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ORIGINAL PAPER

Assessing the effect of zero-trans shortenings on the physicochemical and functional properties in rice cookies

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Abstract

The aim of this study was to investigate the physicochemical and sensory properties of rice cookies prepared from zero trans shortenings. The shortenings were prepared from Ardeh oil and Palm stearin blends a ratios of 50:50 and 60:40 (%weight) by chemical interestification and then the cookies were made from them compared with a sample prepared from the commercial shortening (c-sh) available on the market. The fatty acids profile, slip melting point, solid fat content and chemical properties (peroxide value and free fatty acids) were determined in shortenings. The textural (hardness, adhesiveness) and rheological characteristics of shortenings were determined using texture analyzer and rheometer, respectively. Ardeh oil due to its high unsaturated fatty acid content [oleic (39.48%) and linoleic acids (42.31%)], and natural antioxidants such as Tocopherols (507 mg/kg) as well as good aroma and taste improved the physicochemical and functional properties of shortenings. Textural characteristics (hardness, fracturability) during storage and sensory attributes (texture, flavor and overall sensorial acceptance) as well as chemical properties (peroxide value, pH) of cookies prepared from zero-trans blends (0.2–0.3% trans acids) were better than those of a commercial shortening (4.74%trans fatty acids). Thus, it can be concluded that the produced shortenings used in rice cookies improved the product quality, also due to low levels of saturated fatty acids and zero trans fats, thus it has a potential to improve well-being.

Keywords Bakery shortening · Rice cookie · Physicochemical properties · Texture · Storage

Introduction

Rice (Oryza Sativa) is one of the oldest gluten-free cereals in the world and can be used to produce food suitable for celiac patients [1]. People with celiac disease cannot eat gluten, a protein found in wheat, barley, and rye; instead, they can use food such as rice, corn, potatoes, as well as some flours such as millet, sorghum, cassava, amaranth and buckwheat [2]. Rice flour can provide a comparable amount of fiber and protein without the presence of gluten [3]. Rice cookie is one of the traditional Iranian sweets which has high amount of shortening. Indeed, shortenings with lubricating properties, contribute to better texture, flavor and mouth feel in the final products [1]. Concerns about the adverse effects of trans fatty acids, including an increased risk of cardiovascular disease and legal requirements to include trans fatty acids in food labels have drawn the attention of both researchers and industry owners to alternative methods of hydrogenation [1]. Interesterification is a useful way to achieve this [4].

Interesterification modifies the distribution of fatty acids on the glycerol backbone without changing their chemical composition and can be used to improve spreadability of butterfat and the production of margarine, shortening [5]. Many types of vegetable oils can be used in shortening production [6]. Palm stearin, as a solid component is suitable for shortening production due to its high-saturated fatty acids (65.29%) and high oxidative resistance [7]. Ardeh oil is obtained from sesame seeds by a different method of cold pressing, without any chemical additives [8]. Ardeh oil contains a large amount of unsaturated fatty acids including linoleic acid (42%), oleic acid (40%), palmitic acid (11%), and stearic acid (5%) and vitamin E, so it has a beneficial effect on health [9]. Hence, the purpose of this study was to evaluate the physical, chemical and sensory characteristics of rice cookies that were prepared with interesterified

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shortenings and compared the findings with that of standard cookie produced with commercial shortening.

Materials and methods

Materials

Refined, bleached and deodorized (RBD) palm stearin (PS) and commercial shortening from Behshahr Food Industry Company (Tehran, Iran) and Sesame seeds (*Sesamum indicum* L.), a Pakistani variety were obtained from Shirreza Company. Sodium methoxide (Merck) was applied as the catalyst and all reagents and solvents were of analytical or chromatographical grade. Rice flour was produced from white rice (Hashemi genotype, local type of Guilan province, Iran).

Ardeh oil extraction

Ardeh oil was obtained from sesame seeds after peeling and wet grinding. In the peeling machine, the bran was separated from the kernels and then was soaked in salt water, which caused the bran to rise to the surface of the water. The residual water in the grains was separated via centrifugation and then toasted inside an oven at 90 °C for 1.5 h. In the milling process sesame extract and oil was obtained, which is easily separable due to density difference [10].

Production of shortening samples

Following the thorough melting of PS at 65 °C and homogenization for 10 min, then the Ardeh oil and the palm stearin blended in the following ratios: 50:50, 60:40 (w/w). The interesterification reaction was carried out under vacuum by a rotary evaporator at 70 °C for 60 min in the presence of 0.5 g/100 g of sodium methoxide as a catalyst [11]. Anhydrous sodium sulfate was used to remove residual water and then filtered with a Whatman filter paper No 2.

Interesterified blends were heated to a temperature above the melting point. Next, the samples were stirred and then placed in a container of ice and salt at 18 °C and were well-kneaded to reach the desired texture; the samples remained at 27 °C for 48 h, then used for analysis [12].

