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Investigating the physicochemical characteristics of a functional drink based on sugarcane juice

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ABSTRACT

Many individuals exhibit a proclivity towards integrating healthful and functional regimens into their everyday dietary patterns. Within the realm of food products, beverages offer a fitting choice for infusing them with bioactive compounds. Sugarcane juice, a pleasantly sweet and invigorating beverage, has garnered notable interest in recent times owing to its nutritional merits. The primary objective of this study was to examine the physicochemical and sensory characteristics of sugarcane juice and subsequently optimize the formulation of a functional beverage centered on this ingredient. To optimize the formulation of the aforementioned beverage, the response surface methodology and a Box-Behnken design were employed. Lemon juice (in amounts of 0, 3, and 6 mL), turmeric (in amounts of 0, 0.3, and 0.6 g), and peppermint extract (in amounts of 0, 250, and 500 µL) were incorporated per 100 µL of sugarcane juice. The dependent variables examined in this research encompassed pH, acidity, soluble solids, turbidity, color indices, antioxidant activity, phenolic compounds, and overall acceptance. The outcomes of the study revealed notable trends. As the quantity of lemon juice increased, acidity, turbidity, L* index, b* index, total phenolic compounds, antioxidant activity, and overall acceptance displayed an upward trajectory. Conversely, pH, soluble solids, and a* index exhibited a decline. Moreover, increasing the quantity of turmeric resulted in a marginal increase in soluble solids, b* index, and total phenolic compounds, while causing a reduction in antioxidant activity and overall acceptance of the samples. Furthermore, an increase in the amount of peppermint extract yielded elevated levels of turbidity, a* and b* indices, total phenolic compounds, and overall acceptance of the beverages. However, this increase also led to a decrease in soluble solids and L* index. In conclusion, the optimal composition for the sugarcane juice-based beverage consisted of 6 mL of lemon juice, 0.2 g of turmeric, and 418 µL of peppermint extract. This particular formulation demonstrated superior physicochemical properties and garnered the highest overall acceptance among the samples evaluated. Therefore, it can be recommended as a health-promoting beverage within the food industry.

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1- Introduction

Thank you from the family*Grass* And with a scientific name*Sugar factory*It is one of the major agricultural products cultivated in tropical and subtropical countries of the world. Sugarcane approximately 20percent of the world's manufactured products in 2000-2018 [1]. The two countries of Brazil and India are the largest sugarcane producers in the world with annual production of 768 and 348 million tons per year respectively [2]. However, theThe amount of sugarcane production in Iran in the 98-99 crop year is reported to be 7,750,621 million tons.[3].

Water or extract[1] Sugarcane is rich in sucrose, organic acids and minerals such as potassium, iron, sodium, calcium and magnesium. Sugarcane extract contains 80% water and 20% soluble solids, and its water activity and pH values are 0.99 and 4.6, respectively.[4].

Sugarcane juice is cloudy, prone to foam formation, and its color varies from light gray to dark green. Fresh sugarcane juice is slightly acidic and cannot be easily filtered due to its colloidal state. It can be said that the reason for the green color of sugarcane juice is the presence of iron salts and the reaction with the tannins in it. The presence of colloidal and siliceous substances such as starch, protein, wax and gum causes turbidity and gives a matte appearance to sugarcane juice [4].

Previous researches[5] showed that sugarcane juice contains sucrose, reducing sugars, mineral and organic salts, organic acids, pectin, gum, protein, color, tannin and soluble iron compounds and contains bagasse, clay, chlorophyll, wax, albumin, air and soil as It is also pending.

In addition to mineral salts such as iron, zinc, potassium, sugarcane juice contains vitamins A ،C ،B_1 ،B_2 ،B_3 ،B_5, and B_6 [4], is a large amount of plant nutrients (including chlorophyll), antioxidants [6], proteins and other compounds that play a role in maintaining health. These essential nutrients stabilize blood sugar levels, fight cancer cells, reduce weight, and prevent tooth decay [7].

Enriching this drink with other foods that are rich in bioactive compounds can improve the properties of sugarcane juice.

Turmeric is from the ginger family with a scientific name*Turmeric is long* and English name*Turmeric* It grows in tropical climates and is native to hot Asian countries, including India, Pakistan, Indonesia, southern China, and African and South American countries, and does not grow in Iran [8,9].

The color of turmeric is due to the presence of coloring substances such as curcumin, desmethoxycurcumin and bisdesmethoxycurcumin.Curcumin The effective ingredient is the rhizome of the turmeric plant(C_{12} H $_{20}$ O_6) is a lipophilic polyphenol substance that constitutes 2 to 5% of turmeric powder [8,9].

Due to the presence of polyphenolic compounds and ferulic acid, turmeric has antioxidant, antimicrobial, anti-inflammatory, anti-mutagenic and anti-platelet aggregation properties, and also has a protective and preventive effect against various diseases such as cancer, autoimmune and cardiovascular diseases [9,10].

[1]- Juice

Lime is one of the most important types of citrus fruits with a scientific name*Citrus aurantifolia* from family*Rutaceae* It has a smooth surface, a greenish-yellow color and contains a large amount of citric acid, which causes its sour taste, and it is cultivated in South Asian countries [11]. Iran ranks 10th among the lime producing countries in the world, and the amount of lime production in Iran in the crop year of 2019-1400 was reported to be 678,433 thousand tons [12,13].

Lemon is a rich source of dietary supplements containing carbohydrates, fats, proteins, vitamins such as thiamin, riboflavin, niacin, pantothenic acid, folate, choline, a rich source of vitamin C and contains trace elements such as calcium, magnesium, potassium and zinc. Lemon contains phytochemicals such as tannins, terpenes, polyphenols and flavonoids, which have antifungal, anticoagulant and anti-hypocholesterolemic effects.[2] It has been proven [14]. Lemon juice has several important chemical compounds with therapeutic properties, including citric acid, ascorbic acid and propane tricarboxylic acid. Due to its organoleptic properties, it can be used as an additive in food [11]. Mint with a scientific name*Mentha spicata*L. of the family*Lamiaceae* Is. It is a perennial herbaceous plant, stable and grafted hybrid that reproduces through budding. The mint plant is native to Europe, but it is also cultivated in most of the temperate regions of the world. It is cultivated in Iran, especially in the Alborz, North, Northeast and some other places. Mint acts as a mouth freshener and stomach reliever [15]. Among the phenolic compounds in mint, we can mention the presence of phenolic acids, tannins and flavonoids, and sesquiterpenes and monoterpenes are constituents of mint essential oil [16].

The main constituent of peppermint is a naturally occurring compound called menthol, which is a cyclic monoterpene alcohol that is beneficial to the digestive system and helps enzymes for digestion. It is also recommended for the treatment of digestive disorders, colds and muscle spasms [17].

