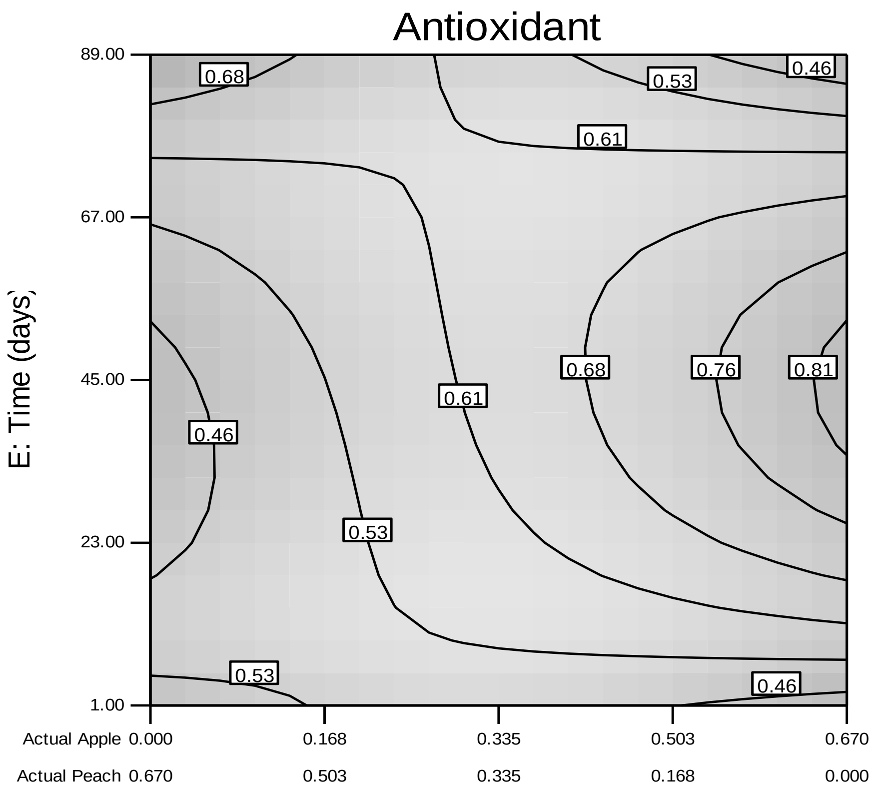


Fig. 4: Contour plot of antioxidant activity based on variables

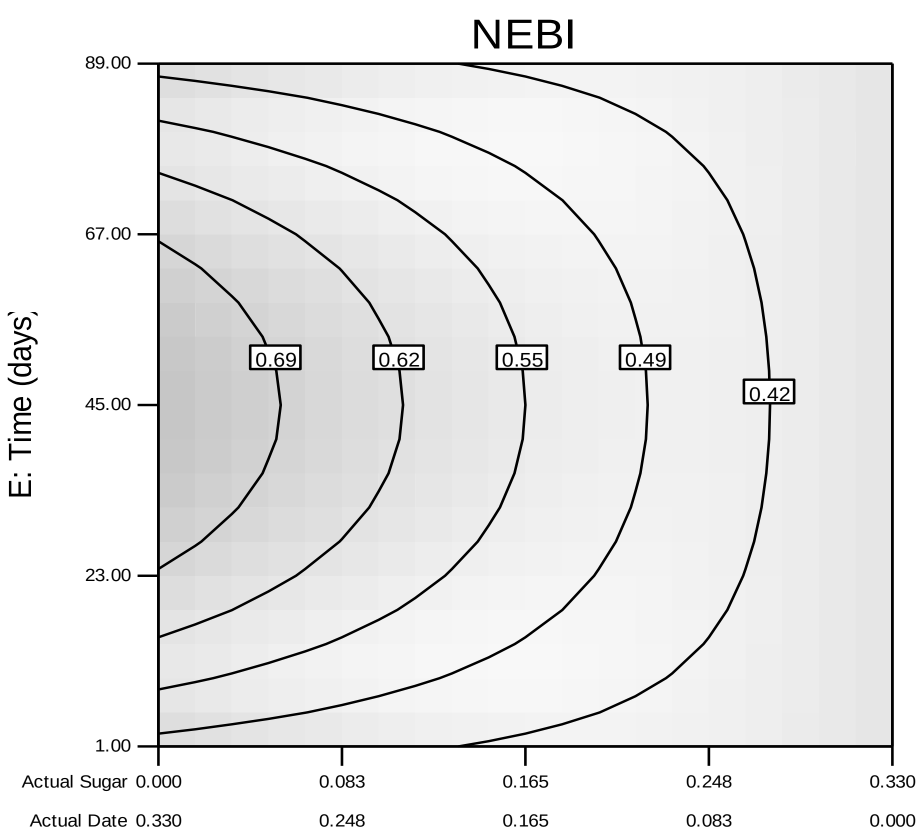


