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Sensory Assessment and Shelf Stability of Deodorized Sheep Tail Fat

A. R. Shaviklo [a] *

[a] Department of Animal Processing, Animal Science Research Institute of Iran, Agricultural Research, Education and Extension Organization (AREEO), Karaj, Iran.

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ABSTRACT: Three *Persian* traditional recipes were used for masking off-odor and off-flavor of the sheep tail fat (STF). The sensory and oxidative stability of the products were also investigated. Room Odor Test (ROT), Free Choice Profiling (FCP), and Quantitative Descriptive Analysis (QDA) methods were used for the sensory evaluation of STF prototypes. The deodorized STF (DSTF) and control prototypes had the same extract yield. No significant differences were found between DSTF prototypes and the control for dry matter, moisture, fat, ash, melting point, iodine value, and saponification index. But, the control had a strong STF odor and flavor, off-odor and off-flavor, and was less accepted. Conversely, deodorized tail fat prototypes had acceptable odors and flavors and gained more liking points. Furthermore, most of the panelists liked DSTF and disliked the control prototypes. The deodorization process did not change the fatty acid compositions of the STF prototypes except for trans fatty acids which were significantly lower in the DSTF as compared to the control. During 90 days storage DSTF remained stable compared to the control in respect of shelf stability and sensory points of view. The novelty of this process can increase STF utilization in the food industry and may help the sensory marketing of this product.

Keywords: Deodorization, Sensory Attributes, Sensory Marketing.

Introduction

Near Eastern countries are dependent on foreign sources for the supply of edible oils, and more than 50% of the oil needed for various food applications is supplied from foreign sources. Undoubtedly, dealing with such an important issue requires comprehensive planning. However, to reduce dependence on imports, all oil sources including sheep tail fat (STF) that can be used in the community's diet should be considered edible oil materials (Doosti *et al.*, 2020a). Fat-tailed sheep make up about 25% of the world's sheep population. Breeds of this sheep are found in northern Africa, southeastern Europe, the Far East, the Middle East, and especially in Turkey and Iran. The weight of the sheep tail fat from individual sheep varies from 3 to 8 kg (Huang *et al.*, 2021).

STF is a traditional product and the experience of its use in cooking is attractive to those who are interested in organic foods (Mahachi *et al.*, 2020). The people of the Middle East have long used sheep tail fat extensively for cooking. In Iran, STF or its oil is used for cooking and preparing various foods (Ghanbari *et al.*, 2006). While it is used in the formulation of meat products in North Africa and the Mediterranean. STF is used to make fermented beef sausages *i.e. Bez sucuk* and a type of South African dry sausage *i.e.*

* Corresponding Author: shaviklo@gmail.com

Droëwors (Mahachi *et al.,* 2020). In northwest China, STF is used as a flavor enhancer (Huang *et al.,* 2021).

STF has a unique flavor after rendering (heat treatment) and it is difficult to remove its odor and flavor which is unpleasant for many consumers. This is a barrier to the market development of this product (Mohapatra and Shinde 2018). Fat rendering is a thermal process that breaks down cellular structures and releases triglycerides from animal sources (tail, by-products). Fat can be obtained by all three methods of dry rendering, wet rendering, and low-temperature wet rendering. The efficiency and quality of the product and its cost depend on the used method (Sharma *et al.,* 2013). Deodorization is a separation process in which a certain amount of volatile compounds separates from the hot oil for a certain time and removes the volatile compounds and the odor-generating agent from the oil (Mohapatra and Shinde 2018; Doosti *et al.,* 2020a).

On the other hand, the high levels of oleic acid in tail fat and the high cost of vegetable oils such as cocoa butter, coconut oil, palm oil, and palm kernel oil have led researchers to focus on improving the properties of STF, such as deodorization. Several authors have reported the deodorization of STF using industrial methods (Ünsal & Yanlic, 2005; Doosti *et al.,* 2020a,b). In these methods, the odor and flavor of STF oil are not eliminated and flavor reversion is also seen. These methods are not applicable due to high production costs. Since STF oil producers typically work on a small-scale production, it is difficult for them to meet these challenges. Hence, they are looking for cheaper and more efficient methods. Using traditional methods could be a practical approach in this case.

Masking off-odor or off-flavors is an important technique for improving the sensory quality of foods or beverages and even medicines. The use of natural aromatic spices and vegetables for this purpose has a long history in food/medicine preparation and its indigenous knowledge can be found in traditional medicine in every human society. The combined effect of several spices or aromatic herbs is usually used to cover the maximum unpleasant odor or flavor. In addition, these compounds can also affect positively the stability of the product (Ghanbari *et al.,* 2006; Lashgari & Javanmard, 2014).

The severity of STF odor and favor should be determined using sensory analysis. The Room Odor Test (ROT) which had been used in the industry for sensory evaluation of frying oils (Evans *et al.,* 1971), can be applied to assess the severity of tail oil odor and its acceptance. Free choice profiling (FCP), a method of sensory descriptive analysis, can be performed by untrained panelists. They should only be able to use the scale when testing the product under evaluation. The easy, fast, and cheap application of this method allows assessors to evaluate the product from the perspective of consumers (Meilgaard *et al.,* 2015). These methods can determine the relationship between sensory characteristics and consumer preferences, and they are more effective in consumer perception of sensory characteristics and product acceptance (Evans *et al.,* 1971; Meilgaard *et al.,*2015).

