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Research Paper / Araştırma Makalesi

Comparison of Novel and Conventional Techniques for Tarhana Production

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ABSTRACT

The new method of direct fermentation was applied to tarhana production. Chemical and sensory differences in tarhana samples between conventional and direct fermentation techniques were determined. A total of 72 volatile compounds in tarhana mixes were detected by headspace analysis during fermentation. Fifteen of these compounds were from aldehyde group, 13 from ketone group, 10 from alcohol group, 7 from alkane group, 5 from acid group, 5 from ester group, 4 from terpene group and 13 from others. The bilateral interactions between techniques or sampling times were significant for 64 compounds and insignificant for 8 compounds according to the analysis of variance ($p<0.05$). Some compounds were not detected in the direct fermentation technique nor conventional technique. A total of 44 compounds were identified in the tarhana samples of direct fermentation and 48 compounds in the tarhana samples of conventional method. Tarhana samples produced by both techniques were compared by sensory evaluation tests. Sourness, taste, smell and color were identified as positive criteria while oxidized flavor as negative criteria. The best sourness, color and taste results were determined in direct-fermented tarhana samples. The panellists liked the direct-fermented tarhana more than the conventional tarhana in terms of off-flavor.

Keywords: Sensory evaluation, Fermentation, Process Design, Tarhana, Volatile compounds

Tarhana Üretiminde Yeni ve Geleneksel Tekniklerin Karşılaştırılması

ÖZ

Tarhana üretimine direkt fermantasyon adı verilen yeni bir teknik uygulanmıştır. Konveksiyonel ve direkt fermantasyon teknikleri arasındaki kimyasal ve duyusal farklılıklar araştırılmıştır. Tepe boşluğu analizi ile tüm fermantasyon süreleri boyunca tarhana karışımlarında toplam 72 uçucu bileşik tespit edilmiştir; 15'i aldehit, 13'ü keton, 10'u alkol, 7'si alkan, 5'i asit, 5'i ester, 4'ü terpen ve 13'ü diğer farklı gruplardandır. Varyans analizine göre 64 bileşiğin teknikler veya süreler arasındaki ikili etkileşimler önemli ve 8 bileşik için önemsiz bulunmuştur ($p<0.05$). Bazı bileşikler, direkt fermantasyon veya konveksiyonel tekniğinde hiçbir zaman tespit edilememiştir. Direkt fermantasyonlu tarhana örneğinde toplam 44, konvansiyonel tarhana örneğinde ise 48 bileşik tespit edilmiştir. Her iki teknikle üretilen tarhana örnekleri duyusal değerlendirme testleri ile karşılaştırılmıştır. Değerlendirmede ekşilik, tat, koku ve renk pozitif kriter olarak alınırken, oksitlenmiş aroma negatif kriter olarak alınmıştır. En iyi ekşilik, renk ve tat sonuçları doğrudan fermente edilmiş tarhanada belirlenmiştir. Panelistler, aroma açısından direkt fermente tarhanayı konveksiyonel tarhanaya göre daha çok beğenmişlerdir.

Anahtar Kelimeler: Duyusal analiz, Fermantasyon, Proses tasarım, Tarhana, Uçucu Bileşenler

INTRODUCTION

There is an intense interest in traditional food consumption worldwide. In the past, many of the traditional foods, which have been ignored historically, have become more known and consumed with the rapid increase in the advertising, communication and transportation means. Hence, many traditional homemade foods have been transformed into industrial production by commercializing. Traditional foods are eaten by enjoyment in out of the place or the countryside, where it is mostly consumed, so they are being included favourite food category. One of these traditional foods is tarhana. Tarhana usually consumed in and around Turkey. For the last decades, scientists have seriously focused on tarhana. Studies on tarhana include many topics such as nutritional properties, food components, bioactive substances, fermentation and sensory properties.

Tarhana has different names and is produced by different techniques from region to region due to many types of tarhana. Maras tarhana is one of these types. The popularity of this tarhana type is increasing day by day. A product, which is made from Maras tarhana and its commercial name is tarhana chips has the potential to replace potato chips in the future. Maras tarhana is basically a dry food obtained by mixing yoghurt and wheat. Tarhana, a fermented food, has a high nutritive value and has a long shelf life. Because it is a great source of water-soluble vitamins, minerals, organic acids and free amino acids, especially for babies and children [1]. In addition to the fact that fermented products are reliable foods in fabrication production, their rich nutritional qualities, taste and aroma also promote the consumption. In other words, to achieve success in a food market, it must be delicious as well as healthy and nutritious properties. Even though the hygiene factor of a product is put forward, its flavour and aroma increase its market ratio [2]. Therefore, determination of volatile organic compounds for food industry gained importance. Foods which include volatile and non-volatile flavours as well as basic ingredients such as proteins and carbohydrates are complex with multi-components. Aroma compounds are defined as volatile molecules detected in the gas phase under normal room conditions by reaching the olfactory tissue (olfactory receptors) in the nasal cavity. The transmission of the aroma components from the foodstuff to the gas phase is related with the interaction also with non-volatile compounds found in the food matrix [3]. The concept of flavouring substances should be used more flexibly, such as the concept of taste ingredients, since a composition can typically contribute positively to the odour or taste of a food, while in another food it may cause an erroneous odour or taste or both. The number of volatile substances in the food is quite low. However, in general, they contain many aromatic components. Specific foods (e.g., coffee) made by thermal processes or foods (e.g., tarhana, bread, beer, cocoa or tea) made by combination with fermentation and thermal processes can contain more than 800 volatile compounds. There are also many varieties of aromatic compounds in fruits and vegetables [4]. Nijssen et al. [5] classified all known volatile compounds according to foods and classes of compounds and published as a table. A total of 7100 components in more than 450 foods listed in it are available as a database on a web page [6].

A new production process was designed for Maras tarhana in this study. The tarhana productions were performed with new production technique and convectional production technique. The changes of the basic chemical parameters and volatile aromatic components in the fermentation processes of both techniques were monitored, and the properties of the end products were compared.