Fig. 5: Contour plots of NEBI based on variables

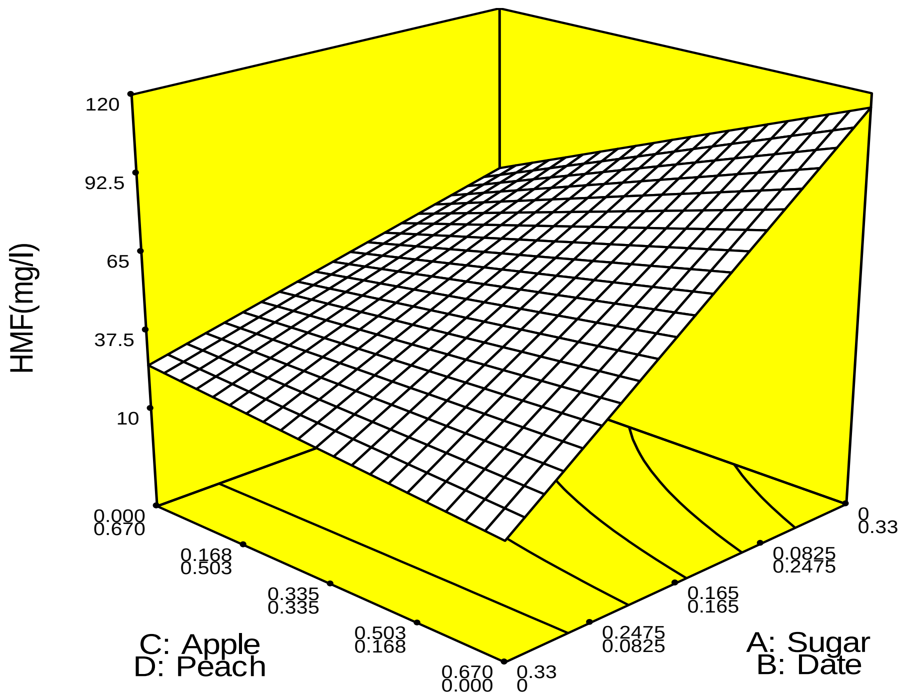
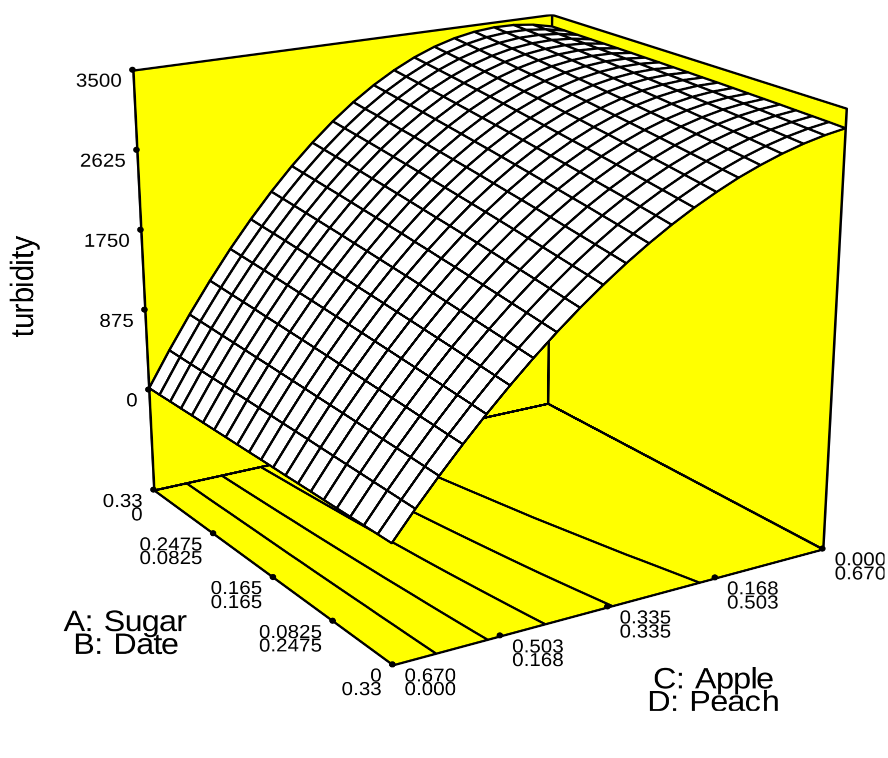