The use of STF is not routine in the food industry due to its unique odor and taste (Mohapatra & Shinde, 2018). Improvement of the sensory properties of STF is a practical approach to developing its sensory marketing and application (Huang *et al.,* 2021). Therefore, the present study was conducted to investigate the influence of deodorization, using 3 traditional recipes, on the physicochemical, fatty acids, lipid oxidation, and sensory properties of STF. Furthermore, the physicochemical properties and stability of the STF and deodorized STF (DSTF) within 90-day storage at room temperature (25±2°C) were compared with the control. The results could be effective in creating added value and increasing productivity in the livestock industry.

Materials and Methods

The STF from Shal/ Chal breed and male sheep was obtained from a local meat market (Tehran, Iran). The following 3 methods of traditional Iranian medicine were used to deodorize SFT: In the first method, initially, 3 kg chopped STF with 3 large onions plus a glass of vinegar, a glass of rose water, and an apple, a tablespoon of clove, were mixed manually. The mixture was heated for about 6 h to el moisture. The resulting oil is then sieved using a cheesecloth. In the second method, 3 kg of STF, a glass of vinegar, 2 glasses of yogurt, 2 big onions, and 10 cardamoms were homogenized manually. The mixture was gently heated, and after 6 hours, the tail oil was sieved using a cheesecloth. In the third method, 3 kg of STF was chopped and 3 tablespoons of salt are added to 3 liters of cold water. The STF pieces were soaked in the brine for 12 hours and were kept in a cool place. The STF was rinsed and poured into a container and 1.5 kg of cow's milk, 10 cardamoms, and a teaspoon of turmeric were added to the mixture. It was boiled gently to eliminate moisture. To make a control sample, 3 kg of STF was ground and heated in a steel container for 3 hours without adding any additives. A cheesecloth was used for sieving the extracted oil for both samples. The DSTF and control prototypes were packed in glass jars and kept for 90 days at room temperature (25±2°C) until evaluation.

- *Analytical analysis*

The percentage of dry matter, moisture, fat, ash, (AOAC, 2005), total nitrogen (Ockerman, 1985), iodine value (g iodine/100 g fat), (INSO: 4888, 2016), saponification index (mg KOH/g fat) (INSO: 10501,2014), melting point (°C) (INSO 4887:2015), fatty acid composition (g/ 100 g) (INSO: 4091, 1997), free fatty acids (%) (INSO: 4178, 2011), peroxide value (meq/kg fat) (INSO: 4179, 2018), thiobarbituric acid reactive substances (TBARS) reported as mg MDA/kg sample of DSTF and control prototypes were measured (Sidewell *et al*., 1954) were determined using standard methods. The extract yield was measured by dividing STF extracted oil by the weight of raw STF.

- *Sensory evaluation*

- *Free Choice Profiling*

FCP was performed in two stages. Initially, 10 experts (4 men and 6 women) with an average age of 30 years were asked to smell and taste the STF prototypes and describe the intensity of odor and flavor using their own words (Meilgaard *et al.*, 2015). The prototypes were presented at 38°C in 50 ml glass jars with the lid being coded with 3-digit numbers. To assess odor, assessors were asked to remove the cap and inhale the odorous compounds through the nose. To evaluate the flavor, they were asked to take about 5 ml of warm oil and spread it completely on their tongue, while at the same time drawing air into the mouth and evaluating the flavor by expelling it from inside the nose. Assessors were asked to rinse their mouths with mineral warm water (about 38°C) before and after testing each sample (INSO: 7412, 1991). In the second session, each assessor was asked to define a list of descriptive terms created in the first session and to evaluate the samples in the mentioned method using their terms. For this purpose, a 15-cm unstructured linear scale, established with the words "extremely weak" and " extremely strong", was prepared, and each assessor evaluated the intensity of each attribute by placing a mark on the scale (Meilgaard *et al.,*2015). In FCP, 4 product samples in each session were scored in three replications over three days. Lukewarm water was provided to the assessors to rinse their mouths.

- *Odor assessment using ROT*

A method suggested by Evans *et al.*, (1971) was modified and applied for ROT. A 9-point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like) was used to determine the liking of STF odor. A 300 ml sample of STF oil and a temperature of 190 °C were used for all prototypes. The STF prototypes were heated in a stainless steel frying pan of 20 cm in diameter. In the room, where the STF oil was heated, locked ventilation to keep the odor of STF prototypes in a closed environment. The assessors entered the room in turn and performed their evaluation at a distance of 1.5 meters from the oven, marking the scale, and left the room immediately. The assessors reset their sense of smell before each evaluation by sniffing coffee beans.

- *Sensory stability*

During 90-day storage, sensory evaluation of the DSTF prototypes and the control was carried out by an expert panel consisting of 5 assessors (2 women) with an average age of 30 years old. They were selected based on ISO standards (ISO 8586: 2012). They had experience in the sensory assessment of oil and fats using the quantitative descriptive analysis (QDA) method (Meilgaard *et al.*, 2007). Sensory analysis was implemented in a standard test room and individual booths (ISO 8589: 2007). Sample preparation and presentation were the same as described for the FCP method.