During a research, the physicochemical, antioxidant and microbial properties of sugarcane juice containing Calamansi lemon were investigated. The results showed that the addition of Calamansi lemon juice had a significant effect on the color, pH, titratable acidity and antioxidant and microbial activity of sugarcane juice. Adding calamansi juice to sugarcane juice significantly increased the antioxidant activity of the drinks [18].

Agarkar[3] et al. [19] produced carbonated drinks based on sugarcane juice containing quinoa (Pakistani tangerine) Indian gooseberry lemon and ginger juices. The results showed that carbonated drinks at the level of 80 psi and containing 60 ppm of sodium benzoate were the best samples. The amount of photochemical compounds in the drinks containing quinoa juice, gooseberry juice, lemon juice and ginger were twice more than the control samples. And the carbonated drinks had a significant taste and overall acceptance compared to the control samples. Among food products, beverages are a suitable option for enrichment with bioactive compounds because they constitute an important part of the modern diet of human societies and countries. The aim of the current research is to produce a beneficial drink from sugarcane juice with extract formulation

[2]- hypocholestrolemic

[3]- Agarkar

Mint, lemon juice and turmeric powder and its physicochemical and sensory properties were investigated.

2- Materials and methods

2-1- Materials: Fresh sugarcane juice was obtained from Imam Khomeini Agriculture and Industry Company located 30 km south of Shushtar city in Khuzestan province in November 1401 and was immediately transferred to the laboratory of the Department of Food Science and Industry of Khuzestan University of Agricultural Sciences and Natural Resources. First, the sugarcane juice was passed through a non-porous white cloth to catch suspended particles, then it was pasteurized at 90 degrees Celsius for 10 minutes, and after cooling to 45 degrees Celsius, it was poured into clean polyethylene bottles and sealed until use. They were kept in the refrigerator. Lemon juice was prepared from fresh lemons from Ahvaz local market, whose juice was extracted by Pars Khazar juicer model-JBG-610SP. Mint extract was also purchased from Qasr Gol Company (Kashan, Iran). Turmeric powder was purchased from Bushehr local market.

2-2- Sample preparation method

Syrup samples were prepared from the combination of sugarcane juice with turmeric, lemon juice and mint extract, with lemon juice, turmeric and mint extract as three variables, respectively, at three levels of lemon juice (0, 3 and 6) ml, turmeric (0, 0.3 and 0.6).) gram and mint extract (0, 250 and 500) microliters were used (Table 1).

2-3- **pH and acidity of the sample**

The pH of the drinks was measured using a pH meter (Metrohm pH-lab-827, Switzerland) [20].

The acidity of ultra-beneficial drinks was measured according to the instructions of the Iranian national standard number 14345 [21].

2-4- Solution solids

The amount of dissolved solids was measured using a handheld refractometer (model 1a-N, Atago Co., Tokyo, Japan) at 25 degrees Celsius and the results were reported in terms of Brix [22].

2-5- Turbidity

First, the drinks were centrifuged at a speed of 1050 g for 10 minutes (Model Z206A, Hermale labortechnik GMBA) and then the absorbance of the drinks was measured using a spectrophotometer (UK, Cambridge, Biochrom, BiowaveII, WPA) in the range of 660 nm against water. Moqtar was read as a witness [23].

6-2- Color parameters

The color indices of the sugarcane syrup samples were measured using a Konica Minolta colorimeter, model 400-CR, Japan [24]. The L* index in the colorimetric system represents the level of brightness, so that zero indicates maximum darkness and one hundred indicates maximum brightness; The a* index represents the amount of greenness-redness, so that the negative range of one hundred to zero is used to express greenness and the range of zero to positive hundred is used to express the amount of redness. The b* factor also indicates the amount of blue-yellowness, which is the range from zero to minus one hundred representative of the amount of blueness and the range from zero to positive one hundred representative of the yellowness of the sample.

7-2- Measuring antioxidant power using DPPH free radical inhibition

In order to evaluate the antioxidant potential, free radical inhibition methodDPPH The method of Williams et al. [25] was used with some modifications. To perform this test, a 0.1 mM solution ofDPPH It was prepared in methanol. 3 ml of the resulting solution was added to 1 ml of the diluted sample. The resulting mixture was shaken well for 30 seconds, and after 15 to 30 minutes in the dark, the absorption of the mixture was measured with a spectrophotometer.(UK, Cambridge,Biochrom,BiowaveII,WPA) was read at a wavelength of 515 nm. And at the end of the test results based on IC_{50} It was reported.

8-2- Total phenolic compounds

To measure the phenolic compounds of the whole sample, Folin Ciocalto method was used. Based on this, 1 ml of sample with a concentration of 0.1 mg/ml was mixed with 2.5 ml of Folin-Ciocalto reagent (diluted with distilled water at a ratio of 10:1) and after 2.5 minutes at room temperature 2 ml of 7.5% sodium carbonate solution was added to it. After one hour in a dark place, the amount of light absorption at a wavelength of 725 nm by a spectrophotometer (UK, Cambridge,Biochrom,BiowaveII,WPA) was measured. And finally, using the standard curve, the activity of the sample was reported in terms of mg gallic acid equivalent [26].

2-9- Sensory evaluation

The sensory evaluation of drinks was done using a 9-point hedonic test by 10 evaluators (men and women) in the age range of 25-37 years [24]. For this purpose, the appearance color, flavor, texture and overall acceptance of the samples which were numbered in small plastic cups with three-digit random codes were evaluated and finally the overall acceptance of the samples was reported.

10-2- Statistical analysis

Statistical analysis of the samples was done using the response level method and Design Expert version 10 software. In this research, the Box Bank planBBD It was used with three independent variables at three levels and five repetitions at the central point. The levels of independent variables and the corresponding codes are listed in Table 1.

1. Random treatments of the experiment based on the independent variables in the Box-Behnken design

Treatment	Lemon juice)ml(	Turmeric)gr(	Mint extract (µl)
1	0	0	0.3
2	3	500	0.6
3	0	250	0.6
4	6	0	0.3
5	3	500	0
6	3	250	0.3
7	6	500	0.3
8	6	250	0

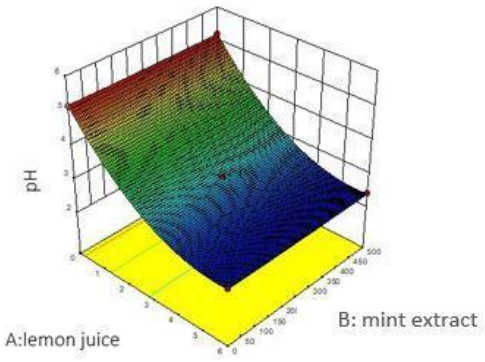
9	0	500	0.3
10	3	0	0.6
11	3	250	0.3
12	3	250	0.3
13	3	0	0
14	6	250	0.6
15	3	250	0.3
16	0	250	0
17	3	250	0.3

3. Results and Discussion

3-1- Checking the pH of the samples

The results obtained from the analysis of variance of the samples showed that the fitted quadratic model was significant ($p < 0.0001$) and the misfit index for these models was insignificant ($p < 0.05$). According to table (2), the linear and non-linear effects of lemon juice were significant at the level of ($p < 0.0001$) and the linear effect of turmeric at the level of $p < 0.05$. While the linear and non-linear effect of mint extract and the interaction effect of these three variables were insignificant ($p<0.05$).