Rice flour preparation

Wet milling method was used to produce rice flour. Initially, the rice was washed with water and then it was soaked in water for 8–10 h, and then placed on a clean cloth in the sun to dry. At this stage, rice grains were milled in a household milling machine (Matheo EG 111S, Germany). Thereafter, a sieve with a mesh size of (125 mμ) was used to achieve the appropriate particle size [13].

Shortening properties

Fatty acid profile

The fatty acids profile of the Shortenings was determined using Gas chromatographic method (SHIMADZU model Nexis 2030). The extracted fats/oil was used to prepare Fatty acid methyl esters (FAME) using the AOCS Ce 2-66 method and then analyzed using AOCS Ce 1e-91 method [14]. The GC was equipped with a FID detector and a separator capillary column (Dikmacap-2330: 60 m × 0.25 mm i.d.). The injection temperature, flame ionization detector and oven temperature were 250 °C, 260 °C and 200 °C, respectively. The carrier gas used was hydrogen at a flow rate of 1.0 mL/min. The identification and quantification of the peaks were performed by comparison with the retention times and areas of the corresponding standards [5].

Tocopherol in Ardeh oil

The tocopherol was identified and quantified in Ardeh oil via high performance liquid chromatography (HPLC) according to AOCS Standard method Ce8-89 [10]. The HPLC used had a Visible—UV detector at 295 nm and LiChrospher® 100 RP-18 (5 µm). Acetonitrile: Acetone: Water was used as a mobile phase (47.5: 47.5: 5). All solvents were specific for HPLC and the system was isocratic with a flow rate of 1 mm/minute at 25 °C. The sample dilution was performed with acetone (10: 1) and the injection rate was 20 µl/min. Tocopherols were quantified by external standard with alpha, beta, gamma and delta tocopherols, high purity standards (Merck). Standards' purity was monitored by measures of $E^{1\%}_{1\ cm}$ in methanol in an HP 8453 spectrophotometer. Tocopherols were identified by co-injection of tocopherol standards by comparison of the retention times and through the addition of standards in the samples. Quantification was performed by plotting calibration curves from tocopherol standards and comparing the peak area of the correspondent peaks in samples.

Slip melting point

The slip melting point (SMP) of shortening was measured using the open capillary tube method, according to the AOCS Cc 3b-92 method [14].The capillary tubes were filled with 1 cm height column of fat melted at 10 °C above their melting point then, the filled capillary tubes were chilled at 5 °C for 16 h before the measurements.

Solid fat content (SFC)

The SFC profile was measured using a Minispec pulsed nuclear magnetic resonance (pNMR) spectrometer (Bruker Spectrospin Ltd, Conventry, UK) according to the AOCS method Cd 16b-93 at various temperatures (0 °C,10 °C, 20 °C, 30 °C, 35 °C, 40 °C and 50 °C) [15].

Chemical properties

Peroxide value (PV) and Iodine value (IV) were determined according to AOCS cd 8-53 and AOCS Cd 1c-85 methods [14], respectively. The induction periods (IP) were measured according to AOCS Cd 12b-92 using a Metrohm Rancimat instrument model 743 (Herisau, Switzerland) at 110 °Ca [14].

Texture analysis of the shortening

The texture characteristics (hardness, adhesiveness) of shortenings were determined using texture analyzer (Brookfield.CT3, USA) fitted with a Cylinder probe: Brookfield TA 15°–45° Perspex (acrylic plastic) Cone mode: Normal (Measure forcein compression) load cell: 10000 g with speed: 1 mm/s, distance: 4 mm and trigger: 4.5 g, according to AOCS method Cc16-60 [16].

Rheological analysis of the shortening

Rheological analysis was carried out using a Physica MCR 301 rheometer (Anton-Paar, GmbH, Graz, Austria). The samples were evaluated using a 40 mm -in-diameter serrated plate with a gap of 2 mm. The strain sweep test conducted to determine the Linear ViscoElastic (LVE) range at 0.001–100%, 1 Hz, and 25 °C. The frequency sweep was performed at 25 °C and 0.1–20 Hz. The thermal behavior was determined using the dynamic temperature sweep test at 1 Hz and 5–60 °C [17].

Cookie preparation

Rice cookie samples were prepared according to Iran's national standard method No. 1819 (1977). Three types of cookies, containing 50:50, 60:40 blends and commercial shortening were baked. The ingredients of the cookies were weighed according to the following formula rice flour, shortening, sugar, egg yolk and vanillin in ratios 100, 50, 50, 6 and 1 g (% weight), respectively. The shortening and sugar were mixed together by a hand mixer at a medium speed for 1–2 min (kitchen mixer, model Techno Te-65, China). Next egg yolk was added and mixed for another 20–30 s, after which the rice flour was added to the mixture. It was kneaded for 5–10 min and then placed in the refrigerator overnight (39°F or 4 °C).The dough was rolled into a small 2.5 cm ball and then the cookie was flattened into a small disk. The cookie dough was baked at 170 °C for 20 min. Cookie preparation was done in triplicate and storage at room temperature until analysis.