- *Statistical analaysis*

XLSTAT statistical program (Version 2016.02.28451, Addinsoft, NY, USA) was used for the statistical analysis of sensory data obtained by FCP. The FCP data were analyzed using Generalized Procrustes Analysis (GPA). The GPA is a multivariate heuristic method that consists of correcting individual data matrices to provide optimum comparability. The consensus matrix is an average of the individual matrices (Xiong *et al.*, 2008). Separate and consensus matrices are typically converted to principal component analysis (PCA) and displayed at a lower level to provide a good opportunity to compare individual data and visualize the consensus matrix. The PCA minimizes differences between assessors, identifies convergence or agreement between them, and summarizes the three-dimensional data set (Shaviklo, 2018). The data matrices of the two types of STF (including control and DSTF) were matched in 5 sensory characteristics for 10 assessors to find a consensus. Statistical Software (Kaysville, UT) NCSS 2021 was used for statistical analysis of physicochemical properties, and ROT data. Student T-test One-way-ANOVA test was used to examine the significant differences between the samples.

Results and Discussion

- *Physicochemical properties*

The DSTF and control prototypes had the same extract yield (80-82%). The residues were impurities like fried tail fat tissue. The yield depends on raw materials, rendering method and time, and oil purity. No significant differences were found between STF prototypes (D1, D2, D3), and the control (C) for physicochemical properties. The range of dry matter, moisture, fat, and ash of STF prototypes including control were 89.09-90.88%, 9.91-10.12%, 85.76-86.10%, and 0.11-0.12% respectively. The total nitrogen content of all STF prototypes was 0.31-0.33% and the melting point was 34.50-34.60 °C.

The proximate analysis of STF depends on breed, nutrition, growing conditions, and age of livestock (Ünsal and Yanlic, 2005). For this reason, the results of this study may not be in line with the other works. However, Ünsal *et al.*,(1995) reported 16.92% moisture, 79.09% fat, and 3.63% total nitrogen for morkaraman sheep. The value of total nitrogen of STF prototypes was negligible compared to the animal products and STF is not considered a source of protein.

The control and DSTF prototypes had an iodine value of 44.51-45.88, and a saponification saponification values of the control and DSTF with vegetable oils show a significant difference between them ($p<0.05$). The iodine values in vegetable oils are as follows: soybean oil 141-120, sesame oil 116-103, olive oil 80-88, cottonseed oil 113-99, corn oil 130-103, safflower oil 136-125, and sunflower oil 150-140. Among the types of vegetable oils, palm oil is very similar to STF, therefore its iodine value has been reported as 54-44 (Hashemi Tonekaboni, 1985). The saponification value of oils and fats varies according to the molecular weight of the triglycerides and their constituent fatty acids. For this reason, saponification value is used as an indicator to assess the average molecular weight of triglycerides and fatty acids that make up oil (Ünsal *et al.*, 1995).

- Sensory intensity assessment

GPA is a useful tool for sensory professionals to statistically analyze sensory data, especially those obtained by the FCP method. Because this method can match a large number of sensory attributes and their different types with assessors. In addition, GPA can be used to visualize or visually describe sample differences, convergence or agreement of ratings, and reproducibility of analysis (Xiong *et al.*, 2008).

Participants in this study identified and evaluated 5 sensory characteristics '*i.e.'* STF odor and flavor, bad off-odor/flavor, and acceptance. Of the total sensory characteristics, 40% were related to odor, 40% to flavor, and 20% to general acceptance. Figure 1 (a) indicates the evaluation of the assessor's performance. It shows that the panelist group was homogenous for evaluating the STF prototypes. Descriptive loading on the first and second factors of sample distribution on FCP data for STF prototypes showed that the assessors agreed on the evaluation of the samples. The distribution of STF prototypes in the consensual matrix indicates the difference between the samples (Figure 1, b).

Figure 2 shows the results of odor and flavor evaluation and sample acceptance. The first and second dimensions describe 99.97% of the total variance for the mentioned attributes. Looking at the space of sensory properties, it can be seen that the assessors have a similar ability to identify and evaluate the sensory intensity of STF, and the result of their consensus in Figure 2 is completely clear. In the product consensus space, as can be seen, DSTF and control have different sensory properties. The control had a strong STF odor and flavor, off-odor and off-flavor, and was less generally accepted. Conversely, DSTF has gained more acceptance points.