The response surface diagrams related to the effect of independent variables on the pH and acidity of the drink were presented in Figures 1-a and 1-b. According to figures 1-a and 1-b, with the increase in the amount of lemon juice, the pH value in the samples decreased and its range varied between 2-5, this can be attributed to the acidic nature of lemon juice, in other words, lemon juice contains a large amount of ascorbic acid. and citric acid, both of which are weak acids and help reduce the pH of most samples [27]. The results of this research were consistent with the observations and Chauhan et al. (2014) [28]. Also, Adrenola (2018) [29] investigated the effect of lemon juice on the physicochemical and antioxidant properties of the smoothie, and the results showed that the decrease in pH depends on the acidic nature of the lemon juice and fruits.



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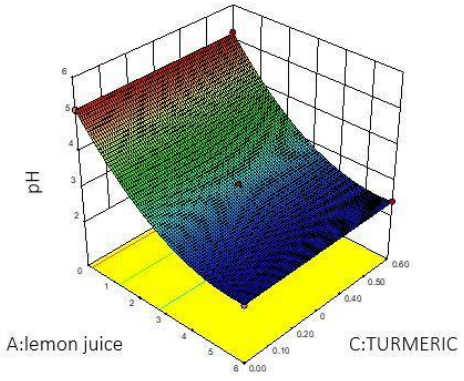

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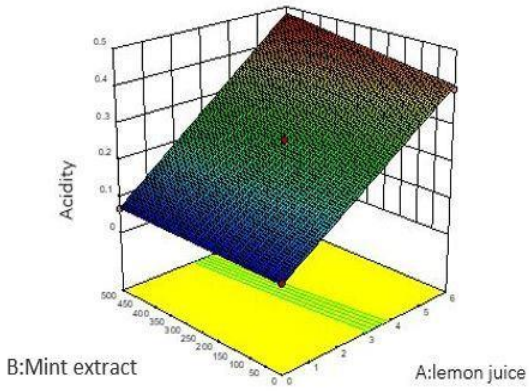
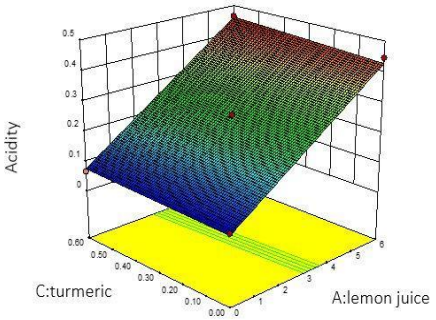


A

Fig 1- Effect of turmeric, lemon juice & mint extract on the pH values of sugar cane juice.

3-2- Examining changes in acidity

Table 2 shows the results of the acidity level of the drink. According to the data in Table 2, the model proposed by R^2 And adj))R^2 It had proportional and significant predictive power. These results show that the fitted quadratic model was significant ($p<0.0001$) and the misfit index for these models was not significant ($p<0.05$). According to the analysis of variance results in Table 1, the linear effect of lemon juice, turmeric and mint extract were significant at ($p<0.0001$), ($p<0.05$) and ($p<0.001$) levels, respectively. Also, the interaction between lemon juice and mint extract was significant ($p < 0.01$). By examining the graphs of the response surface in Figure 2-a and 2-b, it can be said that increasing the amount of lemon juice has increased the amount of acidity in the samples. This was a confirmation of the decrease in the pH of the samples, which may be due to the acidic nature of lemon juice [30]. In other words, there was an inverse relationship between pH and acidity, which was consistent with the results of other researchers' researches [32-31].



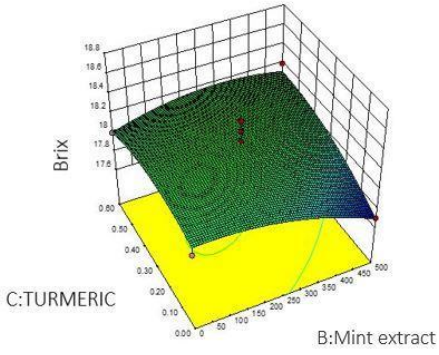
B

Fig 2- Effect of turmeric, lemon juice & mint extract on the total titratable acidity of sugar cane juice.

3-3- Soluble solids (Brix)

The change of solids dissolved in water is shown in Table 2. According to the results estimated from the analysis of variance, lemon juice had a significant linear effect ($p<0.05$) on the samples. Also, the quadratic model fitted for the response of solids dissolved in water was not significant ($p<0.05$) and the misfit index for this model was not significant ($p<0.05$). It is worth noting that the quadratic effect of lemon juice, linear and non-linear and interaction of other variables was not significant. By examining the graph of the response level (Figure 3), it can be said that Brix decreases

with increasing the amount of lemon juice. It can be said that due to the fact that sugarcane juice contains protein [33], the pH decreases with the increase in the amount of lemon juice, and upon reaching the isoelectric point, it causes protein precipitation, which ultimately decreases the Brix of the samples.



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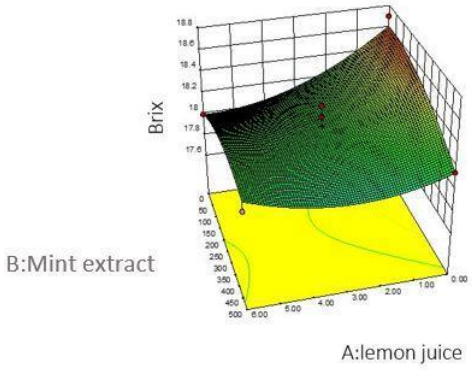