Fig. 6: Three dimensional plots of HMF based on variables

date concentrate percent. In the similar research non-enzymatic browning of peach juice concentrate during storage was obtained (Buedo *et al.*, 2001).

Figure 6 shows three dimensional plots of HMF based on five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the HMF and there are some interactions between variables. The HMF of blend juice samples is increased by increasing of date concentrate content. Burdurlu *et al.* (2006) research confirm the results that were obtained in this research.



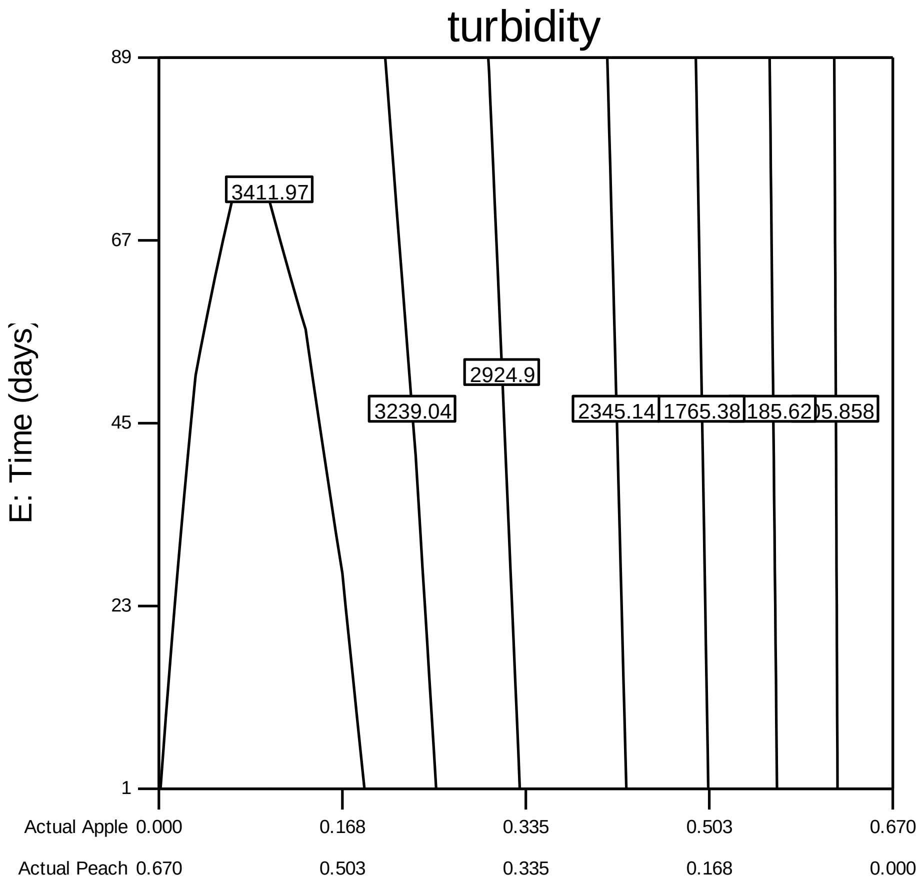


Fig. 7: Contour plot and three dimensional plot of turbidity based on variables

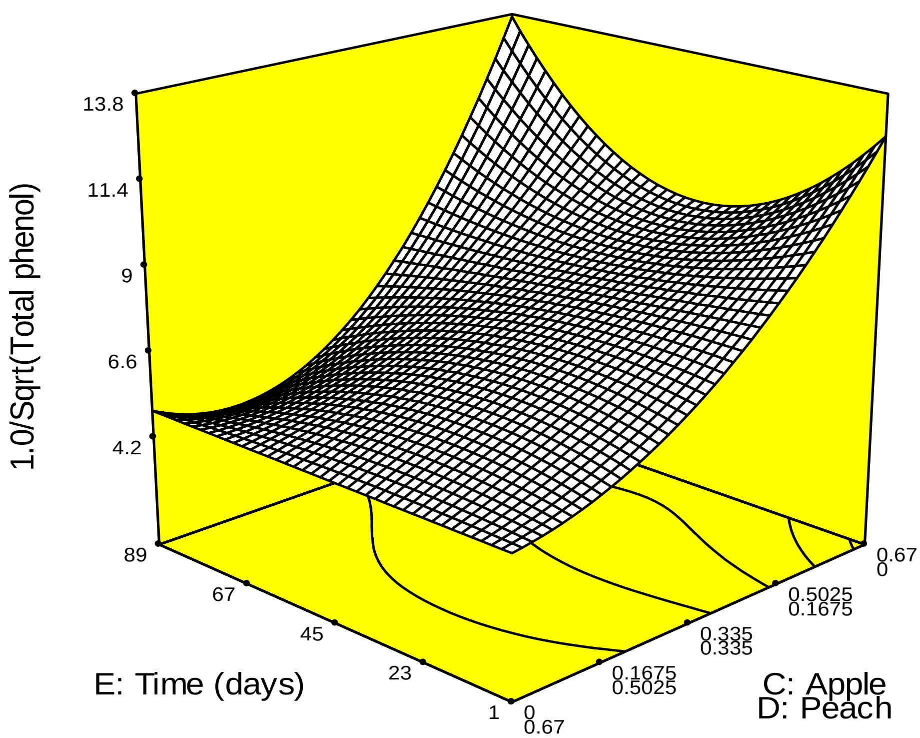
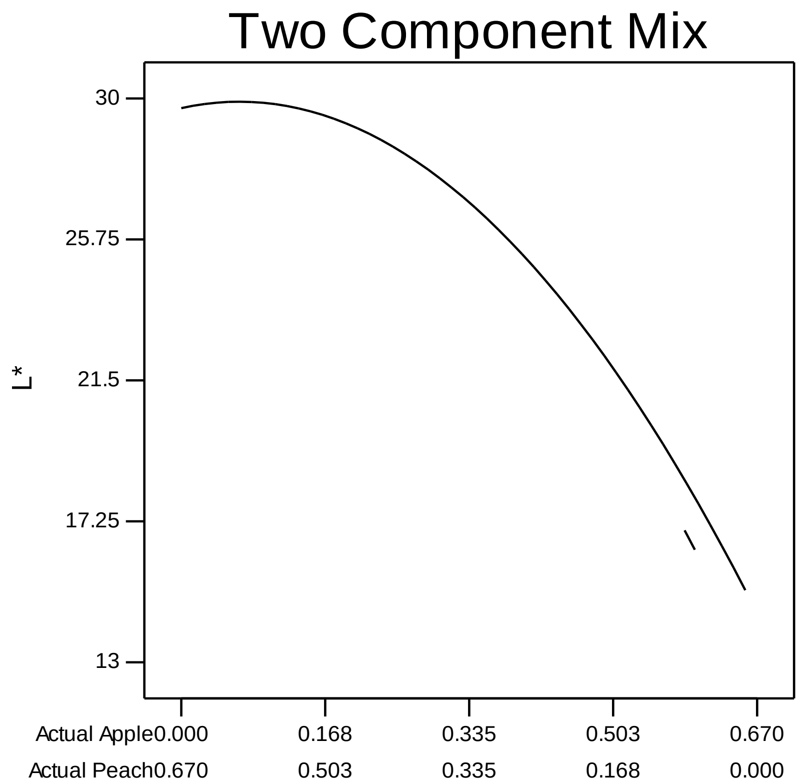
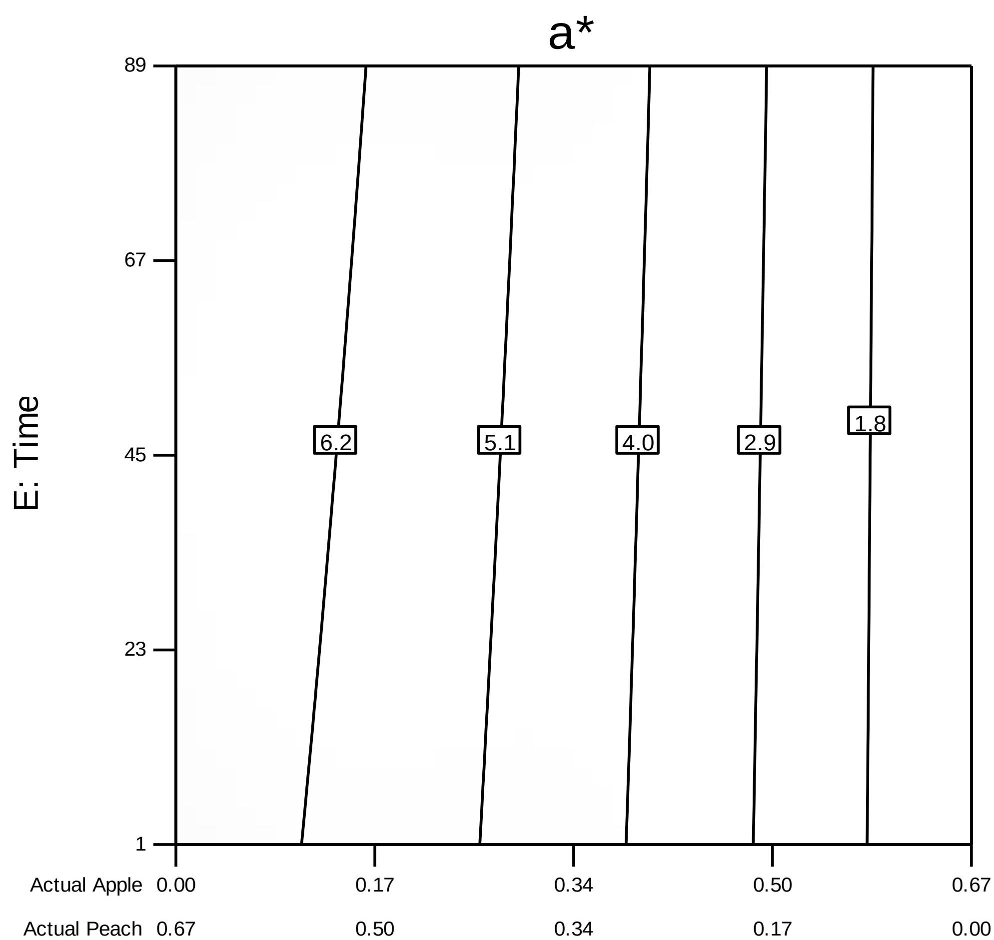


