PROPERTIES OF BREAD MADE WITH PALM-BASED FLUID SHORTENING

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ABSTRACT

Fluid shortening is frequently used as an alternative to solid shortening in the food industry. Fluid shortening is preferred over solid shortening because it is more convenient and easier to handle. The aim of this study was to examine the effects of palm-based fluid and solid shortenings and palm olein (POo) on the physical, firmness and sensory properties of bread. Fluid shortening produced the highest weight of bread and had similar volume, specific volume and density to bread made with solid shortening, while bread made with POo had the lowest volume, specific volume and density. The colour was similar in terms of lightness (L*) and blueness-yellowness (b*) of the crusts of all the bread. The crumbs of all the bread had similar L* and a* (greenness-redness) values. Crumbs of the bread made with fluid shortening were the softest of all. In terms of sensory properties, the bread made with fluid and solid shortenings were preferred, and both received comparable sensory scores for taste, colour, aroma and overall acceptability. On the contrary, bread produced from POo were of inferior physical, textural, and sensory quality. These results indicate that fluid shortening produced bread has comparable properties to those made with solid shortening.

INTRODUCTION

Bread is classified as a fermented product made from flour, shortening, yeast, water, sugar and salt. The bread-making process includes mixing flour with water, yeast, sugar, salt and fat to form a dough. The dough is kneaded until the gluten structure is developed through the hydration of the proteins in the flour (Cauvain, 2012). Fat is an important ingredient in baking products and it plays a variety of roles in providing desirable textural properties to baked goods. The presence of fat, commonly in the form of shortening, is essential in bread-making. The amount of shortening added is approximately 2%-5% of the flour weight (Pareyt *et al.*, 2011).

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Shortening is made of 100% of oils and fats. Plant oils and fats are the most common lipid used for shortening. However, animal fat can also be used to produce shortening (Aguilar *et al.*, 2015). In the making of shortening, the fat blend is texturised to obtain a homogenous and plastic texture. Shortening can be in a solid or liquid/fluid form, depending on the application (Ghotra *et al.*, 2002; Yılmaz and Ögütcü, 2015). It can lubricate, lessen, or shorten the products in which it is used. Furthermore, the addition of shortening contributes to tenderness and texture, incorporates air, acts as a medium for heat transfer, and improves the shelf-life of the food products (Ghotra *et al.*, 2002; Huang *et al.*, 2019).

In bread making, shortening has a vital impact on the incorporation of air during the mixing process which contributes to the volume of the final loaf (Pareyt *et al.*, 2011). Shortening contributes to the development of thin and expandable gluten films that assist in the incorporation of air and for

stabilisation during the mixing process (Watanabe *et al.*, 2003). Shortening with sufficient solid fat is necessary to strengthen the dough, and hence to enhance gas retention during proofing (Chin *et al.*, 2010). According to Ghotra *et al.* (2002), shortenings used in bread-making should have a broad range of plasticity at ambient temperature. The plasticity is determined by the solid-to-liquid ratio of the fat used in the shortening formulation. An extremely high solid fat content (SFC) will negatively affect aeration, while excessive liquid oil will affect the shortening's air-holding ability through the mixing process, (Rios *et al.*, 2014). Othman *et al.* (2015) reported that bakery shortenings used in bread-making should have at least 20% SFC at 25°C and 5% SFC at 40°C. A study by Smith and Johansson (2004) concluded that more preferable bread was obtained when a shortening with a higher SFC was used in the shortening formulation, which resulted in a bread with more volume compared to a bread made without solid fat. Dough made with liquid oil or without any lipid have a more porous structure, very thin cell walls and bigger gas cells (Osuna *et al.*, 2018). According to Stauffer (1996), the inclusion of 5% shortening increased the loaf volume up to 15%-25%. However, excessive fat/shortening can prevent the dough from rising during proving, hence reducing the bread's volume (Dunford, 2017).