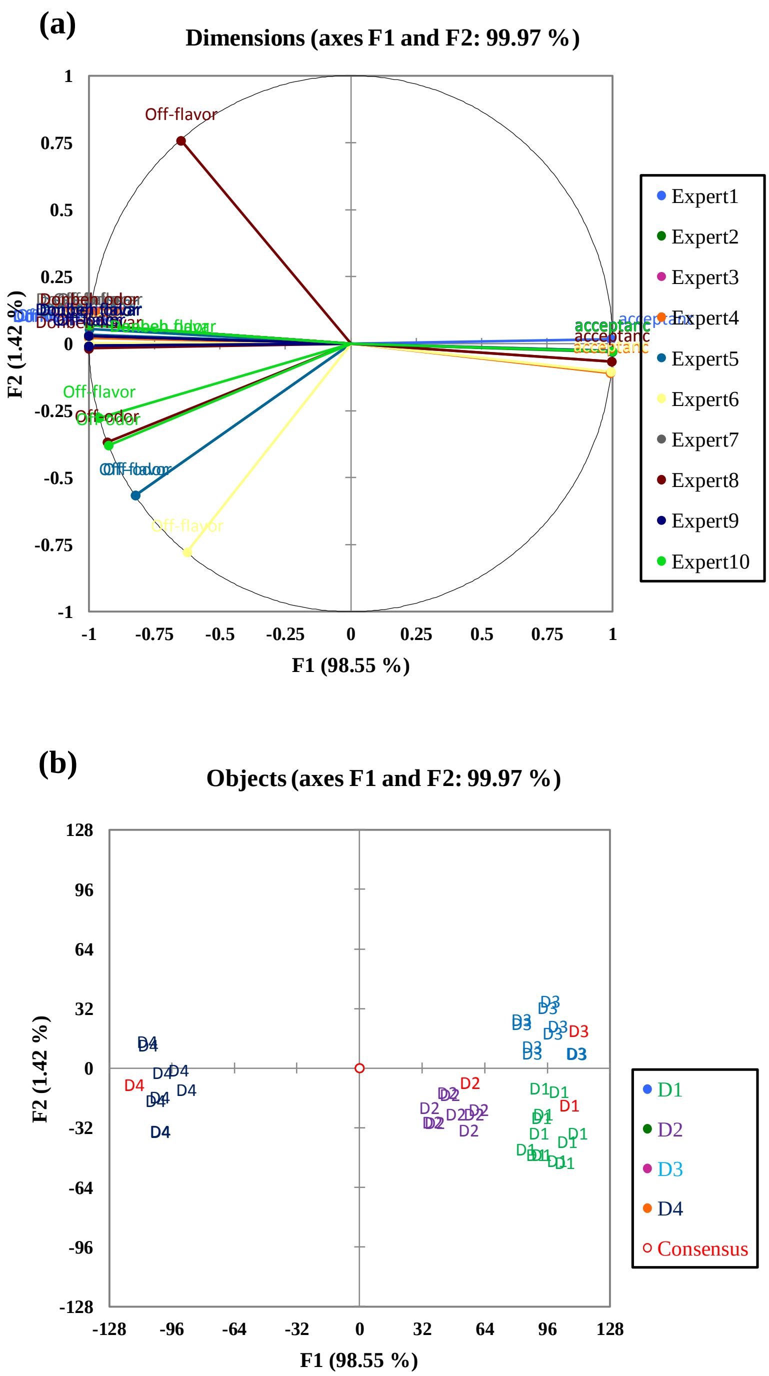

Fig. 1. (a) General Procrustes analysis plots indicate assessors' performances in evaluating DSTF and the control prototypes using the FCP method. (b) Consensus configuration on first (horizontal) and second (vertical) dimensions of the deodorized tail fat (D1, D2 D3) and control (D4) prototypes obtained using GPA from FCP data