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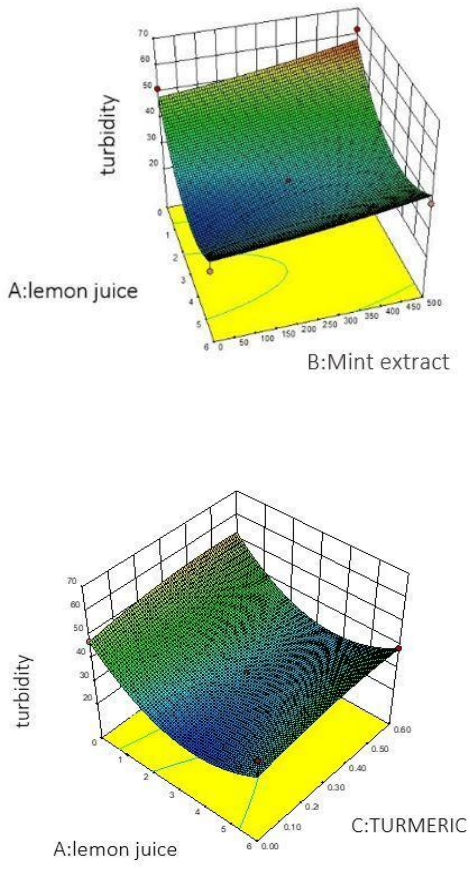
Fig 4- Effect of turmeric, lemon juice & mint extract on the total soluble solids of sugar cane juice

3-4- Turbidity

Existence of values*p*-value less than 0.05 indicates the appropriateness of the proposed model in this research R^2 and R^2adj And it was meaningful. By examining the data of the analysis of variance table, the fitted model for this response was significant ($p<0.05$) and the misfit index for this parameter was insignificant ($p<0.05$). Also, the linear effect of lemon juice is positive and significant at ($p<0.01$), ($p<0.05$) and ($p>0.001$), respectively, and the linear and non-linear effect of turmeric, the non-linear effect of mint extract and their interaction.

positive but not significant ($p<0.05$). Examining the graphs of the response surface in Figure 4 shows that increasing the amount of lemon juice and mint extract in the drink caused an increase in turbidity. Also, the increase of lemon juice decreased the turbidity of the drink and then increased it. This was probably attributed to the presence of ascorbic acid in lemon juice and its reactivity, which was consistent with the results of Alaswar and Kam (2020) [34].



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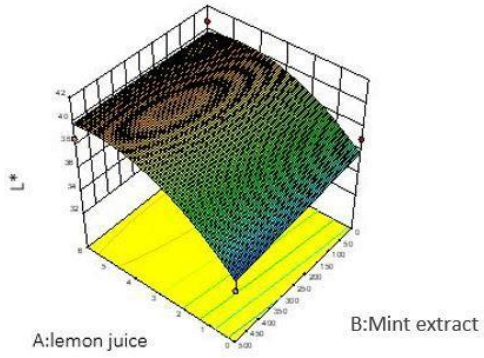
B

Fig 5- Effect of turmeric, lemon juice & mint extract on the turbidity of sugar cane juice

5-3- Color parameters

Color is the most important attribute that affects the acceptance of food products by consumers [35]. Examining changes in indicators b^*،a^* ،L^* It is shown in the analysis of variance table 3. Based on the results, the model proposed in this research for b^*،a^*،L^* From R^2 and R^2adj It has been relevant and meaningful. Also, the fitted model for b indices*،a^*،L^* It is significant at ($p<0.0001$) and ($p>0.05$) levels, respectively, and the misfit index for them is positive but not significant ($p<0.05$). Also, check the table of results of analysis of variance for the answer L^* It showed that the linear and non-linear effects of lemon juice were significant at ($p<0.01$) and ($p>0.05$) levels, respectively, but the linear and non-linear effects of other variables and their interaction were not significant. By examining Figure 5-a, 5-b, it can be said that with the increase of lemon juice, the amount of brightness index of the drink increased and the increase of the amount of mint extract caused a slight decrease in the brightness of the drink. Also, when turmeric is in the lowest amount and lemon juice is in the highest amount, the brightness of the product is at its highest. This may be due to the deposition of flavonoids and other compounds in lemon juice, which was consistent with the research of Molina et al., 2009 [36].* It shows that the linear effect of mint extract and the interaction effect of lemon juice and mint extract are positive and significant at ($p<0.05$), while the linear and non-linear effect of the other two variables and their interaction were not significant. In other words, when mint extract is at its highest amount and lemon juice is at its lowest amount, the index a^* It is at its maximum value. According to the results estimated from the analysis of variance table 3, the amount of index b^*, the linear effect of lemon juice, mint extract and turmeric and the interaction effect of extract and turmeric at the positive and significant

level ($p < 0.0001$) and the nonlinear effect of lemon juice, turmeric and mint respectively at the levels ($p < 0.001$) and ($p < 0.001$) $p>0$) became significant. Also, the interaction effect of the variables was not significant. Examining the chart of response level of index b^* It shows that in general, increasing the amount of lemon juice, mint and turmeric extract increases the b index.* Examples will be.



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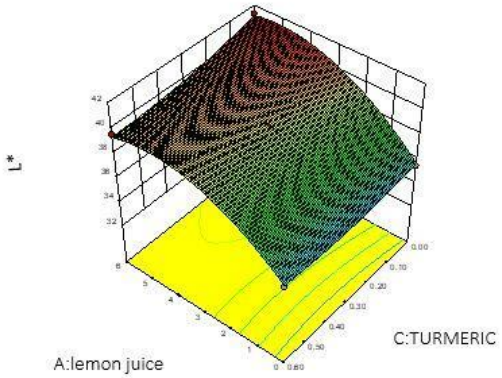

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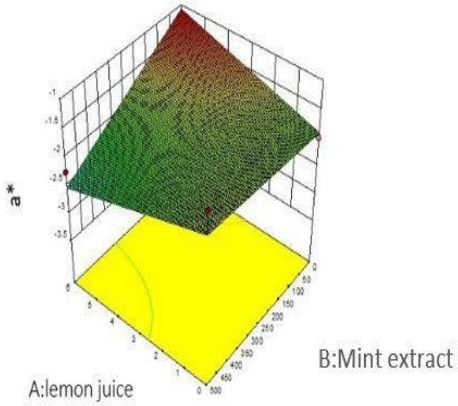

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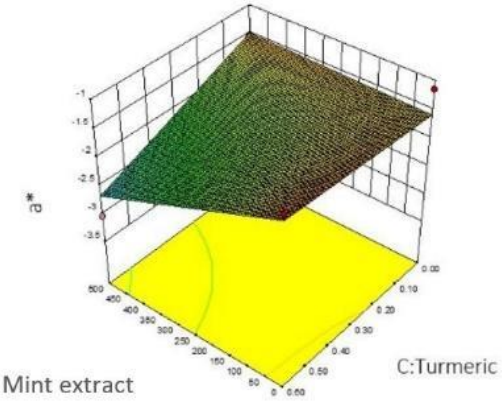