Texture analysis of the cookie

The texture characteristics of rice cookies in terms of hardness and fracturability were measured using a Stable Micro Systems TA4/1000; D texture analyzer (Brookfield.CT3, USA) fitted with a 5 mm cylinder probe on days 1, 7, 14 and 21. Nine determinations from the triplicate samples of each set were carried out. The hardness value was considered as the area under the curve obtained and the linear distance was taken as an indication of fracturability. The analyses were conducted at a test speed of 1 mm/s, distance of 10 mm, and load cell of 1 kg, according to AACC method 74-09 [18].

Physical and chemical analyses of the cookie

The moisture, pH and ash contents of the cookies were measured using AACC 44-15A, 02-52 and 08-01 [18].The peroxide value (PV) on the oil extracted from the cookie was determined according to AOCS method Ca 5a-40 [14].

Sensory evaluation

The samples were evaluated by twenty trained panelists for appearance, flavor, texture and overall acceptance by Graphic Ration Scale method [19]. In this method, a horizontal line or ruler was used, one side for the lowest acceptance and the other for the most accepted approval, divided into equal intervals. The panelists expressed their opinion on the product with a line perpendicular to the horizontal line [20]. The panelists were students and university employees of the Department of Food Science and Technology of the Sari branch in age range 20 to 50 years. The assay was performed in a sensory room with white fluorescent lighting at room temperature. The panelists were given the necessary explanations to resolve the ambiguities. Means ± SD were evaluated for all types of cookies.

Statistical analysis

One-way analysis of variance (ANOVA) was performed and the means were compared using Duncan's multiple range test. All analyses were conducted in triplicate. Data analysis was performed using SPSS software (IBM SPSS Statistics, Version 22, New York, NY, USA. Differences were considered significant at $p < 0.05$.

Results and discussion

Properties of the shortening

Table 1 shows the fatty acid composition of the two bakery-shortening samples, commercial shortening and raw materials. The main fatty acid in palm stearin was palmitic acid (C16:0, 58.75% w/w), while in Ardeh oil it was linoleic (C18:2, 42.31% w/w) and oleic acids (C18:1, 39.48% w/w) which reported to have many health benefits [9]. The major fatty acids in bakery shortenings (50:50, 60:40 blends) were palmitic (37.91%, 31.1%) (w/w) and oleic acids (31.82%, 33.06%) (w/w), respectively; while in commercial shortening it was palmitic acid (31.2% w/w). The saturated fatty acids (SFA) content of shortenings was found to be 37.39% (w/w) in 60:40 blend and 53.45% (w/w) in the commercial shortening (c-sh). The predominant SFA in shortenings was palmitic acid, as reported in Table1.The ratio of saturated to unsaturated fatty acids (UFA/SFA) in palm stearin and Ardeh oil were 0.52 and 4.87, respectively. As the amount of palm stearin in the blends increased, so did the total saturated fatty acids. Thus, palm stearin as a solid component was suitable for shortening [7], while in the Ardeh oil improved the physical and nutritional properties of the products [8]. The highest ratio (UFA/SFA) was observed in the 60:40 blend, due to the higher Ardeh oil content [7]. Trans Fatty acid (TFA) content of 50:50 and 60:40 shortenings were less than 1%, thus, by definition the samples could be regarded as zero trans fat [21, 22]. While TFA of commercial shortening was less than 5% and it is known as a low-trans fat [17].

The presence of tocopherols as an antioxidant in food, especially vegetable oils, is important. Adhikari et al. [23] were measured the amount of tocopherol in rice bran oil, coconut and palm stearin and its values were 153, 44 and 19 ppm, respectively. Fisk et al. [24] reported that the amount of tocopherol in sunflower oil was 214–392 ppm. The value was founded for total Tocopherol was 507 ppm in Ardeh oil, the major tocopherol homologs in all varieties was γ-tocopherol (500 ppm), while α-tocopherols (7 ppm) was very small components, which stabilized the oil against oxidation reactions[9].