MATERIALS and METHODS

Materials

It was purchased sterilized milk (Ülker Co., Ltd., İstanbul, Turkey) from a local market, industrial yoghurt culture (CH-1) from Chr Hansen Co., Ltd. (İstanbul, Turkey), skim milk powder and milk creamy from Pınar Co., Ltd. (İzmir, Turkey) and the abraded wheat (it is a product obtained by abrading slightly outer pericarp of whole wheat in stone mill and it is called as dovme) from a local mill (Kahramanmaraş, Turkey).

Methods

Tarhana production was achieved getting reference to Maras tarhana. The productions were conducted by two techniques; one is a direct fermentation technique (D) which is a new production technique, and the other conventional technique (C).

Stages of Tarhana Production

Flow diagrams of the productions are shown in Figure 1. The stages of the production are described below:

Milk standardization: Milk is standardized in laboratory. Solid content was adjusted to 15% using milk powder, the fat content is set to 3% using milk cream, and it was applied heat treatment at 90°C for 5 minutes.

Cooking of dovme: Dovme was washed with tap water in the laboratory and then was put into a cooking vessel. It was added 3 kg of water for each 1 kg of dovme. It was continued to cook until there were no white spots in dovme.

Yoghurt production: This stage is applied in conventional technique. Firstly, the culture was mixed with 100 mL of milk, and it was pre-inoculated at 44°C for 2 hours. The pre-inoculated milk was added to the milk which would be inoculated (the amount of the culture recommended by the company is 50 U or 90 mg culture/L milk). The fermentation was achieved in inoculation oven adjusted to 44°C for 4 hours. Then yoghurt was kept at 4°C for 24 hours.

Mixing: This step applies to direct fermentation technique. The standardized milk-cooked dovme was

blended 2.5:1 by weight, homogenized by mechanical stirrer and the mixture was obtained.

Inoculation: This step is one of the stages in the direct fermentation technique. The mixture obtained in mixing stage was added the culture using the amount of the culture recommended by the company (90 mg culture/L milk). The fermentation of the mixture was achieved in inoculation oven adjusted to 44°C for 4 hours.

Tarhana mix: This stage is the mixing stage of yoghurt and dovme in the convectional production technique. Tarhana mix contains 2.5:1 by weight of yoghurt-dovme.

Maturation: The mixture was allowed to maturate at 24°C for 24 hours after the inoculation step in direct fermentation technique.

Fermentation and drying: These two steps are common steps of production processes. Fermentation was carried out at 44°C for 24 hours under vacuum. The dough was spread out, with a thickness of about 3 mm, by hand on a special tarhana mat named as "çiğ" (like a sushi mat) and the drying process was carried out in the oven at 60°C. Drying was continued until the water contents of the final products was 10% by weight on wet basis.

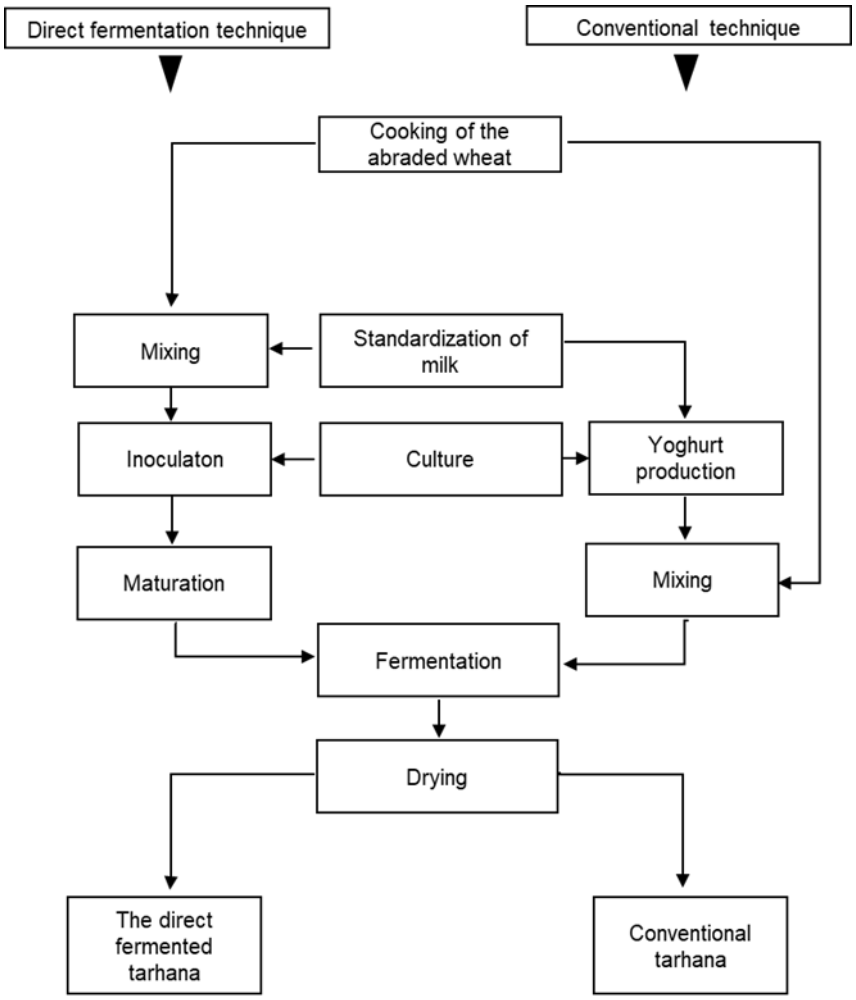

Figure 1. Tarhana processing flow diagram

Sampling and Analysis

Tarhana mix samples were taken in 6 different periods (between 0-24 hours). In the fermentation stages for both productions. They were stored in the deep freezer until the analysis together with the produced tarhanas. Each sample was analysed in triplicate.

