

Research Article

Physicochemical and Sensory Parameters of Vegan Water Kefir Beverages Fermented with Different Fruits

Suzan Tireki

Department of Gastronomy and Culinary Arts, Ozyegin University, Istanbul, 34794, Turkey, Orcid ID:
<https://orcid.org/0000-0002-7424-7378>, E-mail: suzan.tireki@ozyegin.edu.tr

(First received October 12, 2022 and in final form December 25, 2022)

Reference: Tireki, T. Physicochemical and sensory parameters of vegan water kefir beverages fermented with different fruits. *The European Journal of Research and Development*,2(4), 1–12.

Abstract

Fermented foods have drawn the attention of the consumers due to their health advantages particularly after Covid-19 pandemic. Water kefir is one of these fermented foods which is produced by fermenting water-based solution containing sugar source, fruits and/or vegetables with water kefir grains. It is a slightly fizzy and sour beverage with low sugar fruity taste satisfying the needs of consumers who are vegan or having lactose intolerance/sensitivity. Although there are many fruit/vegetable alternatives that can be used in water kefir, figs are stated to be the most used and popularity is not understood fully. Therefore, in this study water kefir was produced with different fruits, namely fig, apricot, peach, mulberry and grapes and the effects on physicochemical properties during fermentation of 3 days were studied. Sensory analysis of beverages made with both dried and fresh peach, apricot and grapes was carried out to see the impact of the use of dried form. pH decreased for all samples and brix increased for all beverages except the one prepared with dried mulberry. L value increased, b* value decreased for all samples and a* value decreased for the samples with dried figs, dried peach, dried grapes and fresh peach, increased for the one fermented with fresh grapes and remained same for the other beverages. Water kefir drinks made with fresh grapes, dried peach and dried apricot had the top three scores for color; samples with fresh grapes, dried peach and fresh apricot had the top three scores for smell; beverages with dried grapes, fresh grapes and fresh apricot had the top three scores for mouthfeel; samples with fresh and dried grapes and fresh apricot had the top three scores for taste; kefirs with fresh and dried grapes and fresh apricot had the top three scores for carbonation and water kefirs prepared with fresh fruits had the highest rankings for preference.*

Keywords: Water Kefir, Fermented Beverage, Vegan, Sensory Analysis

1. Introduction

Consumers have prioritized their health more since Covid-19 pandemic, which has increased demand for foods and beverages that strengthen the immune system.

Fermented products are one of the product categories that has drawn the attention of the consumers [1] with anti-oxidant, anti-carcinogenic, anti-diabetic, anti-microbial, anti-inflammatory and probiotic properties [2]. Water kefir is one of these fermented products and this artisanal beverage is produced by fermenting a water-based solution containing sugar source, fruits and/or vegetables with water kefir grains [3]. It is a slightly fizzy, sour, acidic beverage with low sugar fruity taste [3] satisfying the needs of consumers who are having lactose intolerance/sensitivity or vegan [2].

Water kefir grains contain yeasts, acetic acid bacteria, and lactic acid bacteria in a relationship which is stable and symbiotic [4]. There are more genera of yeast in water kefir grains with respect to milk kefir grains [5]. The unique taste and flavor of water kefir depends on the diversity and symbiotic activity of the microorganisms in the grains [6]. Water kefir grains have 5-20 mm diameter with gelatinous structures and irregular cauliflower like shapes [7] and they are whitish to gray, however, color can be affected by the color of fruits and vegetables used in the beverage [5]. These grains are recoverable after the fermentation process and may be re-used for the following kefir preparation [8].

In water kefir production, sucrose is used as carbon source and fresh or dried fruits and vegetables are used as nitrogen source. Although there are many carbon and/or nitrogen sources such as grapes, strawberry, apple, carrot and onion that can be involved in water kefir, yet fresh or dried figs appear to the most commonly used. It is not fully known why they are the most popular fruit [7]. There is a growing request from the consumers for products with health advantages in the food industry [6]. Therefore, in this study it was aimed to produce water kefir beverages with different fruits, which are figs, apricot, peach, mulberry and grapes and the impacts on physicochemical characteristics (pH, brix, color) during fermentation of three days were investigated. This article also addressed the effect of the fruit form-fresh or dried- used in fermentation by studying the physicochemical parameters accompanied with sensory analysis of the beverages.