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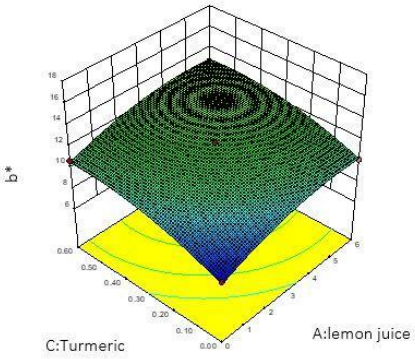

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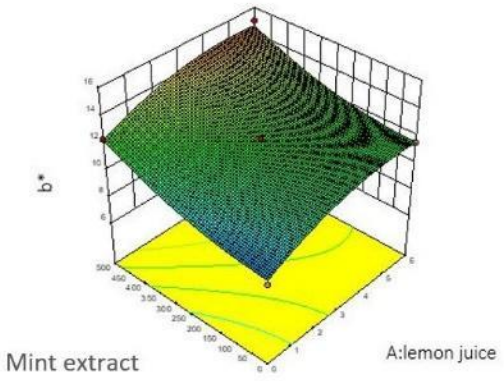


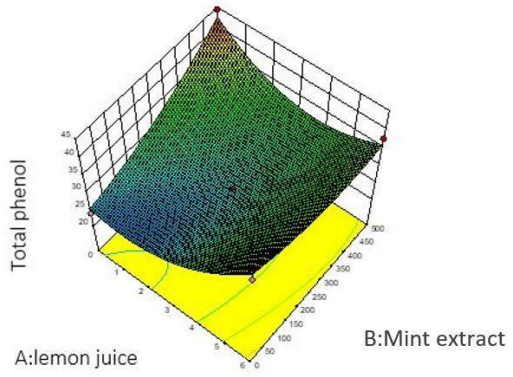
F

Fig 6- Effect of turmeric, lemon juice & mint extract on the color indices of sugar cane juice

3-6- total phenolic compounds

The results of statistical analysis of total phenolic compounds are given in table 4 of analysis of variance. Proposed model for total phenolic compounds from R^2 and R^2adj has been high and significant. The fitted model was significant ($p < 0.01$) and the misfit index was insignificant ($p < 0.05$). Also, the linear effect of mint extract, the quadratic effect of turmeric at the level of $p<0.05$, the interaction effect of lemon juice - mint extract and the quadratic effect of lemon juice were positive and significant at the level of ($p<0.01$). While the linear effect of lemon juice and turmeric, the quadratic effect of lemon juice and mint extract, and the interaction effect of lemon juice - mint extract and turmeric - mint extract were positive and non-significant. According to Figure 6, as it is clear, with the increase of lemon juice and mint extract, an increase in the amount of phenolic compounds of the whole drink is observed. Also, the amount of turmeric in the range of 0.1-0.4 had an increasing effect on the amount of total phenolic compounds. Lemon fruit contains strong bioactive compounds including phenolic compounds [37]. Xi et al. (2017) stated in a research that lemon peel and fruit have a high amount of phenolic compounds [38].

The results of the research of Gatuz et al. (2007) showed that lemon juice contains significant amounts of phenolic compounds from flavonones, hesperidin. It is possible that the increase in the amount of total phenolic compounds is due to the presence of bioactive compounds in lemon juice [39].



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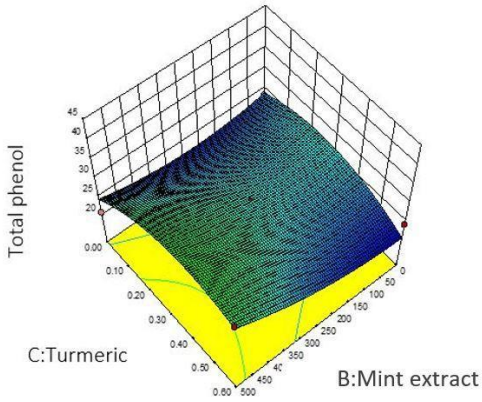
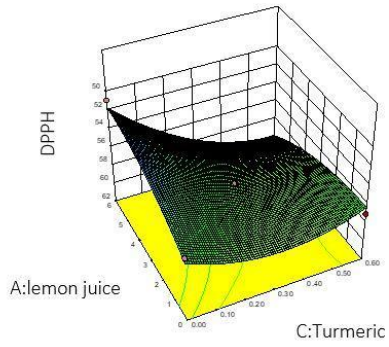


B

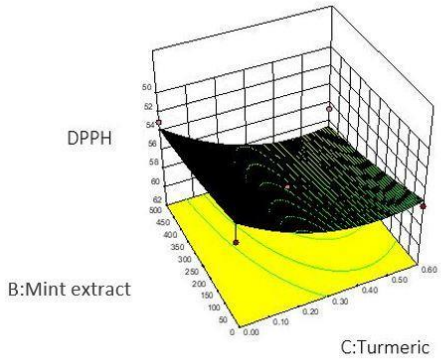
Fig 7- Effect of turmeric, lemon juice & mint extract on the total phenolic content of sugar cane juice

7-3- Antioxidant power using DPPH free radical inhibition

According to the analysis of variance table 4, the fitted model for the free radical inhibitory property was significant at the $p<0.05$ level and the misfit index was insignificant at the $p<0.05$ level. Also, the linear effect of mint extract, the interaction effect of lemon juice-turmeric, and the quadratic effect of turmeric were significant at the $p<0.05$ level, and the linear effect of turmeric was significant at the $p<0.01$ level. On the other hand, the linear effect of lemon juice, the interaction effect of lemon juice - mint extract, mint extract - turmeric, the quadratic effect of lemon juice and mint extract were not significant. Based on Figure 7, in higher concentrations of lemon juice, the effect of higher amounts of turmeric on reducing antioxidant activity is intensified. But by increasing the amount of lemon juice, the radical absorption power of drinks increases. This increase may be due to the high amount of vitamin C in lemon juice [29]. which was consistent with the results of previous researchers [27].