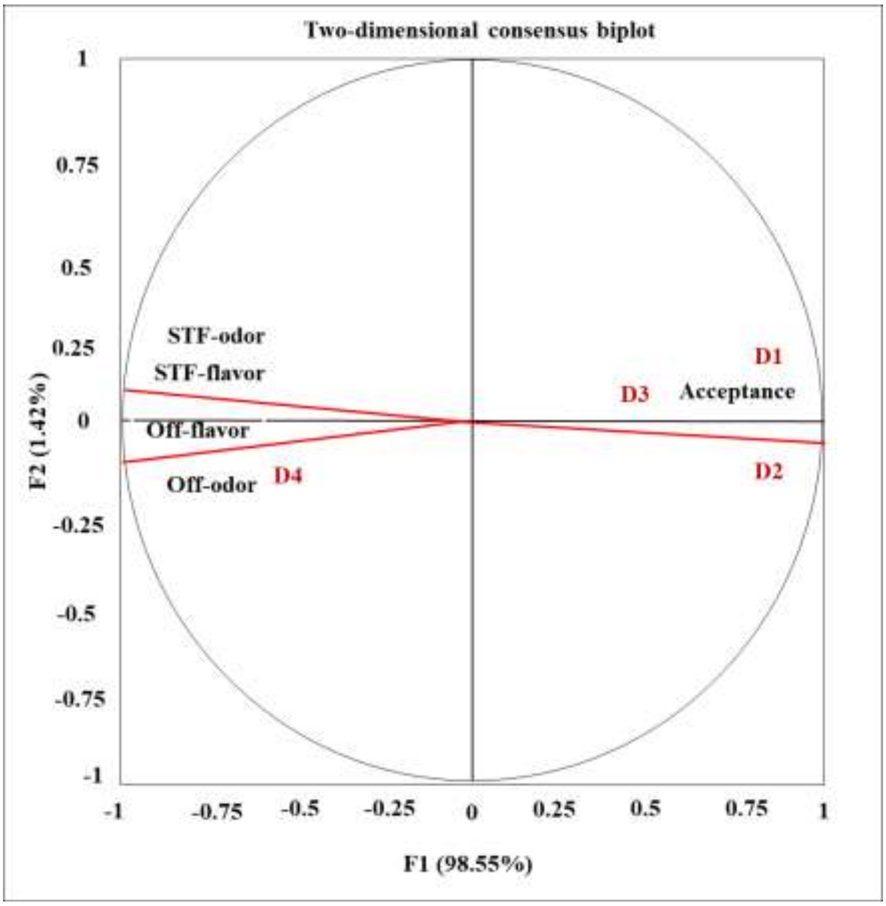

Fig. 2. Two-dimensional consensus biplot demonstrating consensus area of odor, flavor, and acceptance of deodorized tail fat (D1, D2 D3) and control (D4) prototypes.

The results of this study showed that the samples were well separated in the space defined by the first and second dimensions and showed that the assessors were able to determine the differences between the sensory properties of DSTF and control. It was also indicated that FCP is a suitable method for describing and quantifying the sensory properties of STF prototypes.

The severity of STF odor was measured using ROT and the results of the 9-point hedonic scale evaluation were presented in Figure 3. The results indicated that 90% of panelists disliked extremely and 10% disliked very much the control sample. On the other hand, most of the consumers liked DSTF prototypes. Among DSTF prototypes, D1 was accepted by the majority of the consumers (80%) followed by D3 (70%) and D2 (60%). Therefore, D1 was selected as the optimum deodorized prototype for the shelf and sensory stability study. Accordingly, D1 and control were stored 90-day at room temperature (25±2°C).

No similar studies were found on the sensory properties of STF oil to compare data from this study with theirs. However, Dosti *et al.*, (2020a) evaluated the odor severity of ultrasound-assisted deodorized STF samples using a 9-point hedonic method together electronic noise machine. They concluded that both methods showed a reduction in the odor severity of STF oil deodorized by the aforementioned deodorization process.

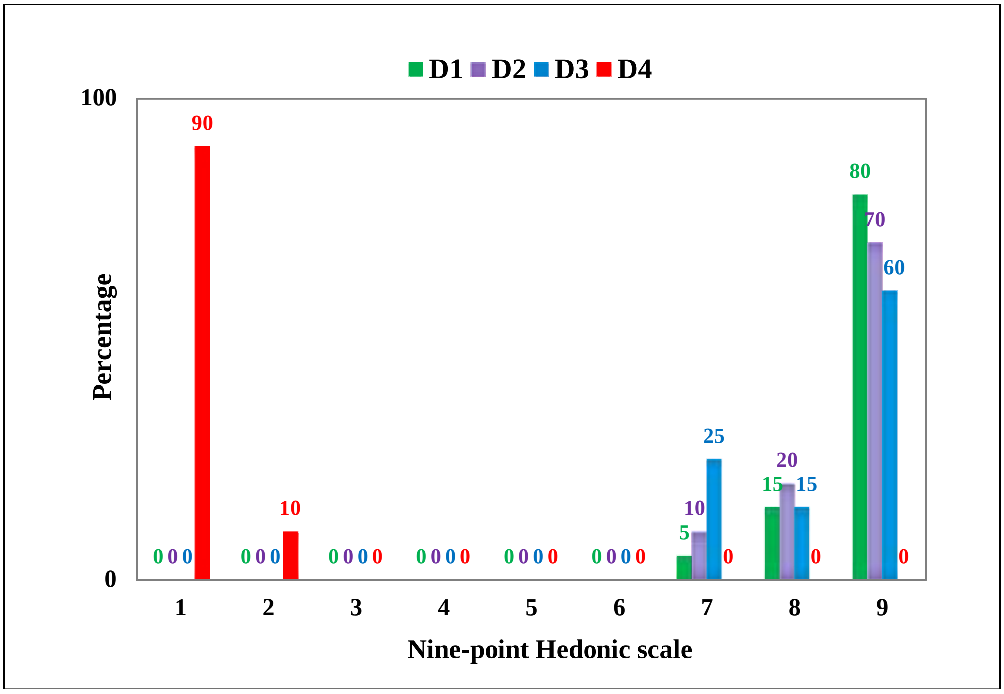

Fig. 3. Nine-point hedonic scale describing how deodorized tail fat (D1, D2 D3) and control (D4) prototypes are liked/disliked by the panelists who used Rome Odor Test.

- ***Fatty acid compositions of the STF prototypes***

A comparison of fatty acid profiles of the deodorized STF (D1) and the control showed that there was no significant difference (p>0.05) in the number of fatty acids in DSTF compared to the control (Table 1). The uniform composition of fatty acids and their very small difference before and after deodorization with the help of the selected process, emphasizes that this process does not have a destructive and oxidative effect or any chemical reaction related to the change in the structure of fatty acids in the STF prototypes. In total, it can be said that 36.69-38.67% of the fatty acids of STF prototypes are palmitic, stearic, and myristic saturated fatty acids, and the rest are unsaturated fatty acids, the most important of which is oleic acid (46.20%). Due to its high content of oleic acid compared to other oils in terms of nutritional value and stability, this oil has good potential for cooking. The predominance of oleic acid in the fatty acid composition of STF has been previously reported (Doosti *et al.*, 2020b).