2. Materials and Methods

Sucrose, bottled water, dried figs, fresh and dried apricot, fresh and dried peach, dried mulberry and fresh and dried grapes were purchased from a local market in Istanbul, Turkey. Water kefir grains were obtained from Etik Farma, Istanbul, Turkey.

Properties of the water used in the experiments were retrieved from the label of the product and given in Table 1. Moisture contents of the dried fruits were estimated from the nutrition labels and shown in Table 2 together with the other nutrients information coming from the labels and the literature.

Table 1: Water properties

Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Iron (mg/L)	pH
32.2	4.2	0.2	5.4	0.007	7.34

Table 2: Nutrient composition of the commercial dried fruits

Dried Fruit	Grapes	Apricot	Figs	Mulberry	Peach
Moisture Content (%) (Estimated)	12.7	27.8	7.0	9.2	4.1
Carbohydrates (g/ 100g)	77.0	61.0	72.7	77.7	83.0
Proteins (g/ 100g)	3.0	3.3	7.2	2.8	6.3
Calcium (mg/ 100g)	50.0*	55.0*	195.0	-	-
Magnesium (mg/ 100g)	-	-	-	112.0	-
Iron (mg/ 100g)	-	-	-	5.9	-

*: Data retrieved from literature [7]

2.1. Water Kefir Production

Water kefir beverages were produced with 60 g sucrose, 40 g fruit, 15 g water kefir grains in 1 liter of water. Figure 1 shows the production of water kefir beverages in the experiments. Firstly, sugar is mixed water and water kefir grains and fruits added to the slurry and mixed gently. Then, samples left for fermentation for 3 days at ambient temperatures in the range of 25-28°C. After fermentation, the beverage was filtered, bottled and stored for 1 day at 4°C in glass bottles for the sensory analysis part of the study.

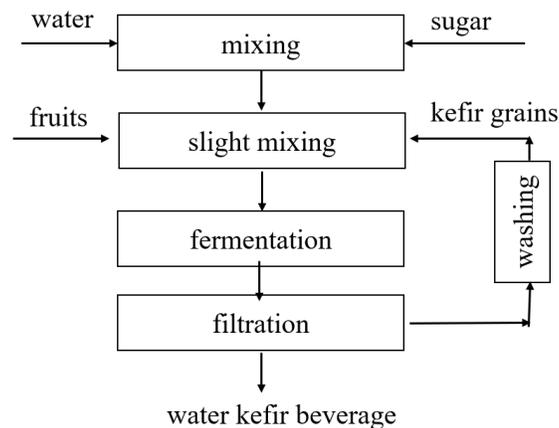


Figure 1: Water kefir preparation

2.2. Physicochemical Measurements

pH of the beverages during fermentation was measured with a pHmeter (Adwa AD12, Szeged, Hungary) and brix was measured with a refractometer (BX90, ATC, New Delhi, India) every 24 hours. Total dissolved solids (TDS) and electrical conductivity (EC) of the water used in the beverages was measured as 1045.33 ± 41.50 ppm and 2090.67 ± 83.00 $\mu\text{s}/\text{cm}$ with TDSmeter (TDS-3, ZYT, Mainland, China) at 24°C. Color of the beverages were evaluated by measuring CIE L*, a*, b* parameters using color analyzer colorimeter (Beley, Fru, China).

2.3. Sensory Analysis

Eight students, academic and administrative staff of Ozyegin University, who have sensory testing experience, were the panelists in the sensory evaluation part of the study. Sensory testing of the samples was done after one day storage in 4°C. Color, smell, mouthfeel, taste and carbonation were scored. Hedonic scale of 9 points used in the scoring shows the following: 9= like extremely, 8= like very much, 7= like moderately, 6= like moderately, 5= neither like nor dislike, 4= dislike slightly, 3= dislike moderately, 2= dislike very much and 1=dislike extremely. Preference ranking was also evaluated for the samples in the sensory analysis part.