Table 2 provides the physicochemical properties of shortening samples. The free fatty acid (FFA) contents

Table 1 Fatty acid composition of bakery-shortening samples and raw materials

Fatty acids (%)			(Ardeh /PS) ratio		
	PS	Ardeh oil	60:40	50:50	C-Sh
C10:0	0.04 ± 0.01	ND	ND	ND	ND
C12:0	0.26 ± 0.01	0.040 ± 0.00	0.09 ± 0.00	0.08 ± 0.00	0.2 ± 0.01
C14:0	1.27 ± 0.02	0.04 ± 0.01	0.56 ± 0.04	0.71 ± 0.04	0.9 ± 0.04
C15:0	0.05 ± 0.00	ND	0.03 ± 0.00	ND	0.04 ± 0.00
C16:0	58.75 ± 0.5	11.39 ± 0.4	31.1 ± 0.4	37.91 ± 0.01	31.2 ± 0.1
C16:1	0.14 ± 0.2	0.33 ± 0.1	0.20 ± 0.01	0.29 ± 0.1	0.1 ± 0.1
C17:0	0.12 ± 0.00	0.05 ± 0.00	0.09 ± 0.1	0.05 ± 0.00	0.08 ± 0.00
C17:1	0.04 ± 0.00	0.03 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	0.04 ± 0.00
C18:0	4.34 ± 0.01	4.80 ± 0.1	4.87 ± 0.01	4.51 ± 0.01	20.8 ± 0.1
C18:1	27.35 ± 0.3	39.48 ± 0.4	33.06 ± 0.5	31.82 ± 0.4	28.7 ± 0.04
C18:2	6.64 ± 0.01	42.31 ± 0.1	26.70 ± 0.04	23.25 ± 0.03	12.3 ± 0.01
C18:3	0.14 ± 0.00	0.36 ± 0.00	0.41 ± 0.04	0.21 ± 0.01	0.5 ± 0.00
C20:0	0.32 ± 0.01	0.44 ± 0.1	0.46 ± 0.01	0.24 ± 0.01	0.1 ± 0.00
C20:1	0.16 ± 0.01	0.32 ± 0.1	0.18 ± 0.00	0.22 ± 0.01	0.19 ± 0.01
C22:0	0.08 ± 0.00	0.08 ± 0.00	0.14 ± 0.00	0.06 ± 0.00	0.07 ± 0.00
C22:2	0.01 ± 0.00	ND	0.04 ± 0.01	0.12 ± 0.01	ND
C24:0	0.06 ± 0.00	0.15 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.06 ± 0.00
C24:1	0.01 ± 0.00	ND	0.04 ± 0.01	0.05 ± 0.00	0.02 ± 0.00
Total trans	0.22	0.18	0.3	0.2	4.74
ΣSFA (%)	65.29^{a}	16.99^{b}	37.39^{c}	43.61^{d}	53.45^{e}
ΣMUFA (%)	27.7^{a}	40.16^{b}	35.3^{c}	32.41^{c}	29.01^{d}
ΣPUFA (%)	6.78^{a}	42.67^{b}	26.99^{c}	23.58^{c}	12.8^{d}
UFA/SFA	0.528^{a}	4.87^{b}	1.63^{c}	1.28^{c}	0.78^{a}

C-sh Commercial shortening; *SFA* saturated fatty acids; *MUFA* monounsaturated fatty acids; *UFA* unsaturated fatty acids; *PUFA* polyunsaturated fatty acids; *ND* not detected. Mean values ± SD (n = 3)

Table 2 Physicochemical properties of bakery-shortening samples

Physicochemical properties	50–50	60–40	C-Sh
FFA (%)	0.08 ± 0.00^{a}	0.078 ± 0.005^{a}	0.1 ± 0.00^{b}
PV (meq O_2 kg^{-1})	0.35 ± 0.001^{a}	0.339 ± 0.001^{a}	0.3 ± 0.01^{a}
IV (g I_2 100 g^{-1})	73.96 ± 1.45^{a}	79.6 ± 1.509^{a}	53.1 ± 0.1^{b}
IP_{110} (hour)	12.85 ± 0.5^{a}	10.11 ± 0.3^{a}	24.2 ± 0.3^{b}
SMP(°C)	48 ± 0.001^{a}	46 ± 0.001^{a}	51.4 ± 0.2^{b}

Mean values bearing the same superscript in the same row do not differ significantly (P > 0.05)

Mean values ± SD (n = 3)

of the shortenings ranged from 0.078 (% as oleic acid) to 0.1%. There were no significant differences in the FFA of two blends (P > 0.05) but there were significant differences between the blends and c-sh which could be related to the quality of the raw materials used and storage conditions (> 0.05% as oleic acid) [7].

The PV of the shortenings ranged from 0.3 mEq O_2/kg to 0.35 mEq O_2/kg. These values were lower than the maximum amount of acceptable value for shortenings (2.00 mEqO_2/kg) with all samples lying within the standard range [25].