The composition of fatty acids and the physicochemical properties of the STF of different breeds of Iranian sheep have been studied by researchers as cited by Emam Djome *et al.* (1995). The researchers reported that a large proportion of the fatty acids that make up STF are oleic acid, followed by palmitic acid and stearic acid, which are consistent with the results.

Ünsal and Yanlic (2015) reported the levels of oleic, palmitic, and stearic acids as 49.35, 23.16, and 11.23 percent, respectively. As can be seen, there are differences between his report, the results of Emam Djome *et al.* (1995), and also the results of this research which might be due to the differences in the composition and properties of the STF and thermal processing used.

As shown in Table 1, the amount of oleic acid in STF is higher than in other fatty acids, and this significant amount of oleic acid causes the use of STF to be considered more. After oleic acid, palmitic acid (23.50-23.08%) and myristic acid (3.35-3.3%) is the second and third fatty acids that are significantly present in STF.

The amount of trans elaidic fatty acid (C18: 1t) in both samples was zero. The level of trans linoleic acid isomer (C18: 2t) in the control was 0.71% which was decreased to 0.21% in DSTF. This significant decrease was due to wet rendering and solubility of fatty acids in water as described by Khuwijitjaru *et al.* (2002). The mechanisms of how this traditional process decreased the level of trans fatty acids in DSTF are unknown at present. One might speculate as to why Avicenna (*Persian physician, and the father of early modern medicine: 980-1037*) recommended this method for deodorizing STF.

Trans fatty acids are very important from a nutritional point of view (Hosseini Vashan *et al.*, 2016). Low trans fatty acids are naturally synthesized by the intestinal bacteria of ruminants such as cattle and sheep and are found in meat, milk, and dairy products after intestinal absorption (Kris-Etherton and Yu, 1997). However, the most important sources of production of trans fatty acids are thermal processes as well as the hardening of vegetable oils during hydrogenation (Masanori, 2002). The amount of trans fatty acids in food directly affects the incidence of cardiovascular disease in humans. If the intake of daily trans fat per person is more than 5% of total daily fat, by reducing the metabolism of triglycerides and inhibiting the metabolism of essential fatty acids, it reduces high-density lipoprotein (HDL) and increases blood low-density lipoprotein (LDL), and causes cardiovascular problems. The most important and abundant types of trans fatty acids are elaidic acid and vaccenic acid (Hu and Willet, 2001).

On the other hand, the effect of lauric and myristic fatty acids is more important than the total amount of saturated fatty acids. If the amount of these two fatty acids is higher, it can be considered an irritant for cardiovascular disease (Valsta *et al.*, 2004). Fortunately, in the present study, the amount of lauric acid was zero and the amount of myristic acid was very low, 3.31-3.75% (Table 1).

Table 1. Fatty acids profile (%) of control and deodorized tail fat

	Fatty acids	Control tail fat	Deodorized tail fat	P value
C4:0	Butyric acid	0.0	0.0	NS
C6:0	Caproic acid	0.0	0.0	NS
C8:0	Caprylic acid	0.0	0.0	NS
C10:0	Capric acid	0.0	0.0	NS
C12:0	Lauric acid	0.0	0.0	NS
C14:0	Myristic acid	3.31±0.18	3.75±0.75	NS
C14:1	cis Myristoleic acid	2.11±0.09	2.31±0.07	NS
C16:0	Palmitic acid	22.08±0.07	21.15±0.99	NS
C16:1	Palmitoleic acid	1.87±0.08	1.16±0.05	NS
C18:0	Stearic acid	12.77±1.07	12.50±0.87	NS
C18:1c	Oleic acid	46.20±1.17	45.76±0.99	NS
C18:2c	Linoleic acid	2.50±0.05	2.46±0.03	NS
C18:1t	Elaidic acid	0.0	0.0	NS
C18:2t	Trans-6- linoleic acid	0.71±0.03	0.21±0.01	p<0.05
C20:0	Arachidic acid	0.86±0.06	0.84±0.09	NS

The numbers are average of 3 analyses. NS: not significant.

Many researchers believe that STF may have a positive effect on consumers' health due to its fatty acid compositions and its stability against oxidation increasing its application in formulated meat products (van Harten *et al.*, 2016; Mahachi *et al.*, 2020; Doosti *et al.*, 2020b). According to the recommendations of traditional medicine and research, long-term consumption of animal fats including STF reduces the level of blood fats. It has been reported that the risk of coronary heart disease with the consumption of such oil is about 30% less than that of hydrogenated vegetable oil (Jafarnejad *et al.*, 2001).

- ***Physicochemical properties of the prototypes within the storage***

Physicochemical properties of deodorizes STF (D) and the control (C) during 90 day-storage are shown in Table 2. No significant difference was reported for melting point among prototypes during 30-day storage. But it was increased significantly on days 60 and 90 of storage.