2.4. Statistical Analysis

One way analysis of variance (ANOVA) was carried out by using IBM SPSS Statistics 27.0.1 software and means were compared at the significance level of 0.05. Duncan's

Multiple Comparison Test was also conducted for the comparisons ($p \leq 0.05$) when significant differences were found between treatments. Experiments were done in three replications and results were shown as mean \pm standard deviation.

3. Results

Fig.2 shows the pH change of the water kefir beverages during fermentation. It was seen that pH decreased for all the beverages after fermentation for three days. The highest pH was measured for the samples prepared with dried figs and dried grapes and lowest pH was observed for the sample with dried peach before fermentation (day=0). On the other hand, the highest pH value of 3.53 was seen for the water kefir prepared with dried apricot and the lowest pH value of 2.70 was measured for the sample with fresh peach after the fermentation (day=3).

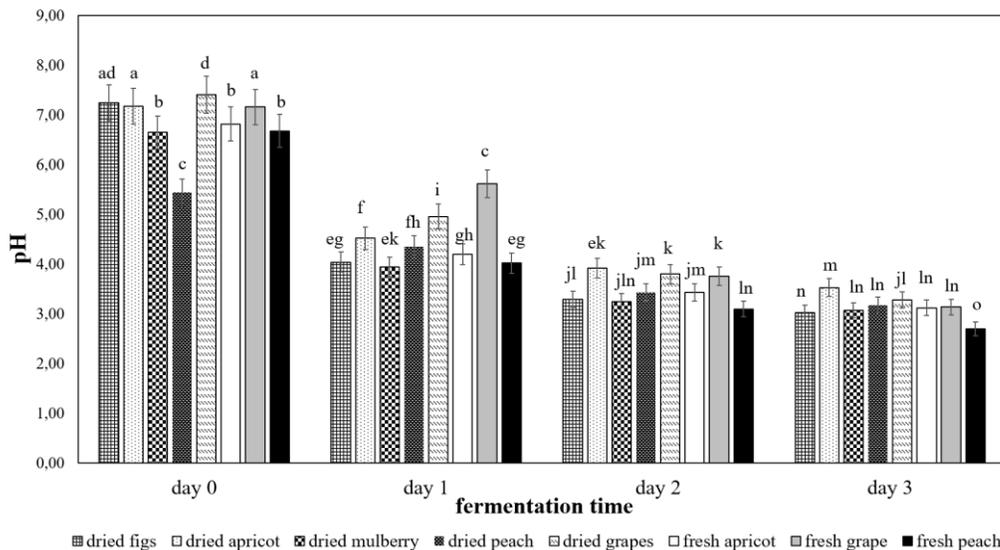


Figure 2: pH change of the water kefir samples during fermentation

Brix or total soluble solids (%) of the water kefir was measured every 24 hours during the fermentation and shown in Fig. 3. Brix value increased after 3 days fermentation for all beverages except the one prepared with dried mulberry. Although the sucrose amount was same in all samples, beverages containing dried mulberry had the highest and beverages with fresh apricot had the lowest brix value before the fermentation. After the fermentation, it was seen that water kefir formulated with dried figs had the highest and the samples with fresh apricot, dried grapes and fresh grapes had the lowest brix value.