The moisture contents were determined by drying the samples at 130°C for 1 h in an air oven. pH values of samples were calculated according to the procedures described by İbanoğlu et al. [7]. Titrable acidity was determined by titration using 0.1 M NaOH and expressed as percent lactic acid [8].

Lactose contents of the samples were determined according to HPLC method described by Erbaş et al. [9]. All solvents and diluents used were HPLC grade. Water was used for all dilutions. Standard solutions of lactose, glucose and galactose were prepared at concentration range from 0.005% and 0.25%. 5 g of sample, 40 mL water and 25 mL methanol were poured in a 100 mL volumetric flask, and the flask was filled to mark with water. Each sample flask was then agitated for 10 minutes. The resulting mixture was transferred to

centrifuge tubes and centrifuged at 3250xg for 30 minutes. Supernatant was filtered using Alltech C18 cartridge. 2.5 mL supernatant was mixed with 7.5 mL acetonitrile. The mixture filtered via 0.45-µm filters (Sigma) was transferred into Eppendorf tube and then stored at -18°C until analysing. For analysis, the sample was defrosted in freezer, filtered through 0,45 µ filter and then 10 µL of sample was injected onto the HPLC including SIL 20AT HT auto sampling unit, DGU-20A5R degasser unit, CTO-10ASVP column oven and RI detector. All instrument control, analyzes and data processing were performed using LC solution version 1.25 software. Lactose content was calculated on total dry basis (g/g).

Solid phase microextraction and identification of volatile compounds in sample was conducted according to the procedures described by Göçmen et al. [10]. 5 grams of sample transferred in 15 mL headspace vial, which was sealed with PTFE/BYTL headspace septa and aluminium cap. The vial was placed to equilibrate headspace volatiles in a 70°C water bath for 15 min, a SPME (Supelco Co., Bellefonte, PA) fiber (50/30 mm DVB/Carboxen/PDMS) was manually inserted into the headspace. Fiber exposure time was 45 min; after that, the SPME fiber was inserted into the GC injection port at 220°C and kept there for 5 min for thermal desorption. Volatiles were separated and analysed using Shimadzu (Japan) GC- 2010 Plus including Shimadzu GC/MS-QP2010 SE detector. It was used Restek Rx-5Sil MS 30 m x0.25 mm x0.25 µm column using split mode (10:1) in the analysis. The injector temperature and transfer line temperature were 250°C. Headspace volatiles were introduced into the chromatograph via SPME. Helium was used as the carrier gas at 1.61 mL/min. The oven temperature program consisted of a single thermal gradient from 40–250°C at 4°C/min. The ionization energy was set at 70 eV. NIST and Wiley databases were used to identify compounds based upon fragmentation spectra. The percentage of the relative peak area (expressed as %A) of a peak in a sample was calculated by dividing the peak area by the total peak area of all identified peaks in the chromatogram. The total ion chromatogram (TIC) of sample was used for peak area integration.

It was used 12 panellists to compare tarhanas produced by both technique in the sensory test [11]. Panellists were selected from the native people who constantly consume Maras tarhana. Education level of panellist varied from elementary to university. The panellist group consisted of 6 women and 6 men. Their ages were 30-40 years old. The panellists evaluated samples based on their perceptions attributes, giving a score between 0 (worst) and 10 (best) for four positive criteria (colour, flavour, sourness, taste) and between -10 (worst) and 0 (best) for a negative criterion (oxidized taste). Panellists cleaned their mouth with tap water (20°C) before evaluating new sample.

The tarhanas produced by two different techniques and the tarhana mixes during fermentation time were statistically compared. Differences were considered to be significant at $p \leq 0.05$. The data, collected from tarhana and tarhana mix samples in triplicate, were subjected to a three-way analysis of variance (ANOVA) using the SPSS software (SPSS for Win, Release 19.0, 2012). The means were compared using Duncan's multiple range test for multiple comparisons, and the “Student” T-test was applied to the two sets of data that were significantly different.

RESULTS and DISCUSSION

The pH, acidity and lactose values of milk, yoghurt, tarhana and tarhana mix samples during the fermentation process are shown in Table 1. The bilateral interactions between technique-time, technique-pH and time-pH were significant for pH of the samples ($p<0.05$) and for acidity too, but insignificant for lactose ($p>0.05$) because of variance analysis of pH, acidity and lactose values of tarhana mix samples. Time and technique for lactose values were separately found to be significant and the averages (x) were evaluated. Irregular changes were observed among the times in all three parameters during the fermentation process. While pH and lactose decreased, acidity values increased. The pH values of tarhana samples after drying were determined the similarity, but it was found the differences for acidity and lactose values. It was concluded that lactose was consumed more, and acidity developed more in direct fermentation technique.

Table 1. pH, acidity and lactose values of tarhana samples

Parameter	Technique	Fermentation time (hour)**						x̄***	Tarhana	Milk	Yogurt
		0	3	6	9	12	24				
pH	C*	4.63^{eX}	4.39^{bcY}	4.32^{aX}	4.39^{cX}	4.38^{bY}	4.46^{dY}		3.88^{X}	6.57	4.14
	D	4.02^{fY}	3.87^{aX}	3.91^{bY}	3.93^{cY}	3.95^{eX}	3.94^{dX}		3.80^{X}		
Acidity (%LA)	C	0.19^{aX}	0.22^{bY}	0.26^{dY}	0.23^{bcX}	0.23^{bcY}	0.24^{cX}		2.29^{X}	0.16	1.05
	D	0.30^{aY}	0.38^{bX}	0.43^{cX}	0.37^{bY}	0.36^{bX}	0.38^{bY}		2.82^{Y}		
Lactose (g/g)	C	2.02	1.88	1.64	1.94	1.76	1.98	1.87^{Y}	5.04^{Y}	6.72	5.50
	D	1.52	1.26	1.16	1.24	1.30	1.30	1.30^{X}	4.08^{X}		
	x̄	1.78^{c}	1.58^{abc}	1.40^{a}	1.58^{abc}	1.54^{ab}	1.64^{bc}				