The IV ranged from 73.96 g/100 g in the 50:50 blend to 53.1 g/100 g in the c-sh. The proportion of saturated fatty acids in the blends decreased, while the iodine number increased; however by increasing IV, the oxidative stability IP_{110} (hour) decreased. A high oxidative stability was observed in the shortening (50:50 blend), due to the high amount of saturated fatty acids. Other researchers achieved similar results including Soares et al. [26]. who investigated the effect of chemical interesterification using blends of palm stearin and palm olein; Oliveira et al. [7]who examined palm stearin and patawa oil and Da silva et al. [5] who worked on palm stearin and olive oil.

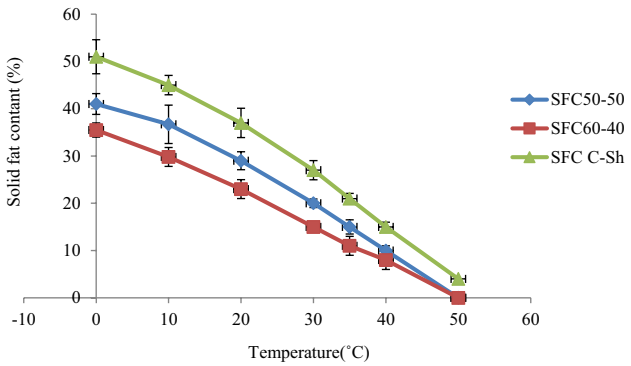

Fig. 1 Solid Fat Content of bakery-shortening samples

Figure 1 displays the SFC profiles in the shortenings samples. The SFC ranged from (60:40 blend: 29.75, 21, 16.7 and 9.5%) and (50:50 blend: 36.7, 27.1, 17.9 and 10.7%) at 10 °C, 20 °C, 30 °C and 40 °C and the SMP was 46 °C and 48 °C, respectively. The SFC in c-sh ranged from 45, 37, 27 and 15% at 10 °C, 20 °C, 30 °C, 40 °C, respectively and SMP was 51.4 °C. The high melting point and SFC range indicates the presence of high amounts of saturated fatty acids in the commercial sample [27]. According to the SMP and SFC of interesterified 60:40% and 50:50% blends of Ardeh oil and palm stearin can be used in producing all-purpose and pie crust shortenings, respectively [12].

Textural and rheological properties of the shortening

Table 3 shows the hardness and adhesiveness as the textural properties of bakery shortening. The hardness values of the two shortenings were lower than those of commercial shortening ($p < 0.05$). The highest hardness was found in c-shortening (36.66 g) while the lowest content was 17.66 (g) in 60:40 blend. Generally, hardness is associated with the melting point and SFC [21]. Indeed, increasing the amount of saturated fatty acids in shortenings results in elevated melting point and SFC thereby causing greater hardness [17]. Similar results were observed in the study by Ribeiro et al. [28], who used soybean oil and its fully hydrogenated soybean oil to produce zero-trans fat. Commercial shortening had the highest adhesiveness values while the lowest content was in 60:40 blend. This result could be due to the fact that c-shortening had a higher tri-saturated triacylglycerol (TAG) than 60:40 and 50:50 blends, while 60–40 blend shortening contained a higher ratio of tri-unsaturated TAG. These results were in line with the research of Kanagaratnam et al. [29], Yanty et al. [30] who investigated the shortening based on palm oil.

The rheological properties for the shortening samples were investigated. Other researchers previously reported non-Newtonian behavior for shortening [17, 31]. Increasing the amount of strain resulted in a decrease in the amount of G′ and G″. The linear viscoelastic region (LVE) on shortening was determined by measuring the strain sweep. Table 4 describes the power law model.

Table 3 Hardness, Adhesiveness of baking-shortening samples

Parameters	C-Sh	50–50	60–40
Hardness(g)	36.66 ± 2.08^{a}	25.33 ± 2.08^{b}	17.66 ± 1.52^{c}
Adhesiveness (g)	16 ± 0.10^{a}	12 ± 1.50^{b}	8.5 ± 0.50^{c}

Mean values bearing the same superscript in the same row do not differ significantly (P > 0.05)

Mean values ± SD (n = 3)

Table 4 The LVE range, G′ at the end of LVE range, and Power Law model parameters of baking-shortening samples

Samples	Srain sweep		Frequency sweep (Power Law model) ($G' = a\omega^b$)		
	γ_1 (%) (Pa)	G′LVE	α (Pa)	b	R^2
50–50	0.112[a]	625712[a]	632,520 [a]	0.04564[a]	0.959
60–40	0.192[b]	216284[b]	217220[b]	0.06860[b]	0.954
C-sh	0.081[c]	693653[a]	685320[a]	0.04389[a]	0.974