Fluid shortening is widely used in the food industry as an alternative to solid shortening. Fluid shortening is preferred over solid shortening as the former is more convenient and easier to handle as it can minimise fat loss due to the residues or fats which remain on the packing materials. It is formulated in such a way so that it can be poured or pumped out at an ambient temperature and remains stable at temperatures ranging from 16°C-32°C (Ghotra *et al.*, 2002; O'Brien, 2020). Typically, fluid shortening is used as a frying fat. However, it can also be used in bakery products such as bread, rolls, buns, pie crusts and cakes (Dunford, 2017). The roles of fluid shortening in bakery products are similar to those of solid shortening. Nur Haqim *et al.* (2018) reported that the performance of fluid shortening made with palm oil (PO) in biscuits is comparable to that of solid shortening. Zhou *et al.* (2011) reported that fluid shortening can produce cakes of good characteristics and firmness.

Application of solid shortening in bakery products was broadly studied (Aguilar *et al.*, 2015; Artan *et al.*, 2010; Chin *et al.*, 2010; Dilek and Bilgiçli, 2021; Manaf *et al.*, 2019; Saghafi *et al.*, 2019). Solid shortening is widely available and used in Malaysia. However, a thorough evaluation of the effects of using fluid shortening on the physical, texture, and sensory qualities of bread has yet to be conducted. Thus, this study was aimed to investigate the performance of fluid shortening made with PO, in comparison with palm-based solid shortening and shortening made with palm olein (POo) which is liquid at ambient temperature. The effects of PO fluid shortening on the physical, textural and sensory properties of bread were also investigated.

MATERIALS AND METHODS

Materials

Refined, bleached and deodourised (RBD) PO (iodine value, IV 52) and palm stearin (POs) (IV 33) were obtained from Sawit Raya Sdn. Bhd., Malaysia. Palm olein (IV 58) (POo) (Delima Oil Products Sdn. Bhd., Malaysia), high protein wheat flour (12.8% protein) (Dr. Oetker Nona, Malaysia), sugar (Central Sugars Berhad, Malaysia), yeast (AB Mauri, Malaysia) and salt (Adabi Consumer Industries Sdn. Bhd., Malaysia) were purchased from the local market.

Production of shortening. Fluid shortening was produced solely from PO according to the method described by Che Man *et al.* (2010). The sample was melted at 70°C for 30 min to eliminate the crystal memory before being placed in a water-jacketed reactor vessel linked to a water bath with flowing hot and cold water. The product was cooled to 20°C and held for 80 min before being raised to 30°C for 40 min and cooled again to 20°C for 40 min while being agitated at a constant speed. Solid shortening containing a mixture of 80% PO and 20% POs was produced in a pilot plant (Gerstenberg and Agger, Copenhagen, Denmark) using the method described by Kanagaratnam *et al.* (2013). The blend was heated to 65°C for an hour to achieve complete melting. The product was cooled to 45°C while passing through the first chilling unit and cooled again to 25°C while passing through the second chilling unit. The blend was subsequently homogenised by passing through a pin worker with a shaft rotation speed of 150 rpm. The shortening was collected in a container and stored at 25°C.

Slip melting point (SMP). SMP of the fats was measured according to Malaysian Palm Oil Board (MPOB) Test Method p4.2: 2004 (MPOB, 2005). A 10 mm fat column was loaded into three capillary tubes. The fat column was chilled by pressing the ends of the tubes containing the samples against a piece of ice and rolling them until the oil column solidified. The tubes were placed in a test tube and kept in a beaker of water that had been calibrated at 10 ± 1°C in a thermostat water bath. The beaker was transferred to the water bath and maintained at a temperature of 10 ± 1°C for 16 hr.