*C: conventional production technique, D: direct fermentation production technique, %LA: percent lactic acid (g/g), **Values followed by the same letter are not significantly different at the level of 5%. series ‘a-e’ show differences between the samples during fermentation in a production technique, series ‘X-Y’ show differences between the samples in the same fermentation time, ***x̄: samples mean

In previous studies on how different applications affect pH values in traditional tarhana production, Herken and Aydin [12], Erdem et al. [13], Işik et al. [14], Gabriel et a.l [15], Bilgiçli et al. [16], İbanoğlu et al. [7], Çolakoğlu and Bilgir [17] found higher pH values than in the study, were lower than the works of Tarakçi et al. [18], Coşkun [19],

but it is consistent with the findings of Koca et al. [20], Alkan and Çon [21], Soyyiğit [22]. Işik et al. [14] found that the pH value of tarhana dough was higher than the pH values of tarhana mixes in the study. As comparing for the acidity values with previous studies, the results were lower than the findings of İnanç and Çolakoğlu [23], Gabrial et al. [15], Soyyiğit [22] and were higher than Koca et al. [20], Erbaş and Certel [24], Alkan and Çon [21], Bozkurt et al. [1], İbanoğlu et al. [7], Çolakoğlu and Bilgir [17]. Erbaş et al. [9] found that the amount of lactose in tarhana dough decreased from 15.80 to 12.00 mg/g, therefore the findings were similar to those.

The flavour and aroma development of tarhana mix samples during fermentation were monitored by headspace analysis. A total of 72 volatile compounds were detected. As a result of analysis of variance, 64 compounds with significant bilateral interactions between techniques or times are given in Table 2a, and 8 compounds with insignificant interactions in Table 2b. 14 compounds in the direct fermentation technique and 6 compounds in conventional technique were never determined at all. In addition, 16 compounds determining only once in direct fermentation and/or conventional technique were found, and 29 compounds being present in all periods were detected during the fermentation process. It was determined that 2,4-dimethyl hexane and pentane had the highest percent area value (19.74% at the zero period) and the lowest percent area value was belong to delta-3-carene (0.22% at the 6th period) amongs the compounds in the direct fermentation whereas the highest number of compounds was belong to the aldehyde group, styrene had the highest percent area value (47.30% in the 6th period), and the lowest percent area value was decanoic acid (0.21% in the 24th period) in conventional fermentation.

Table 2a. List and the amounts of volatile compounds (% of relative peak area of a peak in a sample) in tarhana mix samples during fermentation

Group	Compound	Technique*	Fermentation time (hour)					
			0**	3	6	9	12	24
Aldehydes	Acetaldehyde	C	2.68^{bX}	2.44^{bX}	2.38^{abX}	2.29^{abX}	2.26^{abX}	1.93^{aX}
		D	5.05^{dY}	4.55^{dY}	3.73^{cY}	3.62^{cY}	2.91^{bX}	1.31^{aX}
	3-Methyl butenal	C	-	-	-	0.30	0.34	0.32
		D	-	-	-	-	-	-
	3-Methyl-2-butenal	C	1.44^{eY}	1.04^{dY}	0.90^{cdY}	0.78^{bcX}	0.68^{abX}	0.55^{aX}
		D	0.96^{cX}	0.61^{bX}	0.60^{bX}	0.53^{abX}	0.52^{abX}	0.45^{aX}
	Hexanal	C	8.08^{dY}	7.26^{cdY}	6.76^{bcY}	6.43^{abcY}	5.69^{abY}	5.27^{aY}
		D	5.19^{cX}	4.98^{cX}	3.73^{bX}	3.48^{bX}	3.37^{bX}	2.16^{aX}
	Furfural	C	-	-	-	-	-	0.53
		D	-	-	-	0.26	-	0.43
	(E)-2-hexenal	C	-	-	-	-	0.29	-
		D	-	-	-	-	-	0.32
	Heptanal	C	0.68^{b}	0.66^{b}	0.58^{b}	0.60^{b}	0.35^{aX}	0.30^{aX}
		D	-	-	-	-	0.32^{aX}	0.41^{bX}
	(Z)-2-heptenal	C	0.48^{bX}	0.41^{bX}	0.40^{bX}	0.31^{aX}	0.28^{aY}	0.27^{aX}
		D	0.49^{bX}	0.49^{bX}	0.42^{bX}	0.41^{bY}	0.40^{bX}	0.28^{aX}
	(E.E)-2,4-heptadienal	C	-	-	-	-	-	0.61
		D	-	-	-	-	-	-
	Benzaldehyde	C	2.85^{cY}	2.62^{bcY}	2.46^{bcY}	2.17^{bY}	2.16^{bY}	1.65^{aX}
		D	1.88^{cX}	1.79^{bcX}	1.54^{abX}	1.47^{aX}	1.46^{aX}	1.45^{aX}
	Octanal	C	-	0.49	-	0.42	0.25	-
		D	-	-	-	-	-	0.30
	Benzene Acetaldehyde	C	-	-	-	-	-	0.24
		D	-	-	0.26	-	-	-
	Nonanal	C	2.75^{cY}	2.37^{cY}	1.70^{bX}	1.68^{bY}	1.62^{abY}	1.27^{aY}
		D	1.41^{cX}	1.40^{cX}	1.34^{cX}	1.07^{aX}	0.89^{aX}	0.64^{aX}
	(E)-oct-2-enal	C	0.25^{aX}	0.27^{aX}	0.27^{aX}	0.31^{aX}	0.40^{bX}	0.42^{bX}
		D	0.24^{aX}	0.27^{aX}	0.30^{aX}	0.33^{bX}	0.34^{bX}	0.44^{cX}
	Decanal	C	0.67^{cY}	0.46^{bX}	0.45^{b}	0.40^{abX}	0.33^{aX}	0.31^{aX}
		D	0.42^{aX}	0.40^{aX}	0.39^{aX}	0.38^{aX}	0.37^{aX}	0.36^{aX}