A

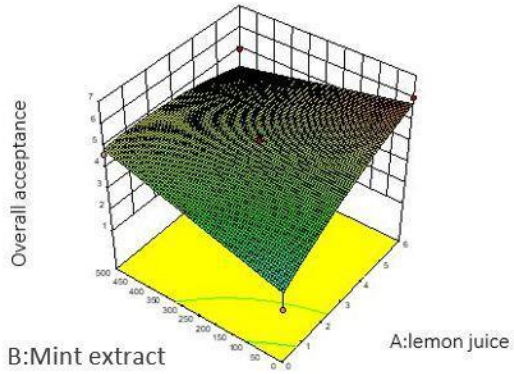


B

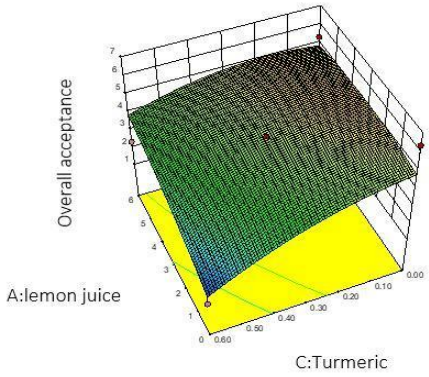
Fig 8- Effect of turmeric, lemon juice & mint extract on the DPPH radical scavenging ability of sugar cane juice

3-8- Sensory evaluation

According to the results of variance analysis of general acceptance shown in Table 4, the proposed model of R^2adj and R^2 It is relevant and meaningful. And their fit test was significant ($p<0.05$), while their non-fit test was meaningless ($p<0.05$). Also, the linear and non-linear effect of lemon juice, the linear effect of turmeric, the non-linear effect of mint extract and the interactive and non-linear effect of lemon juice and mint extract respectively at the levels ($p<0.01$), ($p<0.001$) and ($p>0.05$) has become significant, while the linear effect of mint extract, the quadratic effect of turmeric, the interaction effect of lemon juice-turmeric and mint-turmeric extract were not significant. The response level diagram of the overall acceptance of the samples shows that increasing the amount of lemon juice and mint extract increased the overall acceptance of the samples. In other words, when the amount of turmeric in the drink was reduced, an increase in overall acceptance was observed in the samples.



A



B

Fig 9- Effect of turmeric, lemon juice & mint extract on the overall acceptance of sugar cane juice

4- Optimization of beverage formulation

In order to optimize the beverage formulation based on sugarcane juice, all the measured parameters were considered. And according to the obtained results, optimization was done. Table 5 shows the optimal values of the responses.

Table 2. Analysis of variance (ANOVA) for turbidity, Brix, acidity and pH of sugarcane juice

Turbidity	Brix	Acidity	pH	Source
0.0118^{*}	0.0475^{*}	$< 0.0001^{****}$	$< 0.0001^{****}$	Model (p-value)
0.0078^{**}	0.0245^{*}	$< 0.0001^{****}$	$< 0.0001^{****}$	A- Lemon juice
0.0438^{*}	0.2142^{ns}	0.0005^{***}	0.8869^{ns}	B- Extract
0.2206^{ns}	0.1257^{ns}	0.0130^{*}	0.0328^{*}	C- Turmeric
0.8930^{ns}	0.0564^{ns}	0.0080^{**}	0.6891^{ns}	AB
0.9782^{ns}	1.0000^{ns}	0.4801^{ns}	0.8408^{ns}	AC
0.0636^{ns}	0.1225^{ns}	0.9643^{ns}	0.0555^{ns}	BC
0.0009^{***}	0.0590^{ns}	-	$< 0.0001^{****}$	A^2
0.7403^{ns}	0.1307^{ns}	-	0.2401^{ns}	B^2
0.4276^{ns}	0.1695^{ns}	-	0.8367^{ns}	C^2
$< 0.091^{ns}$	0.6701^{ns}	0.37^{ns}	0.1057^{ns}	Lack of fit
0.8906	0.8169	0.9959	0.9998	R^2
0.7499	0.7814	0.9934	0.9995	Adj-R^2

10.21	4.26	0.71	CV (%)

*Significant at p<0.05, **Significant at p<0.01, ***Significant at p<0.001, ****Significant at p<0001, nsNot significant

Table 3. Analysis of variance (ANOVA) for L*, a*& b*

b^*	a^*	L^*	Source
$< 0.0001^{****}$	0.0238^{*}	0.0198^{*}	Model (p-value)
$< 0.0001^{****}$	0.8848^{ns}	0.0007^{***}	A- Lemon juice
$< 0.0001^{****}$	0.0219^{*}	0.4775^{ns}	B- Extract
$< 0.0001^{****}$	0.0508^{ns}	0.2512^{ns}	C- Turmeric
0.8605^{ns}	0.0205^{*}	0.5749^{ns}	AB
0.6876^{ns}	0.6492^{ns}	0.5121^{ns}	AC
$< 0.0001^{****}$	0.0540^{ns}	0.6051^{ns}	BC
0.0003^{***}	-	0.0118^{*}	A^2
0.0014^{**}	-	0.9210^{ns}	B^2
0.0003^{***}	-	0.4952^{ns}	C^2
0.801^{ns}	0.091^{ns}	0.0701^{ns}	Lack of fit
0.9913	0.7929	0.8711	R^2
0.9801	0.7406	0.7054	Adj-R^2
2.36	12.38	3.03	CV (%)

*Significant at p<0.05, **Significant at p<0.01, ***Significant at p<0.001, ****Significant at p<0001, nsNot significant

Table 4. Analysis of variance (ANOVA) for Overall acceptance, Total phenol, Antioxidant activity

Overall acceptance	Antioxidant activity	Total phenol	Source
0.0015^{**}	0.0258^{*}	0.0061^{**}	Model (p-value)
0.0032^{**}	0.8454^{ns}	0.0560^{ns}	A- Lemon juice
0.4737^{ns}	0.0278^{*}	0.0273^{*}	B- Extract
0.0001^{***}	0.0046^{**}	0.4843^{ns}	C- Turmeric
0.0315^{*}	0.1420^{ns}	0.0063^{**}	AB
0.4473^{ns}	0.0366^{*}	0.0521^{ns}	AC

0.1514^{ns}	0.7365^{ns}	0.1234^{ns}	BC
0.0037^{**}	0.2244^{ns}	0.0021^{**}	A^2
0.0234^{*}	0.6352^{ns}	0.1331^{ns}	B^2
0.8892^{ns}	0.0314^{*}	0.0133^{*}	C^2
0.11^{ns}	0.0671^{ns}	0.091^{ns}	Lack of fit
0.9416	0.8598	0.9111	R^2
0.8666	0.6795	0.7967	Adj-R^2
8.35	2.66	10.08	CV (%)

*Significant at p<0.05, **Significant at p<0.01, ***Significant at p<0.001, ns Not significant

Table 5. physicochemical properties and overall acceptance of the selected formulations of sugarcane juice

lemon juice (ml)	Extract (µl)	turmeric (gr)	pH	Brix	Acidity	TU	L*	a*	b*	Phenol	DPPH	Overall acceptance	
6.000	418.329	0.221	2.374	18.169	0.465	39.943	40.212	-2.138	13.185	35.500	58.166	4.441	Selected

5. Conclusion

Sugarcane juice has various nutrients and antioxidants that can be enriched with other substances to increase its nutritional value, flavor and pleasant properties. The addition of lemon juice increased acidity, brightness, amount of total phenolic compounds, antioxidant activity and overall acceptance of drinks. Mint extract also had an increasing effect on total phenolic compounds and antioxidant activity of beverages. Turmeric increased the amount of total phenolic compounds while decreasing the antioxidant activity and overall acceptance of the samples. And finally, the optimal formulation conditions were obtained with 6 ml of lemon juice, 0.2 grams of turmeric and 418 microliters of mint extract.