Then, the capillary tubes were removed from the test tube and secured with a rubber band to a thermometer, with the lower ends of the tubes aligned with the bottom of the thermometer's mercury bulb. The thermometer was immersed in 400 mL boiling distilled water, with the lower end submerged to a depth of 30 mm in the water. The starting temperature of the bath was adjusted to 8°C-10°C below the expected SMP of the sample. A magnetic stirrer was used to stir the water, and the heat was applied at a rate of 1°C/min, steadily decreasing to 0.5°C/min once achieving the slip point. The heating was continued until the fat column was raised. The SMP was recorded as the temperature at which the fat in the column rise.

Solid fat content (SFC). The SFC of the fats was evaluated using pulsed nuclear magnetic resonance (NMR) (NMS Minispec from Bruker, Germany) in accordance with the American Oil Chemists Society (AOCS) Official Method Cd 16b-93 (AOCS, 2012). Samples were melted at 80°C for 1 hr and filled into NMR tubes of 0.8 cm (diameter) and 3.0 cm (height). Samples were then chilled for 90 min at 0°C, followed by tempering for 40 hr at 26°C, 90 min at 0°C and finally kept for 60 min at desired test temperatures of 5°C, 10°C, 15°C, 20°C, 25°C, 30°C, 35°C, 37°C, 40°C, 45°C, 50°C, 55°C and 60°C prior to each measurement.

Bread preparation. The bread was produced using 1 kg high protein flour, 600 g of water, 40 g of fluid shortening or solid shortening or POo, 40 g of sugar, 20 g of yeast and 10 g of salt. All the dry ingredients (high protein flour, sugar, yeast and salt) were incorporated using an electric mixer (Hobart, US) for 1 min at speed No. 1. Water was then slowly added to the dry ingredients and the mixture was blended for another 1.5 min at the same speed. Subsequently, fluid or solid shortening, or POo were added, and the dough was kneaded at speed No. 2 for 14 min. The dough was then allowed to rest for 10 min at ambient temperature under a damp cloth. After resting, the dough was divided into 250 g portions and proofed for 1 hr before being baked at 200°C (Salva Modular Deck Oven, Industrial S.L.U, Spain) for 16 min. The bread was cooled at ambient temperature for 1 hr before packing and storage.

Weight. The weight of the bread was determined using a digital balance (Mettler, Switzerland).

Volume, specific volume and density. The volume was measured using the rapeseed displacement method according to Approved Method 10-05 (AACC, 2000). The specific volume (mL/g) and density (g/mL) were calculated using the following Equations (1) and (2):

$$\text{Specific volume of bread (mL/g)} = \frac{\text{Volume of bread}}{\text{Weight of bread}} \quad (1)$$

$$\text{Density of bread (g/mL)} = \frac{\text{Weight of bread}}{\text{Volume of bread}} \quad (2)$$

Crust and crumb colours. The colours of the crust and crumb were determined using a Chroma Meter CR-400 (Konica Minolta Sensing, Japan), as described by Makinde and Akinoso (2014). The bread was sliced into cubes of $2 \times 2 \times 2$ cm^3 and placed in the colourimeter. The parameters determined were Commission on Illumination (CIE) colour values L* [L*=0 (black) and L*=100 (white)], a* (-a*=greenness and +a*=redness) and b* (-b*=blueness and +b*=yellowness). The total colour difference (dE*) was calculated using the Scofield Equation (3) below:

$$\delta E^* = \sqrt{(\delta L^*)^2 + (\delta a^*)^2 + (\delta b^*)^2} \quad (3)$$

where δL*=L*-L*reference, δa*=a*-a*reference, and δb*=b*-b*reference and L*reference=100, a*reference=0, and b*reference=0 (Chin *et al.*, 2010).

The colour attributes were recorded using Spectramagic software version 2.11 (1998). All measurements were conducted in three replicates.