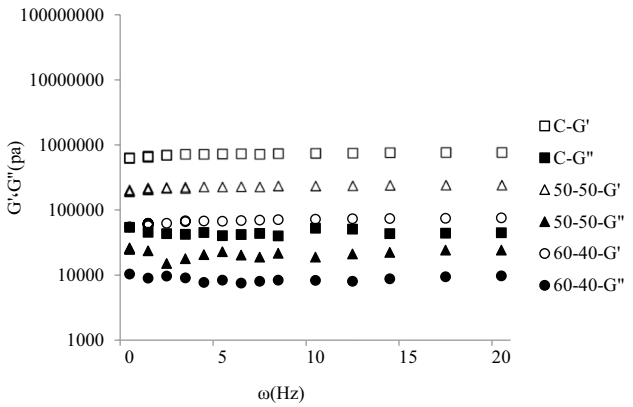

Fig. 2 Frequency sweep test of bakery-shortening samples

$$G' = a\omega^b \quad (1)$$

a: the coefficient shows the magnitude of G′. b: shows the slope of the relationship between modulus and frequency. Due to the high explanatory coefficients, this model has a good fit with the flow behavior of the sample. The coefficients of determination (R^2) were 0.95 or higher for all shortenings. All samples had low γ_1 values, indicating a short LVE length and low stability of the samples in the strain range γ_1 [31]. The highest "α" was found in c-shortening (685,320 Pa) while the lowest content was 217,220 Pa in 60:40 blend. The above phenomena could be attributed to high saturated fatty acid content, causing a high G′. If "b" is approximately equal to 1, the system behaves as viscous materials, while low b values are characteristic of elastic materials thus shortenings had viscous behavior [17].

Figure 2 shows the frequency sweep test of bakery-shortening samples. The lower the b value in the power law model, the closer it is to zero, the elastic modulus does not change with frequency change, indicating the elastic property of the sample [17]. Storage modulus (G′) was greater than loss modulus (G″) and both of them remained constant over the given frequency range, and thus they were independent of frequency. This finding was congruent with Naeli et al. [31]. Usually, high amounts of palm oil in shortening suggest high value of G′ and G″, so that the 50:50 blend was greater than 60:40 blend. These results were in agreement with previous researches by Ahmadi and Marangoni [32] and Costales Rodríguez [33].

Figure 3a demonstrates the variations in G′ and G″ as a function of temperature. Increasing the temperature causes a decrease in G′ and G″ and this is consistent with the pattern shown in the SFC curve (Fig. 1). Commercial shortening had the highest while 60:40 blend had the lowest temperature resistance, which could be attributed to the high percentage of saturated fatty acids. The crossover points of C-shortening, 50–50 and 60–40 blends were 54.3, 52 and 50 °C, respectively. These outcomes showed that a low melting point reduces the crossover points [32].

Figure 3b presents the damping factor of bakery-shortening samples in the temperature ramp test (5–60 °C). The ratio of the viscose modulus to the elastic modulus, called tanδ, is a method for evaluating the viscoelastic behavior. Within this temperature range, the c-shortening had the lowest tan δ, thus elastic behavior and 60–40 blend with the highest range, had viscous behavior [34].

Properties of the cookies

Table 5 outlines the results of chemical properties and sensory evaluation of rice cookies. The results were in accordance with Iranian National Standard 1819.There were no significant differences in the ash and moisture results ($P > 0.05$). The peroxide value and pH in the samples were between 4.15–4.90 ($meqO_2\ kg^{-1}$) and 5–6, respectively. The sample containing commercial shortening had the highest peroxide content and the minimum pH value.The quality of raw materials and storage conditions (temperature, light, Humidity), could have promoted fat oxidation and production of free fatty acids, thereby reducing pH and increasing peroxide levels. Rangrej et al. [35] and Rajiv et al. [36] who used shortenings formulated with palm and flaxseed oil instead of commercial samples, also reported similar results.

Table 5 shows Sensory data. There was no significant difference between the cookies with 50:50 and 60:40 blends for the measured attributes. For Appearance, panelists preferred the cookie 3 prepared from commercial shortening. The obvious color changes between sample 3 and the other two samples were due to the color of the Ardeh oil that affected the final product. As can be seen in Fig. 4.The samples containing Ardeh oils (cookies1 and 2 prepared from 50:50, 60:40 blends), had a better texture, flavor and overall acceptance because of shortening's unique characteristics and good aroma and taste of Ardeh oil.