*C: conventional production technique, D: direct fermentation production technique, **Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

Components and percentage areas of tarhana samples are given in Table 3. The compounds are composed of alcohol, acid, aldehyde, ketone, alkane, terpene group compounds according to their chemical groups. It was determined a total of 44 compounds including 17 aldehydes, 9 ketones, 6 alkanes, 4 alcohols, 3 acids, and 1 terpene group in the direct fermentation technique and a total of 48 compounds including 20 aldehydes, 9 ketones, 5 alcohols, 4 alkanes, 2 acids and 1 terpene group in the conventional fermentation technique. The most aldehyde group compounds were determined in the tarhana samples produced by both techniques. The highest percentage area value was determined as hexanal (27.58) and the lowest acetaldehyde (0.21) among aldehyde group compounds in the direct fermentation technique and respectively as hexanal (30.34) and benzene (0.05) in the conventional fermentation technique.

Table 2a. List and the amounts of volatile compounds (% of relative peak area of a peak in a sample) in tarhana mix samples during fermentation (Continued)

Group	Compound	Technique*	Fermentation time (hour)					
			0**	3	6	9	12	24
Ketones	2-propanone	C	3.11^{cY}	2.56^{bX}	2.28^{bX}	2.22^{abY}	2.17^{abY}	1.78^{aX}
		D	2.97^{bX}	2.84^{bY}	2.53^{bY}	1.90^{aX}	1.66^{aX}	1.62^{aX}
	3-Hydroxy-2-butanone	C	0.43	0.56	0.63	0.73	0.86	1.35
		D	-	-	-	-	-	-
	2-pentanone	C	1.82^{cX}	1.57^{cX}	1.27^{bX}	1.20^{bX}	1.16^{abX}	0.93^{aX}
		D	2.57^{cY}	2.37^{bcY}	2.11^{bY}	1.66^{aY}	1.64^{aY}	1.49^{aY}
	1-phenylethanone	C	1.56^{dY}	1.22^{cY}	1.12^{cY}	0.86^{bY}	0.80^{bY}	0.25^{d}
		D	0.79^{cX}	0.63^{bX}	0.41^{aX}	0.32^{aX}	0.56^{bX}	-
	2-nonanone	C	5.44^{bX}	5.32^{bX}	4.62^{bX}	3.53^{aX}	3.46^{aX}	3.20^{aX}
		D	8.25^{cY}	5.94^{bX}	5.70^{abY}	5.65^{abY}	5.28^{abY}	4.69^{aY}
	Nonyl methyl ketone	C	1.62^{cX}	1.57^{cX}	1.50^{cX}	1.22^{bX}	1.09^{abX}	0.91^{aX}
		D	2.68^{cY}	1.88^{bX}	1.87^{bX}	1.81^{bY}	1.67^{abY}	1.39^{aY}
	2-tridecanone	C	0.65^{cX}	0.56^{bcX}	0.52^{bX}	0.39^{aX}	0.37^{aX}	0.36^{aX}
		D	0.75^{cX}	0.59^{bX}	0.56^{bX}	0.55^{bY}	0.50^{bY}	0.32^{aX}
	6-Methyl-5-hepten-2-one	C	1.42		-	-	-	-
		D	2.43	2.39	2.34	2.27	1.53	-
	2,3-butanedione	C	-	-	-	-	1.66	-
		D	-	-	-	-	-	-
	2.3-pentanedione	C	-	-	-	-	-	-
		D	2.73	1.60	1.85	1.30	-	-
	2-bütanon	C	-	-	-	-	-	-
		D	2.25	1.93	1.66	1.56	1.34	1.31
Esters	Ethyl acetate	C	3.68^{eY}	2.83^{dY}	2.30^{cX}	1.53^{bX}	1.28^{bX}	0.56^{aX}
		D	3.14^{cX}	2.18^{bX}	2.07^{bX}	1.96^{bY}	1.21^{aX}	1.30^{aY}
	2-Ethylhexyl acetate	C	0.65^{cX}	0.62^{cX}	0.59^{bcX}	0.51^{bX}	0.28^{a}	-
		D	0.84^{cY}	0.76^{bcY}	0.66^{bY}	0.30^{aY}	-	-
	2-ethyl-1-hexylpropionate	C	0.78^{bX}	0.62^{abX}	0.54^{aX}	0.54^{aY}	-	-
		D	1.06^{cY}	0.86^{bY}	0.72^{bY}	0.32^{aX}	-	-
	Linalyl acetate	C	0.47	0.47	-	-	-	-
		D	-	-	-	-	-	-
Terpenes	Alpha-Pinene	C	3.48^{cY}	3.15^{cY}	1.52^{bY}	0.81^{aX}	0.65^{aX}	0,64^{aX}
		D	2.02^{dX}	1.61^{cX}	0.93^{bX}	0.81^{bX}	0.77^{bX}	0.42^{aX}
	dl-limonene	C	3.45^{eY}	2.05^{dY}	1.07^{cY}	0.96^{bcX}	0.64^{abX}	0.46^{aX}
		D	1.85^{bX}	0.90^{aX}	0.89^{aX}	0.82^{aX}	0.79^{aX}	0.78^{aY}
	Camphor	C	-	-	-	-	-	0.63
		D	-	-	-	-	-	-

*C: conventional production technique, D: direct fermentation production technique, **Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

Table 2a. List and the amounts of volatile compounds (% of relative peak area of a peak in a sample) in tarhana mix samples during fermentation (Continued)