Firmness. Firmness was done using a texture analyser (model TA.XT plus, Stable Micro System, England) with a 50 mm probe (P/50) diameter cylindrical probe. Bread crumb samples were cut into cubes of $4 \times 4 \times 4$ cm^3. The conditions for the analysis were: a pre-test speed of 2.0 mm s^{-1}, a test speed of 5.0 mm s^{-1}, a post-test speed of 5.0 mm s^{-1}, a distance of 20.0 mm, trigger type of auto-20 g, and time of 5 s (Akyüz and Mazı, 2020). Measurements were conducted in three replicates.

Sensory evaluation. Sensory evaluation of crumbs of the fresh bread was conducted by 30 untrained panellists consisting of MPOB staff and students. The sensory evaluation was performed in a laboratory using a 9-point hedonic scale under fluorescent light and at ambient temperature. The sample of bread was cut in 4×4 cm^2 and coded with random three digits. Panellists were asked to determine the sensory attributes of the bread samples based on their degree of like (scale of 1-9) where 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither

like nor dislike, 6=like slightly, 7=like moderately, 8=like very much and 9=like extremely. The attributes evaluated were appearance, texture, taste, colour, aroma and overall acceptability as suggested by Feili *et al.* (2013).

Statistical analysis. The data were statistically analysed using Minitab (Version 16, Minitab Inc., USA) statistical software package by which the data were subjected to analysis of variance (ANOVA). Means were subjected to Tukey's test and a *p*-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Slip Melting Point (SMP)

SMP is the temperature at which the fat softens. The SMP of fluid shortening, solid shortening and POo, and the phase of the products at an ambient temperature of 25°C are as shown in *Table 1*. The SMP of all the samples were significantly different ($p<0.05$) as the products ranged from POo which was liquid with SMP of 16.66°C, fluid shortening was semi solid with SMP of 38.23°C and solid shortening with SMP of showed significantly highest ($p<0.05$) SMP (46.53°C). Solid shortening is commonly used in bread making. Othman *et al.* (2015) suggested that the applicable SMP for bakery shortening ranged from 40.40°C to 45.25°C.

TABLE 1. SMP OF FLUID SHORTENING, SOLID SHORTENING AND PALM OLEIN

Sample	Phase at an ambient temperature of 25°C	Slip melting point (°C)
Fluid shortening	Partially solid	38.23[b] ± 0.30
Solid shortening	Solid	46.53[a] ± 0.25
RBD POo	Liquid	16.66[c] ± 0.28

Note:*Means within each column bearing different superscript letters differ significantly ($p<0.05$) from one another.

Solid Fat Content (SFC)

SFC is defined as the proportion of solid present at a particular temperature. The values describe the physical properties of a product at a specific temperature (Ramli *et al.*, 2008). The SFC of fluid shortening, solid shortening and POo are as shown in *Figure 1*. In this study, the bread was made at 25°C (ambient temperature), hence the percentage of solid fat present at this temperature was crucial. Fluid shortening had a low percentage of solid fat of 15.53% SFC at 25°C. The lower level of solid fat in the fluid shortening enables the product to be flowable and pourable. Solid shortening had 25.29% SFC at 25°C, hence, this product was firm and soft, making

it an acceptable fat for bread making. POo was fully liquid at 25°C. Saghafi *et al.* (2019) explained that the SFC and melting point of fats are interrelated, an increase in SFC, which is an increase in the percentage of solid fat will increase the melting point of the fat.