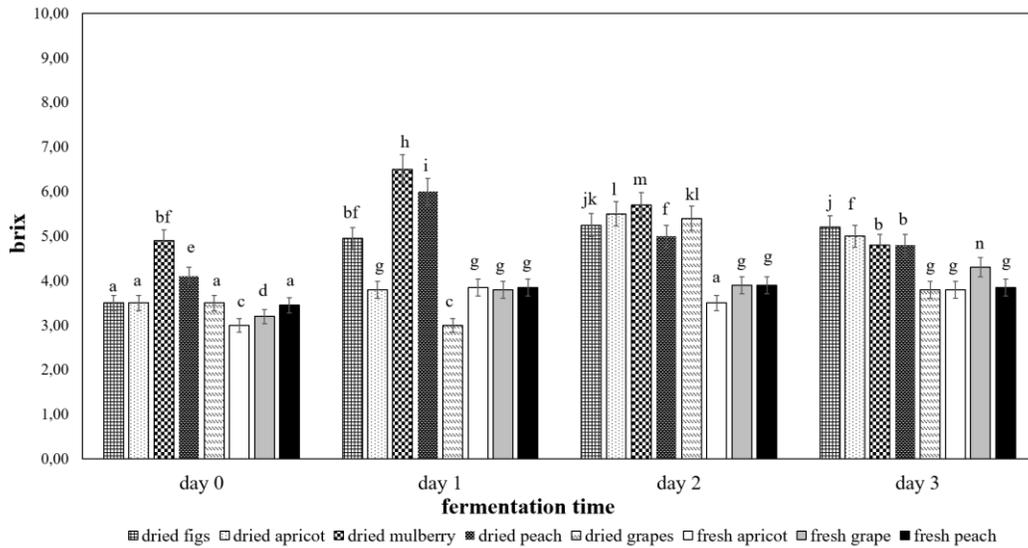


Figure 3: Brix change of the water kefir samples during fermentation

Color change of the water kefir samples is presented as before and after fermentation of three days in Table 3. L^* , a^* , and b^* values of the beverages were measured. L^* , a^* , and b^* shows brightness/darkness, redness/greenness and yellowness/blueness, respectively [9]. L^* value increased and b^* value decreased for all samples and a^* value decreased for all samples except the ones with fresh grapes, dried apricot, dried mulberry and fresh peach.

Sensory results of water kefir prepared with different type and forms (dried versus fresh) of fruits were shown in Fig. 4 for color, smell, mouthfeel, taste and carbonation parameters with 9-point hedonic scale. Beverages made with fresh grapes, dried peach and dried apricot had the top three scores for color; samples with fresh grapes, dried peach and fresh apricot had the top three scores for smell; beverages with dried grapes, fresh peach and fresh apricot had the top three scores for mouthfeel; and drinks with fresh grapes, dried peach and fresh apricot had the top three scores for taste.

In addition, panelists ranked the beverages for preference to evaluate the form of the fruit. Eight panelists evaluated the samples in three sensory sessions as follows: beverages with fresh and dried grapes were tasted in the first session, samples with fresh and dried peach were tasted in the second session and kefir with fresh and dried apricot were tasted in the third session. Preference ranking results are shown in Table 4.

Table 3: Color of water kefir beverages

Parameter	Fruit	Before fermentation	After Fermentation
L* value	dried figs	16.40±0.525 ^a	19.23±0.613 ^f
	dried apricot	16.19±0.506 ^{abj}	18.47±0.258 ^{fgi}
	dried mulberry	13.91±0.815 ^c	16.81±0.263 ^{ah}
	dried peach	14.19±1.188 ^{cd}	18.91±0.468 ^{fi}
	dried grapes	15.27±0.345 ^{bej}	17.59±0.322 ^{gh}
	fresh apricot	15.90±0.311 ^{bej}	18.77±0.289 ^{fi}
	fresh grapes	14.86±1.211 ^{cde}	16.30±0.287 ^{aj}
	fresh peach	15.18±0.477 ^{bde}	17.92±0.234 ^{gi}
a* value	dried figs	-0.79±0.062 ^{ab}	-1.05±0.051 ^{fg}
	dried apricot	-0.66±0.140 ^b	-0.99±0.123 ^{abf}
	dried mulberry	-0.07±0.101 ^{ce}	-0.05±0.035 ^{ce}
	dried peach	-0.32±0.399 ^c	-1.28±0.123 ^{fg}
	dried grapes	-0.95±0.061 ^{ab}	-1.35±0.025 ^g
	fresh apricot	0.41±0.254 ^d	-0.68±0.164 ^b
	fresh grapes	-0.27±0.243 ^c	0.78±0.212 ^h
	fresh peach	0.10±0.307 ^e	-0.20±0.085 ^{ce}
b* value	dried figs	-1.18±0.220 ^a	-1.96±0.229 ^e
	dried apricot	-1.16±0.064 ^a	-2.00±0.445 ^e
	dried mulberry	-0.70±0.269 ^{bd}	-1.71±0.125 ^e
	dried peach	-1.19±0.176 ^a	-3.95±0.160 ^f
	dried grapes	-2.41±0.167 ^c	-4.56±0.025 ^g
	fresh apricot	-0.46±0.217 ^d	-2.36±0.032 ^c
	fresh grapes	-0.94±0.265 ^{ab}	-3.37±0.185 ^h
	fresh peach	-0.79±0.225 ^{bd}	-2.38±0.197 ^c