The texture properties of the cookies (Hardness, Fracturability) are shown in Fig. 5 Cookie1 with 60:40 shortening had the minimum values of hardness and fracturability compared to with long shelf life. However, no significant

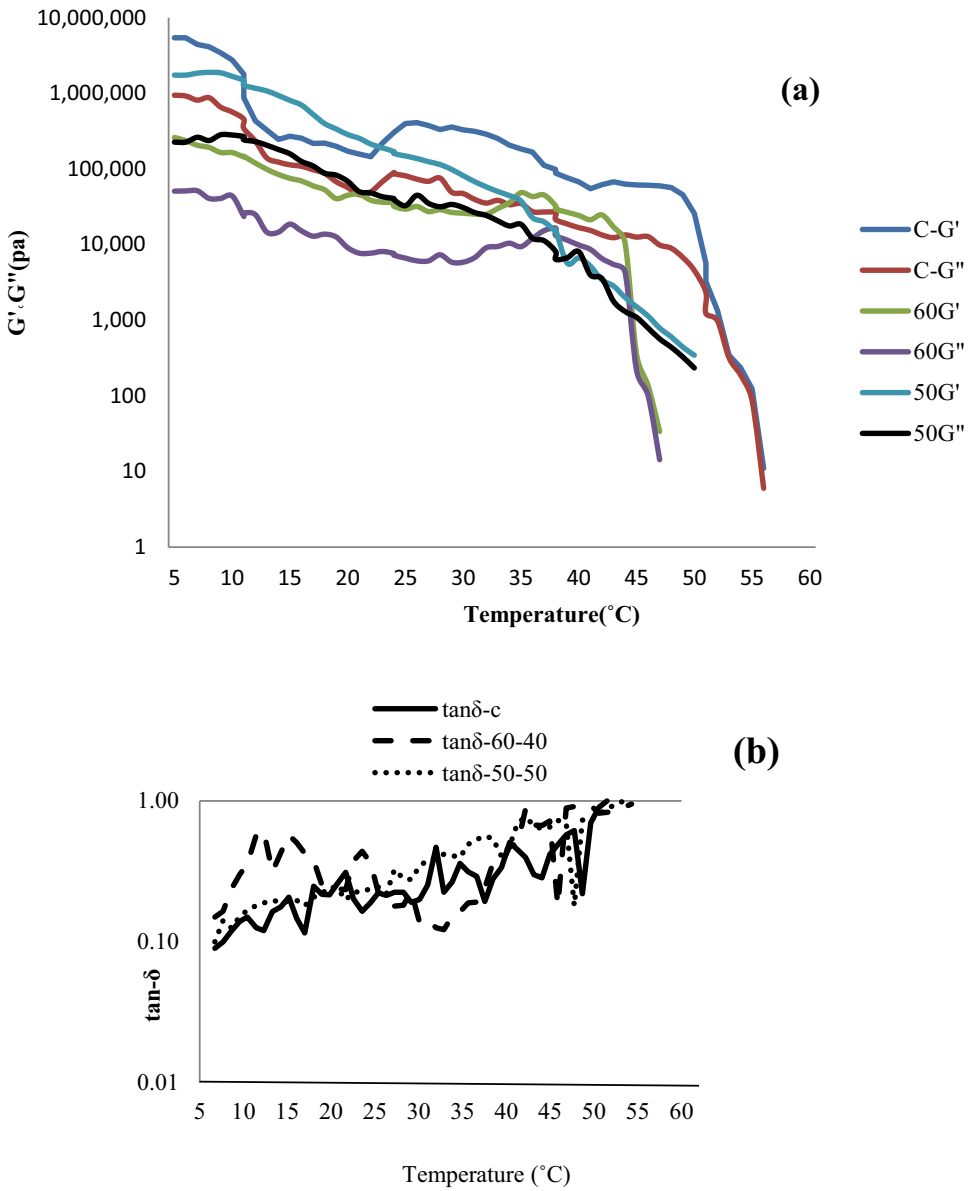

Fig. 3 Temperature ramp test (**a**) and tan-δ (**b**) of bakery-shortening samples

Table 5 Chemical properties and sensory evaluation of the rice cookies produced by bakery shortening

Sample	Ash (%)	Moisture (%)	pH	PV (meqO_2 kg^{-1})	Acceptance attributes			
					Appearance	Texture	Flavor	Overall acceptance
Cookie1	0.04 ± 0.00^a	5.03 ± 0.10^a	6.00 ± 0.50^a	4.15 ± 1.50^a	8.10 ± 1.21^a	7.35 ± 0.04^a	9.56 ± 0.91^a	8.23 ± 1.21^a
Cookie2	0.04 ± 0.01^a	5.00 ± 0.04^a	5.92 ± 0.30^a	4.20 ± 0.80^a	7.87 ± 0.15^a	7.01 ± 0.50^a	9.31 ± 1.03^a	8.1 ± 0.40^a
Cookie3	0.05 ± 0.00^a	4.80 ± 0.01^a	5.00 ± 0.05^b	4.90 ± 1.42^b	9.21 ± 0.03^b	6.50 ± 1.23^b	7.23 ± 0.50^b	7.1 ± 0.50^b

Cookie 1: was formulated with 60–40 blend, cookie 2: with 50–50 blend and cookie 3: with c-shortening

Mean values bearing the same superscript in the same column do not differ significantly ($P > 0.05$)

difference was observed between the 50 and 60 blend samples. It was observed that, the cookies made with less saturated fatty acids shortening had less hardness and fracturability. Saghafi et al. [17] reported similar results.