The presence of solid fats and liquid oils in a shortening (semisolid or partial solids state) are crucial in ensuring the required quality of bread (Nor Aini and Che Maimon, 1996). The liquid oil in shortening provides a lubrication effect on bread, allowing the lubrication of gluten particles by breaking the protein and starch structure (Tamstorf *et al.*, 1988). The liquid oil portion softens and tenderises the crumb, hence, the moisture mouthfeel during chewing (Stauffer, 2002). During storage, the liquid component keeps the bread crumb moist by preventing moisture migration from the core of the bread to the dry surface region, which might result in a consistent leathery texture. This effect allows the bread to have a longer shelf life in terms of firmness. The solid fats in a shortening are essential to help the development of the dough's structure, influencing important qualities including volume, grain, and texture of the final product. Brooker (1996) stated that the aeration is aided by fat crystals, which form membranes to capture microscopic air bubbles. Hence, the specific concentration of solid fats is necessary to support the required performance of shortening. Shortening is made from 100% oils and fats, thus, it has two distinct properties that are essential for bread making, which is being insoluble in water and cannot be hydrated by it (Figoni, 2004). Therefore, solid fats encapsulate the structure of gluten protein and starch granules, prohibiting them from absorbing water during the mixing process to form a firm dough structure. Solid fats also play an important role in the proofing stage. The solid fats, which coat the gluten matrix during mixing, further strengthen the gluten matrix, allowing for more gas retention during proofing. On the other hand, the use of liquid oil had a deleterious impact on the gluten network, making it weaker and less extensible than dough made with shortening containing saturated fats. The liquid oil is absorbed into the gluten structure, causing it to clump together. Bread made with liquid oil exhibited the porous structure of the gluten network with large gas cells (Osuna *et al.*, 2018; Watanabe *et al.*, 2003).

Weight of the Bread

The weight of bread made with fluid shortening was not significantly different ($p>0.05$) from that of bread made with POo (*Table 2*). The bread made with solid shortening was one time lighter ($p<0.05$) than the other two breads. These results indicate that the SFC of the fats affects the weight of the bread. The same behaviour was reported by Smith
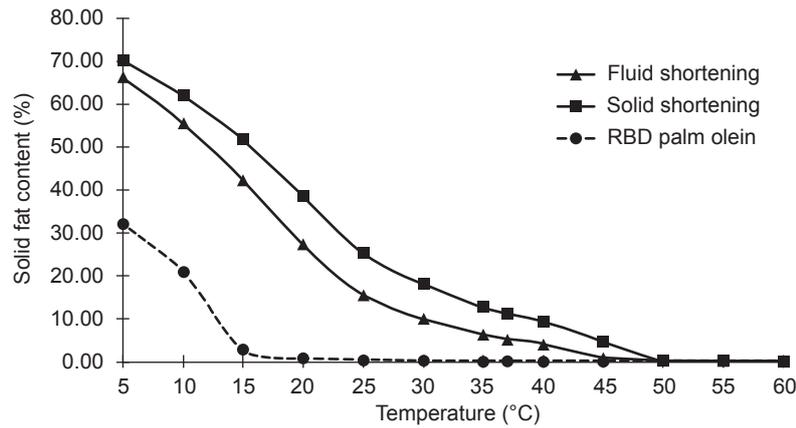
Figure 1. SFC as a function of temperature for fluid shortening, solid shortening and palm olein.

TABLE 2. WEIGHT, COLOUR AND FIRMNESS OF BREAD MADE WITH FLUID SHORTENING, SOLID SHORTENING AND PALM OLEIN AT 25°C

Parameter		Sample		
		Fluid shortening	**Solid shortening**	**POo**
Weight (g)		223.67[a] ± 1.60	220.47[b] ± 1.22	226.13[a] ± 0.64
Colour of crust	L*	53.57[a] ± 2.06	57.13[a] ± 1.71	56.59[a] ± 1.28
	a*	12.52[a] ± 0.25	11.84[ab] ± 0.53	11.54[b] ± 0.31
	b*	19.84[a] ± 1.44	23.12[a] ± 1.56	23.18[a] ± 1.30
	δE*	52.05[a] ± 1.29	50.15[a] ± 0.87	50.56[a] ± 0.87
Colour of crumbs	L*	73.75[a] ± 2.81	72.24[a] ± 0.88	73.43[a] ± 0.23
	a*	-0.85[a] ± 0.16	-0.87[a] ± 0.08	-0.82[a] ± 0.16
	b*	9.89[b] ± 0.11	9.53[b] ± 0.08	11.61[a] ± 0.89
	δE*	28.08[a] ± 2.58	29.36[a] ± 0.82	29.01[a] ± 0.49
Firmness (g)		183.80[c] ± 11.95	232.39[b] ± 3.59	377.11[a] ± 4.79