Fig. 8: Three dimensional plots of total phenol based on variables


Two Component Mix
L*
30
25.75
21.5
17.25
13
Actual Apple 0.000 0.168 0.335 0.503 0.670
Actual Peach 0.670 0.503 0.335 0.168 0.000


a*
E: Time
89
67
45
23
1
6.2
5.1
4.0
2.9
1.8
Actual Apple 0.00 0.17 0.34 0.50 0.67
Actual Peach 0.67 0.50 0.34 0.17 0.00

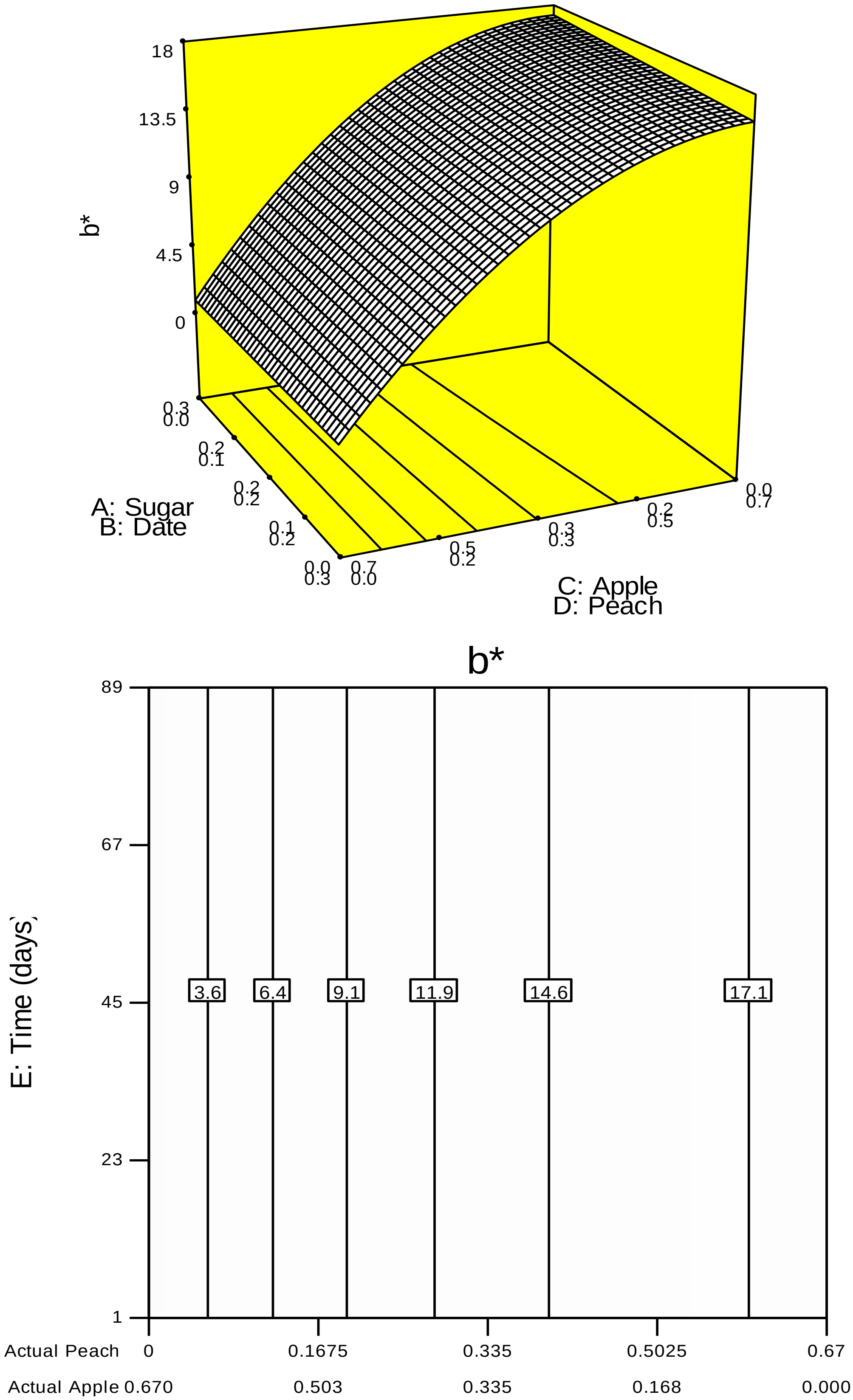


Fig. 9: Contour plots and three dimensional plots of L*, a* and b* based on variables