DSTF (D) and control (C) had a significant difference for PV, TBARS, and FFA after production and during 90-day storage at room temperature. The two prototypes had the same levels of iodine value and saponification index up to 60 days of storage, but significant differences were found on days 60 and 90 in control samples. The PV, TBARS, and FFA values were increased within the storage in the control.

During storage, lipid degradation continues to be hydrolytic and autoxidative, and many complex chemical reactions occur. As a result physicochemical properties like FFA, PV, TBARS and iodine values, melting point, and saponification index, can change, and these parameters have a critical function in reducing the quality of fatty products (Ünsal *et al.*, 1995; Ghanbari *et al.*, 2004; Lashgari and Javanmard, 2014).

Table 2. Physicochemical properties of STF and DSTF oil within 90 days of storage at room temperature (25±2°C)

Samples*	PV	TBARS	FFA	MP	IV	SI
C0	0.11±0.01[a]	0.22±0.02[a]	0.17±0.08[a]	34.50±1.24	45.88±1.24	176.23±2.14
D0	0.08±0.01[b]	0.15±0.01[b]	0.10±0.06[b]	34.60±1.11	44.12±1.52	177.31±2.26
	p≤0.05	*p≤0.05*	*p≤0.05*	*NS*	*NS*	*NS*
C30	0.35±0.02[a]	0.26±0.01[a]	0.19±0.05[a]	34.92±1.35	44.72±1.24	171.15±2.21
D30	0.10±0.01[b]	0.17±0.03[b]	0.11±0.07[b]	34.55±1.26	44.33±1.52	177.12±1.84
	p≤0.05	*p≤0.05*	*p≤0.05*	*NS*	*NS*	*NS*
C60	0.81±0.03[a]	0.30±0.03[a]	0.18±0.05[a]	35.55±0.99[a]	41.24±1.24	188.01±2.21[a]
D60	0.07±0.02[b]	0.16±0.04[b]	0.10±0.03[b]	34.50±0.87[b]	45.62±1.52	176.90±1.84[b]
	p≤0.05	*p≤0.05*	*p≤0.05*	*p≤0.05*	*NS*	*p≤0.05*
C90	0.55±0.01[a]	0.35±0.04[a]	0.31±0.03[a]	36.45±0.78[a]	39.77±1.24	161.65±2.21[b]
D90	0.08±0.03[b]	0.17±0.05[b]	0.11±0.04[b]	34.58±0.85[b]	45.23±1.52	176.35±1.84[a]
	p≤0.05	*p≤0.05*	*p≤0.05*	*p≤0.05*	*NS*	*p≤0.05*

[*]C: control; D: deodorized. Numbers (0, 30, 60, 90) indicate storage days.
PV: Peroxide value (meq g O2/kg fat); TBARS: Thiobarbituric acid reactive substances (mg malonaldehyde/kg fat); FFA: Free fatty acid (%); MP: Melting point (°C); IV: Iodine value (g iodine/ 100 g F); SI: saponification index (mg KOH/g F). Values are means of 3 analyses. Different superscripts show significant differences within a column section ($p < 0.05$). Results are presented as means values (n = 6).

The levels of melting points of STF prototypes are different from other works cited by Ünsal *et al.,* (1995). It was found that the melting point of the control increased during the storage time (Table 2). Because autoxidation of the unsaturated fatty acids within 90-day storage increased the levels of saturated fatty acids. The melting point values of STF depends on the animal breed, age, and nutrition, therefore the melting point of the STF of different sheep species, are different from each other (Ünsal *et al.,* 1995).

No similarity is observed when comparing the iodine values of some common animal fats such as mutton tallow (31-47), beef tallow (32-47), and butter (26-45), with the STF prototypes (Hamilton, 1989). This difference depends on the values of the saturated and monounsaturated fatty acids of the products (Ünsal *et al.,* 2015).

Autoxidation of the polyunsaturated fatty acids during storage may increase saturated fatty acid values and decrease the iodine values within the storage (Ünsal *et al.,* 1995; Lashgari and Javanmard, 2014; Ünsal *et al.,* 2015). These decreasing effects are consistent with the incremental values observed at melting points during 90 days of storage. The results indicated that saponification indexes of the control were decreased at the days 60 and 90 of storage (Table 2). The higher FFA value in the control during 90-day storage is due to autooxidation and lipolytic deterioration. Increasing the FFA value can increase the saponification index. However, FFA contents are oxidized during storage time and may decrease the saponification levels. Saponification indexes of the STF are different from those reported for some common animal fat such as beef visceral fats (190-200), sheep fat (192-195), and butter (216-235) cited by Swern (1979) and Hamilton (1989). Deodorized STF using onion, rose water, apple pieces, and cloves were stable during storage possibly due to the ingredients used. The antioxidant activity of these ingredients has been reported previously.

- *Sensory stability of the STF prototypes*

Figure 4 describes sensory changes of deodorized tail fat (D1, D2 D3) and control (C) prototypes stored for 90 days at 25±2ºC as evaluated by an expert panel. PCA diagrams provide unique information that can be used independently of other graphical methods. Since it is displayed as a set, it is more effective and the charts complement each other. In PCA diagrams, each component is described as the maximum possible variance, and each new component is based on the previous component. The higher the percentage of variance described, the more reliable the information obtained (Shaviklo, 2018).