Group	Compound	Technique*	Fermentation time (hour)					
			0**	3	6	9	12	24
Alkanes	2.4-dimethyl hexane&pentane	C	18.92^{bX}	17.50^{bY}	17.49^{bY}	4.04^{aX}	3.51^{aX}	1.30^{aX}
		D	19.74^{dX}	9.56^{cX}	7.44^{bX}	7.20^{bY}	3.49^{aX}	2.79^{aY}
	Heptane	C	9.20^{bY}	7.39^{aX}	7.09^{aX}	6.75^{aX}	6.45^{aY}	6.17^{aY}
		D	8.24^{bX}	7.78^{bX}	7.38^{bY}	7.31^{bY}	4.84^{aX}	4.80^{aX}
	Decane	C	-	0.23	-	0.27	-	-
		D	-	-	-	-	-	-
	Dodecane	C	0.79^{dX}	0.73^{dY}	0.49^{cY}	0.42^{bcX}	0.30^{abX}	0.29^{aX}
		D	0.77^{bX}	0.40^{aX}	0.38^{aX}	0.36^{aX}	0.34^{aX}	0.30^{aX}
	Tridecane	C	-	0.80	0.55	0.47	0.33	0.29
		D	0.44	-	-	-	-	-
	Heptadecane	C	0.31	-	0.38	-	-	2.04
		D	-	-	-	-	-	-
	Nonadecane	C	0.53^{cX}	0.49^{cX}	0.46^{bcX}	0.38^{abX}	0.34^{aX}	-
		D	0.63^{cY}	0.57^{bcY}	0.52^{bX}	0.48^{bY}	0.35^{aX}	-
Alcohols	Ethanol	C	-	-	-	-	-	0.47
		D	-	-	0.38	-	-	-
	1-Butanol	C	-	-	-	-	-	0.96
		D	-	-	-	-	-	-
	1-pentanol	C	0.49^{aX}	0.55^{aX}	0.61^{aX}	0.74^{bcX}	0.76^{bcX}	0.89^{cX}
		D	1.21^{dY}	1.19^{eY}	1.12^{deY}	1.00^{cdX}	0.92^{bcX}	0.83^{bX}
	Hexanol	C	1.67^{cX}	1.41^{cX}	1.41^{cX}	1.03^{bX}	0.69^{aX}	0.56^{aX}
		D	4.48^{dY}	4.35^{dY}	4.25^{cdY}	3.62^{cY}	2.41^{bY}	1.61^{aY}
	Trans-2-octenol	C	-	-	-	-	0.29	-
		D	-	-	-	-	0.32	-
	1-Heptanol	C	-	-	-	-	-	-
		D	-	0.28	0.28	-	-	-
	2-nonanol	C	-	-	-	-	-	-
		D	-	0.39	-	-	0.46	0.53
	2-methoxy-4-ethenyl phenol	C	-	-	0.30	-	-	-
		D	0.89	-	-	0.31	0.33	-

*C: conventional production technique, D: direct fermentation production technique, **Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

Table 2a. List and the amounts of volatile compounds (% of relative peak area of a peak in a sample) in tarhana mix samples during fermentation (Continued)

Group	Compound	Technique*	Fermentation time (hour)					
			0**	3	6	9	12	24
Acids	Acetic acid	C	3.76^{cX}	3.62^{cX}	2.11^{bX}	1.70^{bX}	1.59^{bX}	1.08^{aX}
		D	9.58^{cY}	7.26^{bY}	7.18^{bY}	6.57^{bY}	6.40^{abY}	4.93^{aY}
	Octanoic acid	C	2.75^{dX}	1.22^{cX}	0.72^{bX}	0.63^{bX}	0.35^{aX}	0.31^{aX}
		D	5.48^{dY}	4.92^{dY}	3.07^{cY}	2.24^{bY}	0.88^{aY}	0.63^{aX}
	Decanoic acid	C	0.45^{bX}	0.40^{bX}	0.27^{aX}	0.25^{aX}	0.23^{aX}	0.21^{aX}
		D	0.83^{dY}	0.73^{cdY}	0.69^{cY}	0.64^{bcY}	0.51^{bY}	0.35^{aX}
	Hexanoic acid	C	-	-	-	-	-	-
		D	2.32	-	-	2.28	-	-
Others	Chloroform	C	2.51^{cY}	2.12^{bX}	1.84^{bX}	0.82^{aX}	0.58^{aX}	0.57^{aX}
		D	2.39^{cX}	2.27^{cX}	1.75^{bX}	1.70^{bY}	0.70^{aX}	0.66^{aX}
	Benzene	C	3.39^{cY}	2.84^{bY}	2.74^{bY}	1.46^{aY}	1.08^{aY}	1.04^{aY}
		D	1.88^{cX}	1.18^{bX}	1.10^{bX}	1.00^{bX}	0.54^{aX}	0.41^{aX}
	Toluene	C	2.91^{cY}	2.60^{cY}	2.06^{bY}	1.59^{aY}	1.51^{aY}	1.51^{aY}
		D	1.91^{cX}	1.84^{cX}	1.17^{bX}	0.72^{aX}	0.70^{aX}	0.64^{aX}
	Naphthalene	C	0.31^{a}	0.36^{ab}	0.40^{abX}	0.45^{bcX}	0.52^{cdX}	0.55^{dX}
		D	-	-	0.50^{aY}	0.85^{bY}	1.24^{cY}	1.91^{dY}
	Ethylbenzene	C	-	-	-	0.39	0.40	0.39
		D	-	-	-	-	-	-
	1,2-dimethyl benzene	C	0.56	0.53	-	0.55	-	0.31
		D	-	-	-	-	-	-
	2-Pentylfuran	C	5.05^{cX}	4.58^{cY}	2.73^{bX}	2.58^{bX}	1.78^{aX}	1.44^{aX}
		D	5.51^{cY}	4.21^{bX}	4.01^{bY}	3.95^{bY}	3.79^{bY}	2.87^{aY}
	p-Dichlorobenzene	C	0.35^{aX}	0.40^{aX}	0.48^{abX}	0.53^{bX}	0.60^{bX}	0.65^{bcX}
		D	2.40^{aY}	4.90^{aY}	9.53^{bY}	13.16^{cY}	13.20^{cY}	19.29^{dY}
	Cymene	C	0.26	0.37	-	-	-	-
		D	-	-	-	-	-	-
	Trans-Caryophyllene	C	-	-	-	-	-	0.30
		D	-	-	-	-	-	-
	o-Xylene	C	-	-	-	-	-	-
		D	-	0.28	-	-	-	-
	Alpha Humulene	C	-	-	-	-	-	0.31
		D	-	-	-	-	-	-