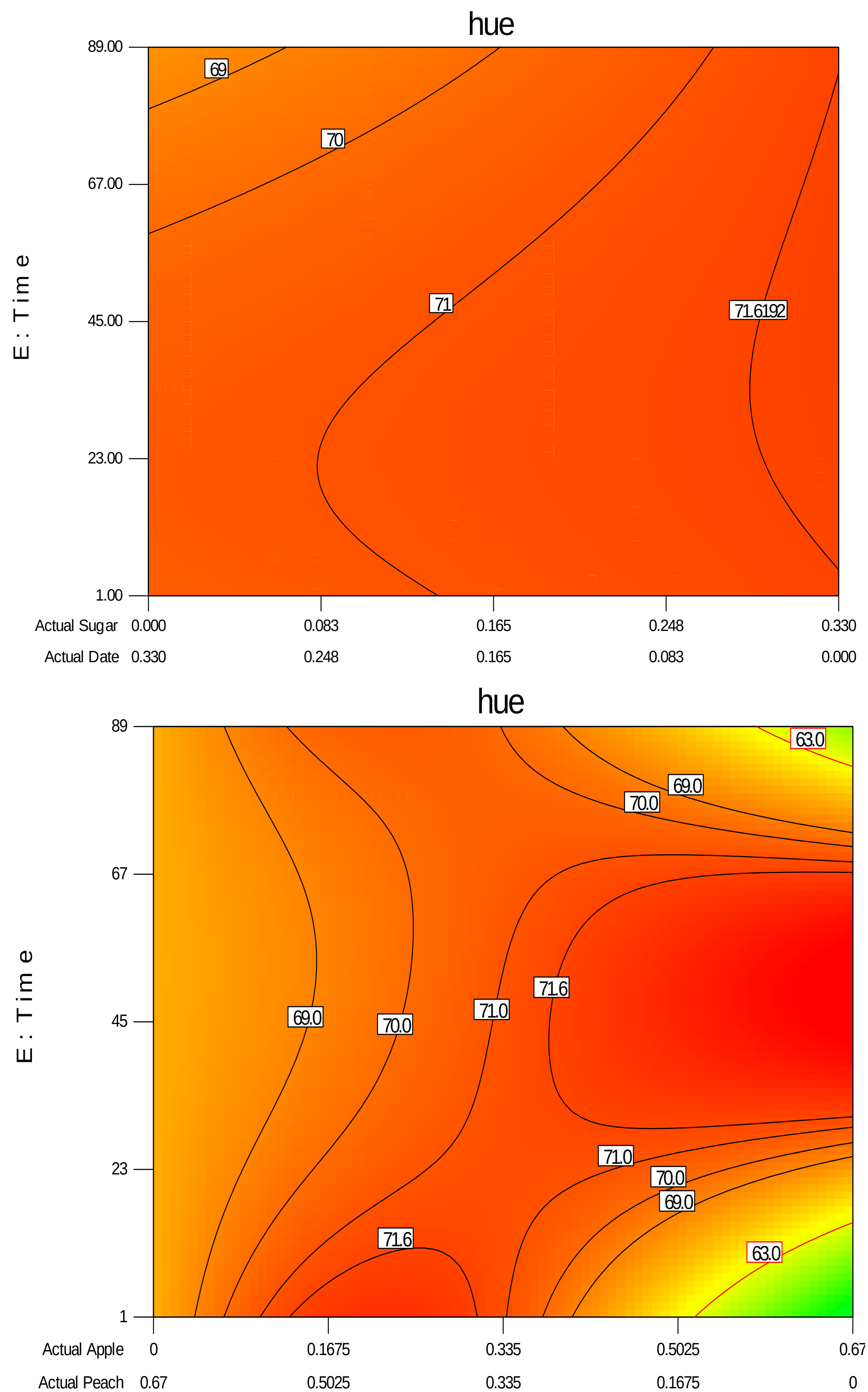


Fig. 10: Contour plot and three dimensional plots of hue angle based on variables

Figure 7 shows contour plot and three dimensional plots of turbidityversus five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the turbidity and there are some interactions between variables. The turbidity of blend juice samples is increased strongly by increasing of peach percent and increasing of date concentrate content of juice sample and storage time cause to increase turbidity slightly.

Figure 8 shows three dimensional plots of total phenol based on five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the total phenol and there are some interactions between variables. The phenol of blend juice samples is increased by increasing of apple juice content. Almost the similar results were obtained in the previous researches (Suárez-Jacobo*et al*., 2011).

Contour plots of juice color properties based on variables: The contour plots based on the model function were used to predict responses to survey influence of each variable on the analyzed color properties. Figure 9 shows contour plot and three dimensional plots of L^*, a^* and b^*versus five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the L^*, a^* and b^* and there aresome interactions between variables. The L^*, a^* and b^* are decreased by increasing of apple juice percent, b^* is decreased by increasing of date concentrate percent. The L^*, a^* and b^* are almost constant in the different storage time.