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7- Resources

[1] Zheng, Y., Dos Santos Luciano, A. C., Dong, J. & Yuan, W. (2022). High-resolution map of sugarcane cultivation in Brazil using a phenology-based method. *Earth System Science Data*, 14(4), 2065-2080.

[2]Thibane, Z., Soni, S., Phali, L. & Mdoda, L. (2023). Factors impacting sugarcane production by small-scale farmers in kwazulu-Natal Province-South Africa. *Hellion*, 9(1), 1-8.

[3]Iran Ministry of Agriculture-Jahad. Technology and Information and Communication Center of the Ministry of Agricultural Jihad Agricultural Statiatics. Volume 3 2020(.19- https://maj.ir/Dorsapax/userfiles/Sub65/amar99-1400.pdf

[4] Kaavya, R., Pandiselvam, R., Kothakota, A., Banuu Priya, E. P., & Arun Prasath, V. (2019). Sugarcane juice preservation: A critical review of the state of the art and way forward.*Sugar Tech*, 21, 9-19.

[5] Chen, J.C.P. & C.C. Chou.)1993(. CaneSugar handbook, a manual for cane sugars manufacturers & their Chemists. New York: Willey, 401–403.

[6] Singh, A., Lal, U. R., Mukhtar, H. M., Singh, P. S., Shah, G. & Dhawan, R. K. (2015). Phytochemical profile of sugarcane and its potential health aspects. *Pharmacognosy Reviews*, 9(17), 45-54.

[7] Singh, S. U. M. A. N., Gaikwad, K., & More, P. K. (2014). Spoilage of sugarcane juice a problem in sugarcane industry. *International Journal of Agricultural Engineering*, 7(1), 259-263.

[8] Fallah Hosseini., H., Zahtekash, M. & Haghighi, M (2009).A review on pharmacological effects of *Turmeric is long* L. (Turmeric). *Journal* of *Medicinal Plants*, 9(33), 1-15. (In Farsi).

[9] Kocaadam, B. & Şanlier, N. (2017). Curcumin, an active component of turmeric (*Turmeric is long*), and its effects on health. *Critical Reviews in Food Science and Nutrition*, 57(13), 2889-2895.

[10] Soleimani, V., Sahebkar, A., & Hosseinzadeh, H. (2018). Turmeric (*Turmeric is long*) and its major constituent (curcumin) as nontoxic and safe substances. *Phytotherapy Research*, 32(6), 985-995.

[11] Cruz-Valenzuela , M. R. , Tapia-Rodriguez , M. R. , Vazquez-Armenta , F. J. , Silva-Espinoza , B. A. , & Ayala-Zavala , J. F. (2016). Lime (*Citrus aurantifolia*) oils. In *Essential Oils in Food Preservation, Flavor and Safety*. Academic Press, 531-537.

[12] FAOSTAT: Food and Agriculture Organization of the United Nations (FAO): FAO

Statistical Databases., (2021). https://www.fao.org/faostat/en/#data/QCL/visualize.

[13] Iran Ministry of Agriculture-Jahad. Technology and Information and Communication Center of the Ministry of Agricultural Jihad. Agricultural Statiaticsc. Volume 3 .(2021).-17
https://maj.ir/Dorsapax/userfiles/Sub65/amarbaghi (1400).pdf.

[14] Sarfaraz, S., Sarwar, G., Fatima, W., Ramzan, S., Amjad, R., Tareen, R., & Irfan, S. (2015). Evaluation of diuretic potential of lemon juice and reconstituted lemon drink. *World Journal of Pharmaceutical Research*, *4*(7), 254-9.

[15] Abdolmaleki, A., Rajabi, A & .Sanginabadi, F. (2013). Evaluation of the analgesic and anti-inflammatory effects of aqueous extract of peppermint (*Mentha piperita*). *Scientific Journal of Kurdistan University of Medical Sciences.* 18 (1), 67-74. (In Farsi).

[16] Imran, A., Quispe, C., Zeeshan, A., Imran, M., Nadeem, M., Gilani, S. A., & Cruz-Martins, N. (2021). Development and antioxidant characterization of Ginger-Mint drink prepared through different extraction techniques. *Journal of Food Measurement and Characterization*, 15, 2576-2590.

[17] Swarnalakshmi, C. S., Manisha, C. P., Harini, B., Akshara, J., Joshika, G., & Keerthana, R. (2019). Optimization and standardization of lemon grass incorporated into pseudostem and mint extracts based isotonic drink. *International Journal of Advance Research, Ideas and Innovation in Technology*, *5*(3), 1089-1093.

[18] Noor, N. A. M., Murad, M., & Esah, E. M. (2018). Physicochemical, antioxidant and microbial properties of fresh black stem sugarcane juice with addition of calamansi juice. *Malaysian Science*, *47*(09), 2047-2054.

[19] Agarkar, B. S., Aggarwal, P., & Yaqoob, M. (2019). Preparation of carbonated sugarcane juice beverages blended with fruit juices. *Agricultural Research Journal*, *56*(1), 124-133.

[20] Arshad, M. K., Fatima, I., Ahmad, W., Ellahi, S., Mumtaz, M., Akhtar, M. U., & Siddique, W. A. (2023). Mint (Mentha): A herb and used as a functional ingredient. *Scholars Intermatlonal Journal of Traditional and Complementary Medicine* , *6*(3), 38-52.

[21] Iranian National Standard "Fruit juices, fruit nectars and carbonated fruit drinks - characteristics and test methods" No. 14345

[22] Hojjati b, M., Jafari, S. & Noshad, M. (2018). Effect of Xanthan Gum and Soluble Soybean Polysaccharide on Functional Characteristics of Flixweed (*Descurainia Sophi* L.) Syrup. *Journal of Food Processing and Preservation*, 10(2), 63-80. (In Farsi).

[23] Dehghan, B., & Raftani Amiri, Z. (2022). Evaluation of the effect of green tea extract on probiotic survival in Pinacolada drink based on whey under simulated gastric and intestinal conditions. *Journal of food science and technology (Iran)*, *19*(122), 115-127. (In Farsi).

[24] Holkem, A. T., Neto, E. J. S., Nakayama, M., Souza, C. J., Thomazini, M., Gallo, F. A., & Favaro-Trindade, C. S. (2020). Sugarcane juice with co-encapsulated

Bifidobacterium animal subsp. lactis BLC1 and proanthocyanidin-rich cinnamon extract. *Probiotics and Antimicrobial Proteins*, (12), 1179-1192.