*C: conventional production technique, D: direct fermentation production technique, **Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

Table 2b. Statistical analysis results of the compounds determined to have not significant interaction between the techniques or the fermentation times during fermentation process

Compound	Technique*		Fermentation time (hour)						
			0	3	6	9	12	24	x̄
Heptan-2-one	C		11.76	12.02	12.90	13.24	13.90	14.13	12.97^{Y}
	D		10.09	10.32	10.50	11.48	12.05	12.90	11.35^{X}
		x̄							
Pent-3-en-2-one	C		0.83	0.35	-	-	-	-	0.59^{X}
	D		1.69	-	0.40	-	0.29	-	0.79^{Y}
		x̄	1.26^{b}	0.35^{a}	0.40^{a}		0.29^{a}		
Butyl acetate	C		0.61	0.67	0.43	0.33	0.33	0.29	0.45^{Y}
	D		0.39	-	-	-	-	-	0.39^{X}
		x̄	0.50^{b}	0.67^{c}	0.43^{b}	0.33^{a}	0.33^{a}	0.29^{a}	
Delta-3-carene	C		1.27	0.80	0.32	-	-	-	
	D		-	-	0.22	0.61	-	-	
		x̄	1.27^{d}	0.80^{c}	0.27^{a}	0.61^{b}			
Octen-3-ol	C		0.93	0.81	0.69	0.68	0.51	0.29	0.71^{Y}
	D		0.66	0.50	0.47	0.29	-	-	0.48^{X}
		x̄	0.80^{e}	0.65^{d}	0.58^{c}	0.49^{bc}	0.51^{bc}	0.29^{a}	
2-Ethyl hexanol	C		-	-	-	-	1.65	-	
	D		-	2.34	1.96	-	1.71	1.44	
		x̄		2.34^{c}	1.96^{bc}	-	1.68^{b}	1.44^{a}	
Butanoic acid	C		-	-	-	-	-	0.59	0.59^{X}
	D		1.01	0.98	0.95	0.46	0.37	0.29	0.68^{X}
		x̄	1.01^{b}	0.98^{b}	0.95^{b}	0.46^{a}	0.37^{a}	0.44^{a}	
Styrene	C		-	-	47.30	37.44	28.04	26.06	37.21^{Y}
	D		-	11.81	-	-	-	16.05	13.93^{X}
		x̄		11.81^{a}	47.30^{d}	37.44^{c}	28.04^{b}	26.06^{b}	

*C: conventional production technique, D: direct fermentation production technique, **Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

Table 3. The volatile compounds and the percentage of the relative peak areas in tarhana samples produced by conventional and direct fermentation production technique

Group	Compound	Conventional*	Direct fermentation
Alcohol	Hexanol	0.16^{X}	0.35^{Y}
	1-Pentanol	0.66^{X}	0.82^{X}
	Octen-3-ol	1.38^{X}	1.01^{X}
	Trans-2-octenol	0.17	-
	3-methyl-6-propyl phenol	0.51^{Y}	0.26^{X}
	Total	*2.88*	*2.44*
Acid	Acetic acid	1.19^{X}	3.85^{Y}
	Lactic acid, methyl ester	0.10^{X}	0.94^{Y}
	Hexanoic acid	-	0.63
	Total	*1.29*	*5.42*
Aldehyde	Acetaldehyde	-	0.21
	3-Methyl butenal	0.12	-
	4-pentenal	0.21^{X}	0.24^{X}
	Hexanal	30.34^{X}	27.58^{X}
	Heptanal	5.18^{X}	4.78^{X}
	Furfural	0.27^{X}	0.38^{X}
	(Z)-2-heptenal	8.64^{X}	6.80^{X}
	Benzaldehyde	1.45^{X}	1.50^{X}
	Octanal	3.43^{X}	3.11^{X}
	Benzene Acetaldehyde	0.24^{X}	0.37^{Y}
	(E)-oct-2-enal	4.45^{Y}	3.06^{X}
	Nonanal	5.12^{X}	5.45^{X}
	Decanal	0.55^{X}	0.57^{X}
	Deca-2(E).4(E)-dienal	1.09^{Y}	0.41^{X}
	2- butenal	0.33^{X}	0.40^{X}
	Pentanal	2.97^{X}	3.26^{X}
	Hex-2(E)-enal	0.77^{X}	0.78^{X}
	(E,E)-2,4-heptadienal	0.34^{X}	0.27^{X}
	Nona-2(E),4(E)-dienal	0.44	-
	Dec-2(E)-enal	3.00^{Y}	1.74^{X}
	Undec-8(Z)-enal	0.42	-
	Total	*69.36*	*60.91*
Ketone	2-propanone	3.71^{X}	4.67^{X}
	Pent-3-en-2-one	0.61^{X}	0.76^{X}
	1-octen-3-on	0.37^{Y}	0.23^{X}
	6-Methyl-5-hepten-2-one	0.62^{X}	0.67^{X}
	1-phenylethanone	0.43^{X}	0.63^{Y}
	2-nonanon	0.58^{X}	0.45^{X}
	Nonyl methyl ketone	0.50^{Y}	0.31^{X}
	Oct-3(E)-en-2-one	0.32^{X}	0.22^{X}
	(3E)-3-nonen-2-one	0.91^{Y}	0.42^{X}
	Total	*8.05*	*8.36*
Alkane	Decane	0.35^{X}	0.55^{Y}
	Undecane	0.28^{X}	0.62^{Y}
	Dodecane	2.02^{X}	3.55^{Y}
	Tridecane	2.89^{X}	3.56^{X}
	Heptadecane	-	0.32
	Nonadecane	-	0.29
	Total	*5.54*	*8.89*
Terpene	dl-limonene	1.66^{X}	3.54^{Y}
Other compounds	Benzene	0.05	-
	Toluene	1.20^{X}	1.23^{X}
	o-Xylene	0.20^{X}	0.38^{Y}
	Styrene	2.39^{X}	3.37^{Y}
	2-Pentylfuran	5.24^{Y}	4.47^{X}
	2,5-dimethyl furan	0.16	-
	Octahydro -2,3'-bifuran	0.38	-
	Total	*9.62*	*9.45*