Figure 10 shows contour plot and three dimensional plots of hue angle versus five factors (apple juice, peach juice, date concentrate and sugar percent and storage time). Results show that all variables have affected the hue angle and there are some interactions between variables. The hue angle is decreased by increasing of date concentrate.

CONCLUSION

In this study date concentrate was used as a sugar substitute in the blend fruit juice. The Effect of five factors including; sugar syrup (%w/w), date concentrate (%w/w), apple concentrate (%w/w), peach puree (%w/w) and storage time (day) on the physicochemical/color properties of juice samples were investigated. An experimental design based on a D-Optimal Combine Design (DOCD) was used to study the different factors effect on the physicochemical/color properties of mixed fruit juices. Different quality indices, including acidity, vitaminCcontent, total phenolics content, antioxidant capacity, NEBI, HMF, turbidity, formalin index and color properties (L^*, a^*, b^*, b_i and hue angle) were measured. Results showed that:

- Vitamin C content of blend juice samples is decreased by increasing storage time and increasing of date concentrate in the juice samples can increase vitamin C content that has a beneficial effect on the human health
- The peach percent in the blend juice strongly affects the acidity. The blend juice acidity is increased by increasing peach percent
- The L^*, a^* and b^* are decreased by increasing of apple juice percent, b^* is decreased by increasing of date concentrate percent. The L^*, a^* and b^* are almost constant in the different storage time
- The NEBI of blend juice is increased by increasing of date concentrate percent

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