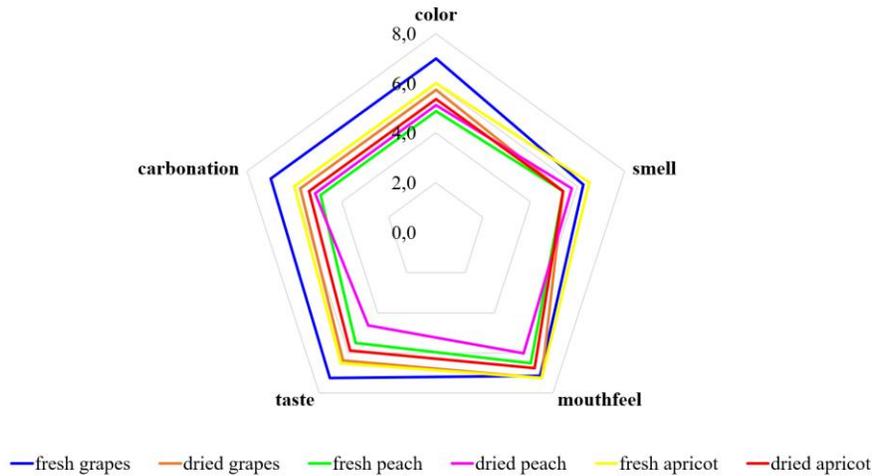


Figure 4: Sensory analysis of water kefir samples

Table 4: Preference ranking results of water kefir beverages in sensory evaluation

Fruit	Number of Panelists	
	Ranked the beverage as 1 st	Ranked the beverage as 2 nd
Fresh grapes	6	2
Dried grapes	2	6
Fresh peach	7	1
Dried peach	1	7
Fresh apricot	7	1
Dried apricot	1	7

4. Discussion and Conclusion

pH shows the acidity of a product, and it is used to assess the quality of a fermented beverage since it affects the taste, flavor and mouthfeel parameters [10]. As shown in Fig. 2, pH decreased significantly for all water kefir samples during the fermentation. This was in accordance with the previous studies [2, 4, 6]. Average pH drops was 3.69 units, and minimum 2.26 and maximum 4.22 units were observed for the beverages prepared

with dried peach and dried figs, respectively. Decrease of pH shows the acidification of the beverage. Increase of acidity in kefir products during fermentation is due to the consumption of mainly carbohydrates present in the substrate by the yeasts and the bacteria in the grains [4]. Carbohydrate amounts were analyzed for the fruits from Table 2 and carbohydrate data was found as 8.99, 5.66 and 14.75 g/ 100 g fruit for the fresh fruits of peach, apricot and grapes [11], respectively. However, minimum pH decrease was seen for the water kefir fermented with dried peach (Fig. 2) and dried peach had the highest carbohydrate amount (Table 2). Hence, another factor might have played an important role and calcium is considered to be that factor since calcium concentration is stated to affect water kefir properties with higher buffering capacity for lower pH values [7]. For the fruits, dried figs had the highest calcium level (Table 2), so highest pH drop was seen for that fruit containing kefir (Fig. 2).