Multivariate analysis indicated that 97.5% of the distribution or dispersion of sensory data between the DSTF and control prototypes was characterized in the first two principal components. The PCA plot (Figure 4) indicated the effect of deodorization and storage time on sensory attributes. The control (C) and DSTF prototypes are situated on different sides of the PCA plot. As can be seen, DSTF prototypes are located in the upper left half of the graph and side by side, and their predominant sensory characteristic is acceptance. While the control samples are placed in the upper right half of the chart and next to each other, and their predominant sensory characteristics are the smell and taste of oil and the unpleasant smell and taste. Also, oxidation indices including PV, TBARS, and FFA are located in that area and indicate the oxidation of control samples. These indicators are higher in the control sample

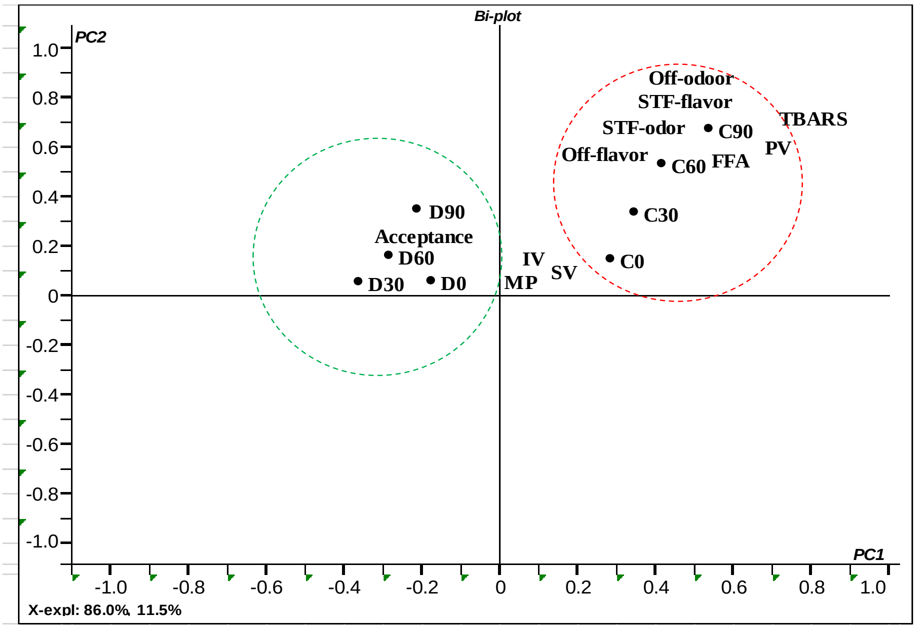

Fig. 4. Principal component analysis (PCA) describes sensory changes of deodorized tail fat (D) and control (C) prototypes stored for 90 days at 25±2ºC as evaluated by an expert panel. Numbers show the storage days.

on day 90 of storage indicating that odors, flavors, and acceptance of the control were affected by the storage time.

The intensity of off-odor, off-flavor, and STF odor and flavor increased at the end of the storage in the control due to the development of lipid oxidation which was significant. It is documented that the sensory attributes of animal fat and oil such as odor, flavor, and acceptance during storage are significantly affected by lipid oxidation (Mahachi *et al.*, 2020). In order to reduce or eliminate lipid oxidation and thereby preserve sensory quality during long-time storage, the use of natural antioxidants in the product formulation has been recommended. The use of natural ingredients in increasing the shelf life of STF has been reported (Ghanbari *et al.*, 2004; Lashgari and Javanmard, 2014).

It can be said with confidence that the additives used in the first recipe (D1) have antioxidant activities and have caused the sensory and oxidative stability of the DSTF. In confirmation of this statement, the antioxidant activity of different spices including onion and clove (Yashin *et al.*, 2017), and apple peels (Wolfe *et al.*, 2003) have been reported. The antioxidant properties of rose water are due to the existence of flavonoids, tannins, triterpenoids, and saponins in this product (Safia *et al.*, 2019). Vinegar is also a natural antioxidant, containing bioactive compounds such as flavonoids, phenols, and organic acids (Bakir *et al.*, 2016). The combination of these compounds masked unpleasant odor and flavor and protected the DSTF oil from oxidation during storage. This reveals that traditional recipes are knowledge-based and can be used in the food industry to improve food quality.

Conclusion

The STF attracts more attention from the public, and the evaluation of its sensory attributes is very important to developing more acceptable products. The results of this study showed that the first method, the recipe of which is attributed to Avicenna, to deodorize STF or minimize its odor intensity has been very effective and this will help the sensory marketing of this product. The FCP together with the ROT proved to be fast and valid methods for describing the sensory attributes of STF. On the other hand, the low level of trans fatty acids in STF prototypes can alleviate the concern about negative publicity against this product. Therefore, according to the satisfactory results of the shelf and sensory stability, the method of STF deodorization and its sensory evaluation methods can be proposed to the industry to increase the scale of production. Sensory marketing in target bazars to evaluate consumers' acceptance is recommended for the commercialization of the product.

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