The hardness of all samples increased during room temperature storage (24 °C). The main cause of the hardness and staleness of gluten-free products could be due to reduction of moisture and the easier migration of water to

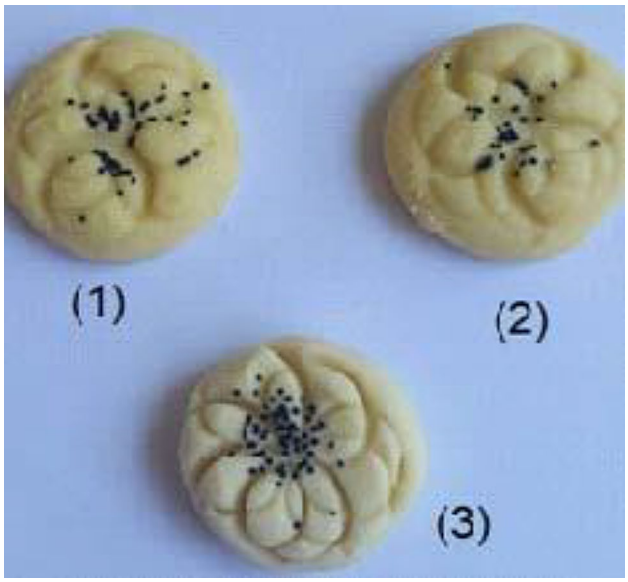

Fig. 4 The cookies produced with three different shortenings. (Cookie 1: was formulated with 60–40 blend, cookie 2: with 50–50 blend and cookie 3: with c-shortening)

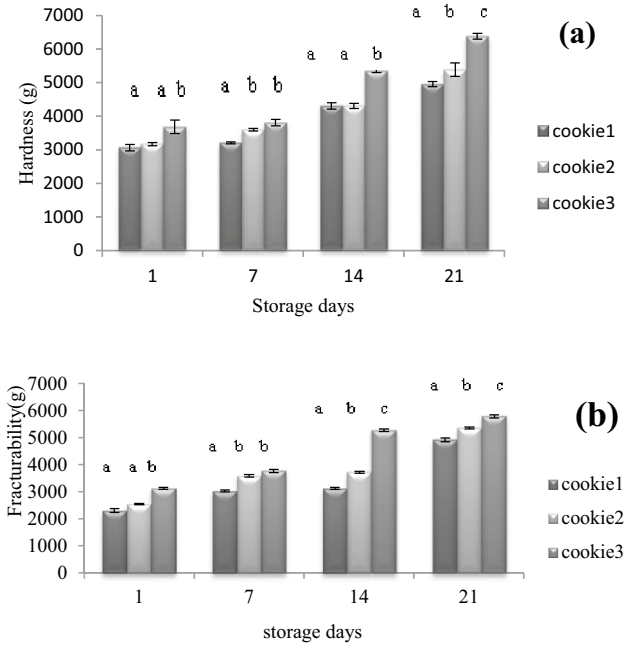

Fig. 5 Hardness (**a**) and Fracturability (**b**) values during storage in the cookie samples

the outside of the product resulting from the absence of gluten [37].

The minimum fracturability was observed in the sample prepared with 60: 40 blend, while the highest was found in the sample prepared from commercial shortening. There was a direct relationship between increased hardness and fracturability, as a result, the shelf life of Cookies 1 and 2 was longer than Cookie3 (with c-shortening). Ganorkar [38], Bassinello et al. [39] and Arifin et al. [40], achieved similar results in their research on different oils in the preparation of cookie.

Conclusion

During the chemical interesterification reaction of Ardeh oil and palm stearin, two types of zero trans shortenings were obtained. The comparison of physicochemical properties (SFA, SMP, SFC, PV, and FFA) as well as rheological and textural characteristics (hardness, adhesiveness) between the prepared shortenings and commercial shortening showed that the values determined in the produced shortenings were lower than those of commercial shortening ($P < 0.05$). The results indicated that the samples containing interesterified shortenings had the lowest peroxide content, also the evaluation of the texture properties showed that these cookies had less hardness and fracturability during storage ($P < 0.05$). The cookies produced by the blend shortenings showed the highest sensory evaluation scores. Trans fatty acid presented in the formulated shortenings was 0.2–0.3% (zero-trans), while in the commercial shortening (4.74%), it was lower than 5%, though it was regarded as a low-trans. Interesterification reaction, without affecting fatty acid profiles, improves the oil properties and preserves their nutritional value through producing zero trans-fat products; thus, cookies prepared from zero-trans blends were healthier for consumers.

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