Brix (total soluble solids) measurement is an important part of the quality analysis of beverages and agricultural products [12]. The brix of all water kefirs increased after 3 days fermentation except the one fermented with dried mulberry (Fig. 3). The highest increase of brix was seen for the sample with dried figs and it was about 49% and the lowest increase of 9% was observed for the dried grapes. On the other hand, the brix increase in dried mulberry samples was very slight and it was about 2%. There are very limited studies in the literature, only one study [2] reported brix decreases during fermentation showing about 60% sugar reduction, in which fermentation time was shorter (24 hours) and substrate was different than this study. Since the fermentation time is longer brix increase might be explained with the enhancement in the hydrolysis of acids and carbohydrates [13]. In addition, increase of brix can be linked to the fact that when the pectin of the fruit used in the fermentation is degraded, free calcium coming from the water and the fruit may cause stable gel formation increasing the total solids of the beverage [14].

Color is one of the main properties affecting the consumer acceptance of products since color of a food predetermines the consumers' opinions regarding taste and quality [15]. L^* value is between 0 and 100, where 0 means black and 100 means white. According to the color measurement results shown in Table 3, L^* value showing the lightness/darkness increased for all the samples after 3 days of fermentation. Similarly, Parades et al. (2022) reported significant increases in L^* after 48 hours of fermentation [16]. It was observed that a^* parameter for color declined for the water kefirs fermented with dried figs, dried peach, dried grapes and fresh peach and it was increased for the beverage with fresh grapes and remained same for the samples with dried apricot, dried mulberry and fresh peach. a^* values were negative after the fermentation for all water kefirs except the one prepared with fresh grapes (Table 3). Positive a^* values show reddish colors and negative values show greenish ones [16]. b^* parameter decreased for all beverages and values were all negative (Table 3). Positive b^* values indicate yellowish

and negative ones indicate bluish colors [16]. Changes in color during fermentation can be related to the color of the fruit substrate used. It was also mentioned that change in lightness and redness could be due to browning processes taking place during the fermentation [16, 17].

Intrinsic properties of food products can be estimated through sensory analysis conducted via counting in function of the responses to the senses which come from physiologic responses [18]. Sensory evaluation for color, smell, mouthfeel, taste and carbonation of the water kefir was conducted and shown in Fig. 4. Beverages made with fresh grapes, dried apricot and dried peach had the top three scores for color with 7.0, 6.0 and 5.1 out of 9.0. For the smell parameter, water kefir prepared with fresh apricot, fresh grapes and dried peach had 6.5, 6.3 and 5.8 points, respectively, and were the top three beverages in this parameter. For the mouthfeel parameter showing the texture of the beverages, samples fermented with dried grapes, fresh apricot and fresh grapes had the top three scores. Samples prepared with fresh grapes, fresh apricot and dried grapes were the top three kefir for the taste and carbonation parameters. As a summary for these sensory results, it can be concluded that water kefir fermented with fresh grapes, fresh apricot and dried grapes were the most liked samples in terms of the stated parameters. In order to evaluate the form of the fruit preference ranking was also carried out (Table 4) and it was found that beverages prepared with fresh fruits had the highest rankings.

Standardization of industrial water kefir production is a big challenge to reproduce the same quality and sensorial profiles over fermentation cycles [19]. This study will provide an insight for the researchers and the food industry to decide on the type and form of the substrate to be used in the fermented water kefir beverages.

References

- [1] Buech, J. (2022). 3 Drink trends to watch-out for in 2022. Mintel. Retrieved from: <https://www.mintel.com/blog/drink-market-news/3-drink-trends-to-watch-out-for-in-2022> (accessed: November, 26, 2022).
- [2] Tzavaras, D., Papadelli, M., & Ntaikou, I. (2022). From milk kefir to water kefir: Assessment of fermentation processes, microbial changes and evaluation of the produced beverages. *Fermentation*, 8, 135.
- [3] Moretti, A. F., Moure, M. C., Quinoy, F., Esposito, F., Simonelli, N., Medrano, M., & Leon-Pelaez, A. (2022). Water kefir, a fermented beverage containing probiotic microorganisms: From ancient and artisanal manufacture to industrialized and regulated commercialization. *Future Foods*, 5, 100123. <https://doi.org/10.1016/j.fufo.2022.100123>.
- [4] Bueno, R.S., Ressutte, J.B., Hata, N.N.Y., Henrique-Bana, F.C., Guergoletto, K.B., de Oliveira, A.G., & Spinosa, W.A. (2021). Quality and shelf life assessment of a new beverage produced from water kefir grains and red pitaya, *LWT*, 140, 110770.