[25] Brand-Williams, W., Cuvelier, M. E., & Berset, C. L. W. T. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food Science and Technology*, *28*(1), 25-30.

[26] Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American journal of Enology and Viticulture*, *16*(3), 144-158.

[27] Livia, N. (2023). Analysis of the addition of soda and lime juice towards the antioxidant activity, pH, Brix, Color, and sensorial property of sparkling butterfly pea beverage. *i3L – Indonesia International Institute for Life Sciences*, 18-22.

[28] Chauhan, O. P., Archana, B. S., Singh, A., Raju, P. S., & Bawa, A. S. (2014). A refreshing beverage from mature coconut water blended with lemon juice. *Journal of food science and technology*, 51, 3355-3361.

[29] Aderinola, T. A. (2018). Effects of pumpkin leaves on the chemical composition and antioxidant properties of smoothies. *Abstract Retrieved From Proceedings of the 4th Regional Food Science and Technology Summit (Refosts) Akure, Ondo State Nigeria Akure*, 281-287.

[30] Xu, G., Liu, D., Chen, J., Ye, X., Ma, Y., & Shi, J. (2008). Juice components and antioxidant capacity of citrus varieties cultivated in China. *Food Chemistry*, *106*(2), 545-551.

[31] Wang, S., Lin, T., Man, G., Li, H., Zhao, L., Wu, J., & Liao, X. (2014). Effects of anti-browning combinations of ascorbic acid, citric acid, nitrogen and carbon dioxide on the quality of banana smoothies. *Food and Bioprocess Technology an International Journal*, 7, 161-173.

[32] Castillejo, N., Martínez-Hernández, G. B., Gómez, P. A., Artés, F., & Artés-Hernández, F. (2016). Red fresh vegetables smoothies with extended shelf life as an innovative source of health-promoting compounds.*Journal of food science and technology*, *53*, 1475-1486.

[33] Arif, S., Batool, A., Nazir, W., Khan, R. S., & Khalid, N. (2019). Physiochemical characteristics nutritional properties and health benefits of sugarcane juice. In *Non-Alcoholic Beverages.* Woodhead Publishing, 227-257.

[34] Alaşalvar, H., & Çam, M. (2020). Ready to drink iced teas from microencapsulated spearmint (*Mentha spicata* L.) and peppermint (*Mentha piperita* L.) extracts physicochemical, bioactive and sensory characterization. *Journal of Food Measurement and Characterization*, *14*(3), 1366-1375.

[35] Eyidemir, E., & Hayta, M. (2009). The effect of apricot kernel flour incorporation on the physicochemical and sensory properties of noodle. *African Journal of Biotechnology*, *8*(1), 85-90.

[36] Gonzalez-Molina , E. , Moreno , D. A. , & Garcia-Viguera, C. (2009). A new drink

rich in healthy bioactives combining lemon and pomegranate juices. *Food Chemistry*, 115(4), 1364-1372.

[37] Dong, X., Hu, Y., Li, Y., & Zhou, Z. (2019). The maturity degree, phenolic compounds and antioxidant activity of Eureka lemon [Citrus limon (L.) Burm. f.]: A negative correlation between total phenolic content, antioxidant capacity and soluble solid content. *Science of Horticulture*, *243*, 281-289.

[38] Xi, W., Lu, J., Qun, J., & Jiao, B. (2017). Characterization of phenolic profile and antioxidant capacity of different fruit part from lemon (*Citrus limon* Burm.) cultivars. *Journal of Food Science and Technology*, *54*, 1108-1118.

[39] Gattuso, G., Barreca, D., Gargiulli, C., Leuzzi, U., & Caristi, C. (2007). Flavonoid composition of citrus juices.*Molecules*, *12*(8), 1641-1673.

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بررسی ویژگی‌های فیزیکوشیمیایی نوشیدنی فراسودمند برپایه آب نیشکر

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چکیده

اکثر مصرف‌کنندگان تمایل به استفاده از رژیم های سلامت بخش و فراسودمند در برنامه غذایی روزانه خود دارند. در بین محصولات غذایی، نوشیدنی‌ها گزینه مناسبی جهت غنی‌سازی با ترکیبات زیست فعال هستند. آب نیشکر یک نوشیدنی شیرین و انرژی‌زا بوده که در سال‌های اخیر به‌دلیل ارزش تغذیه ای مورد توجه قرار گرفته است. پژوهش حاضر، به‌منظور بررسی ویژگی‌های فیزیکوشیمیایی، حسی و در نهایت بهینه‌یابی فرمولاسیون نوشیدنی فراسودمند برپایه‌ی آب نیشکر انجام شد. بدین‌منظور فرمولاسیون این نوشیدنی شامل آبلیمو (۰، ۳ و ۶) میلی‌لیتر، زردچوبه (۰، ۰/۳ و ۰/۶) گرم و عصاره‌ی نعنا (۰، ۲۵۰ و ۵۰۰) میکرولیتر در هر ۱۰۰ میلی‌لیتر آب نیشکر به‌وسیله‌ی روش سطح پاسخ و در قالب طرح باکس بنکن بهینه‌سازی شد. که مقادیر pH، اسیدیته، مواد جامد محلول، کدورت، شاخص‌های رنگ، فعالیت آنتی‌اکسیدانی، ترکیبات فنولی و پذیرش‌کلی متغیرهای وابسته‌ی این پژوهش هستند. نتایج نشان دادند که با افزایش مقدار آبلیمو، مقادیر اسیدیته، کدورت، شاخص L^*، شاخص b^*، ترکیبات فنولی کل، فعالیت آنتی‌اکسیدانی و پذیرش کلی افزایش یافتند درحالی‌که pH، مواد جامد محلول و شاخص a^* کاهش پیدا کردند. همچنین با افزایش مقدار زردچوبه، در میزان مواد جامد محلول، شاخص b^* و ترکیبات فنولی کل افزایش ناچیزی مشاهده گردید اما فعالیت آنتی‌اکسیدانی و پذیرش کلی نمونه‌ها کاهش یافته بود. افزایش میزان عصاره‌ی نعنا باعث افزایش در کدورت، شاخص a^* و b^*، ترکیبات فنولی کل و پذیرش کلی نوشیدنی‌ها گردید درحالی‌که باعث کاهش مقادیر مواد جامد محلول و شاخص L^* شد. در پایان نوشیدنی آب نیشکر حاوی ۶ میلی‌لیتر آبلیمو، ۰/۲ گرم زردچوبه و ۴۱۸ میکرولیتر عصاره‌ی نعنا دارای بهترین خواص فیزیکوشیمیایی و بالاترین پذیرش کلی بود که می‌تواند به‌عنوان یک نوشیدنی سلامت‌بخش در صنعت پیشنهاد شود.