*Values followed by the same letter are not significantly different at the level of 5% (series 'a-e' for the samples in a production technique, series 'X-Y' for the samples in the same fermentation time

The lowest group in the total percent area was acid group in the conventional technique, the alcohol group in the direct fermentation technique. When both techniques are compared, the total percent area of the acid, ketone,

alkane and terpene groups in the direct fermentation technique was found to be higher than the conventional technique, while the percent area of alcohol, aldehyde and others were found to be lower than the conventional technique. In studies on volatile components, Coppa et al. [25] detected 1-pentanol, 2-furanmethanol, 2-octanol, 1-dodecanol in milk, Kati et al. [26] detected ethanol and butanol components in sour wheat dough. But Coppa et al., [25] and Kati et al. [26] did not detect those components in tarhana samples.

In the studies on the volatile components in the acid group of tarhana, Carpino et al. [27] identified 8 components (Hexanoic acid, octanoic acid, n-decanoic acid, heptanoic acid, nonanoic acid, undecanoic acid, tetradecanoic acid, n-hexadecanoic acid), Göçmen et al. [10] identified 1 component (butanoic acid). The acid group components determined by Carpino et al. [27] and Göçmen et al. [10] were not detected in the present study, the different components were detected. It was reported that the hexanal had the highest value among the aldehyde group components in wheat [28, 29]. Therefore, those results show similarity the results of the present study. Eight volatile components included in the ketone group (2-pentanone, 2-heptanone, 2-nonanone, 2-decanone, 2-undecanon, 2-dodecanone, 2-tridecanon, 2,3,4- trimethylacetoptenone, 2-tetradecanon, 2-pentadecanon) were determined in milk on the study by Shimoda et al. [30] and 2-nonanone was also detected in tarhana samples. Göçmen et al. [10] found 2 ketone group components (terpinolene, α-humulene) in tarhana, but those volatile compounds were not detected in the present study.

The type of wheat, the cooking temperature, time, amount of water, the starter culture, the type and composition of milk, the processes applied to the milk, even the feeding patterns of the animals from which the milk is obtained can be effective on aroma components of tarhana mixes during fermentation. Although the raw material and amount of tarhanas produced by both techniques are the same, the differ effects of the two production techniques are shown on volatile components.

A total of 44 components were found in the tarhana sample produced by the direct fermentation technique, and a total of 48 components in the tarhana sample produced by the conventional technique. Carpino et al. [27] determined a total of 20 compounds (including 12 aldehydes, 3 alcohols, 1 free acid ester, 1 sulphur component, 1 terpene and 2 unidentified unstable components) in the sun-dried tarhana sample, and a total of 11 compounds (including 8 aldehydes, 2 sulphur components and 1 alcohol) in the oven-dried tarhana sample. The number of components in the tarhana samples produced with both production techniques was found to be more than by the number of components identified by Carpino et al. [27] and Göçmen et al. [10]. Göçmen et al. [10] found a total of 41 components (17 aldehydes, 6 esters, 4 ketones, 7 alcohols, 2 terpenes, 1 phenol, 1 furan, 1 sulphur compound, 1 acid and 1 other component) in vacuum dried tarhana, and 23 components (10 aldehydes, 3 esters, 3 ketones, 5 alcohols, 1 sulphur compound and 1 other component) in the sun-dried tarhana sample.

Sensory evaluations of the tarhana samples are shown in Figure 2. Sourness is a desirable feature in conventional tarhana. The new technique has brought this feature to tarhana more. The expectations of the panellists from colour were whiteness. The direct fermented tarhana received the best liking score for color.

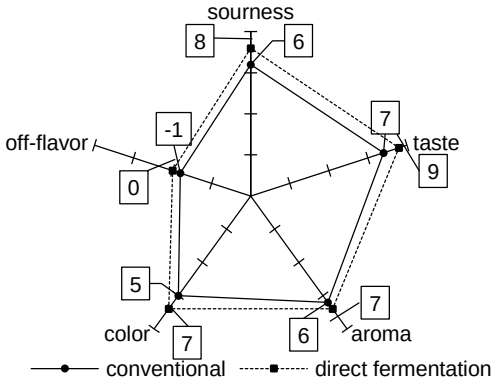

Figure 2. Sensory evaluation of tarhana samples

Oxidized taste is never desired in fermented food products, especially in fermented milk products. The new technique succeeded in reducing the oxidized taste in tarhana. In terms of taste, the direct fermentation technique gave near perfect result (9 points). And aroma scores for tarhanas were close to each other; 6 points for the conventional tarhana and 7 points for the direct fermented tarhana. In the overall evaluations of tarhanas produced with both techniques, conventional tarhana collected 23 points and directly fermented tarhana 31.

CONCLUSION

In this study, tarhana was produced with a new production technique (direct fermentation), the chemical and the sensory properties were investigated and compared with the conventional technique. While all pH and lactose values in the direct fermentation technique were determined to be lower than the conventional technique, titration acidity values were found to be higher. Those chemical results were supported with sensory

evaluation. The total number of volatile components in conventional tarhana were higher than the number of components in the direct fermented tarhana. However, that does not mean that conventional production is better in terms of taste and aroma. Because the sensory evaluation results show the opposite. Moreover, the direct fermentation technique gave the better results according to other results of sensory evaluation, too. As a result, a new process was gained to tarhana production.

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