- [5] Guzel-Seydim, Z.B., Gökirmakli, C., & Greene A.K. (2021). A comparison of milk kefir and water kefir: Physical, chemical, microbiological and functional properties. *Trends in Food Science & Technology*, 113, 42-53.
- [6] Atik, D.S., Gurbuz, B., Boluk, E., & Palabiyik, I. (2021). Development of vegan kefir fortified with *Spirulina platensis*. *Food Bioscience*, 42, 101050.
- [7] Lynch, K. M., Wilkinson, S., Daenen, & Arendt, E.K. (2021). An update on water kefir: Microbiology, composition and production. *International Journal of Food Microbiology*, 345, 109128.
- [8] Guzel-Seydim, Z., Kok-Tas, T., Ertekin-Filiz, B., & Seydim, A.C. (2011). Effect of different growth conditions on biomass increase in kefir grains. *Journal of Dairy Science*, 94(3), 1239-1242.
- [9] Wang, J., Fu, Y., Granato, D., Yu, P., Yin, J., Zeng, L., & Yong-Quan Xu, Y. (2022). Study on the color effects of (-)-epigallocatechin-3-gallate under different pH and temperatures in a model beverage system. *Food Control*, 139, 109112.
- [10] Dwiloka, B., Rizqiati, H., & Bhakti Etza Setiania, B.E. (2020). Physicochemical and Sensory Characteristics of Green Coconut (*Cocos nucifera* L.) Water Kefir. *International Journal of Food Studies*, 9, 346-359.
- [11] Turkish Food Composition Database (2014). TürKomp, Turkish Food Composition Database, version 1.0, Food Institute, TÜBİTAK Marmara Research Center, Gebze, Kocaeli. Retrieved from: <http://www.turkomp.gov.tr> (accessed: December, 2, 2022).
- [12] Jaywant, S.A., Singh, H., & Arif, K.M. (2022). Sensors and Instruments for Brix Measurement: A Review. *Sensors (Basel)*, 22(6):2290.
- [13] Purewal, S.S., Kamboj, R., Sandhu, K.S., Kaur, P., Sharma, K., Kaur, M., Salar, R.K., Punia, S., & Siroha, A.N. (2022). Unraveling the effect of storage duration on antioxidant properties, physicochemical and sensorial parameters of ready to serve Kinnow-Amla beverages. *Applied Food Research*, 2, 100057.
- [14] Tireki, S. (2021). A review on packed non-alcoholic beverages: Ingredients, production, trends and future opportunities for functional product development. *Trends in Food Science & Technology*, 112, 442-454.
- [15] Kilcast, D., & Subramaniam, P. (2000). *The stability and shelf life of food*. Woodhead Publishing Ltd., Cambridge, UK.
- [16] Paredes, J.L., Escudero-Gilete, M.L., & Vicario, I.M. (2022). A new functional kefir fermented beverage obtained from fruit and vegetable juice: Development and characterization. *LWT*, 154, 112728.
- [17] Randazzo, W., Corona, O., Guarcello, R., Francesca, N., Germanà, M.A., Erten, H., Moschetti, G., & Settanni, L. (2016). Development of new non-dairy beverages from Mediterranean fruit juices fermented with water kefir microorganisms. *Food Microbiology*, 54, 40-51.
- [18] Pertuzatti, P. B., Esteves, S. M. R., Alves, J. E., Lima, L. C., Borges, J. E., 2015. Sensory evaluation of bakery and confectionery products prepared through semi industrial and artisanal processes. *American Journal of Food Science and Technology*, 3 (4), 32- 36.

- [19] Patel, S.H., Tan, J.P., Borner, R.A., Zhang, S.J., Priour, S., Lima, A., Ngom-Bru, C., Cotter, P.D., & Duboux, S. (2022). A temporal view of the water kefir microbiota and flavour attributes. *Innovative Food Science and Emerging Technologies*, 80, 103084.