Note:*Means within each row bearing different superscript letters differ significantly ($p<0.05$) from one another.
L* - lightness-darkness; a* - greenness-redness; b* - blueness-yellowness.

and Johansson (2004), who reported that the bread made with shortening that contains 60% SFC at ambient temperature was lighter compared to those made with shortening that contains 20% of SFC. Chin *et al.* (2010) claimed that the weight of bread made with higher melting point shortening produced lighter bread. Fluid shortening which had a lower SFC than solid shortening at 25°C was not able to provide the lightness provided by solid shortening.

Volume and Specific Volume of the Bread

Cross-sections of the bread showing differences in volume are depicted in *Figure 2*. Bread made with fluid and solid shortenings had comparable values for volume (*Figure 3*) and specific volume (*Figure 4*). The volume of the bread samples made with solid and liquid shortenings was significantly higher ($p<0.05$) than that of the bread samples

made with POo, and this explained the higher SFC level in the fluid and solid shortenings. During the bread-making process, solid fat shortening acts as a gas-stabilising agent, influencing the incorporation of air into the dough (Alvarez-Jubete *et al.*, 2010; Scheuer *et al.*, 2014), which impacts loaf volume (Pareyt *et al.*, 2011; Scheuer *et al.*, 2014). Smith and Johansson (2004) explained that during baking, the loaf volume of bread made with shortening of high solid fat increased, due to an increase in the surface area, thus, facilitating more evaporation of water. This results in drier bread with a lower weight. The findings suggest that the SFC of the shortening influenced bread volume. A higher SFC resulted in a higher loaf volume. These findings are in line with the findings of Smith and Johansson (2004) who reported that the loaf volume of bread was higher when made with shortening with higher solid fat than those made with liquid oil.

Fluid shortening　　　　　　Solid shortening　　　　　　POo

Figure 2. Cross-sections of bread showing the differences of volume as affected by the type of shortening.
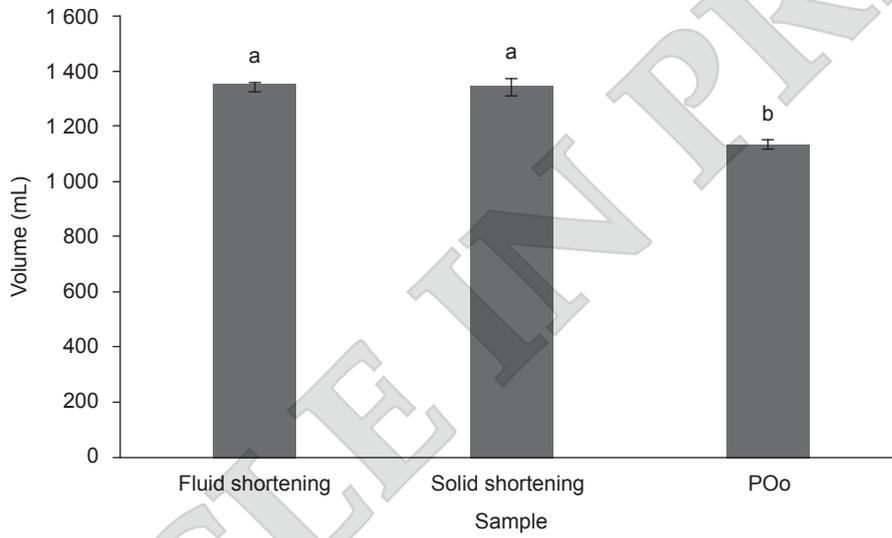

Figure 3. The volume of bread made with fluid shortening, solid shortening and palm olein at 25℃.
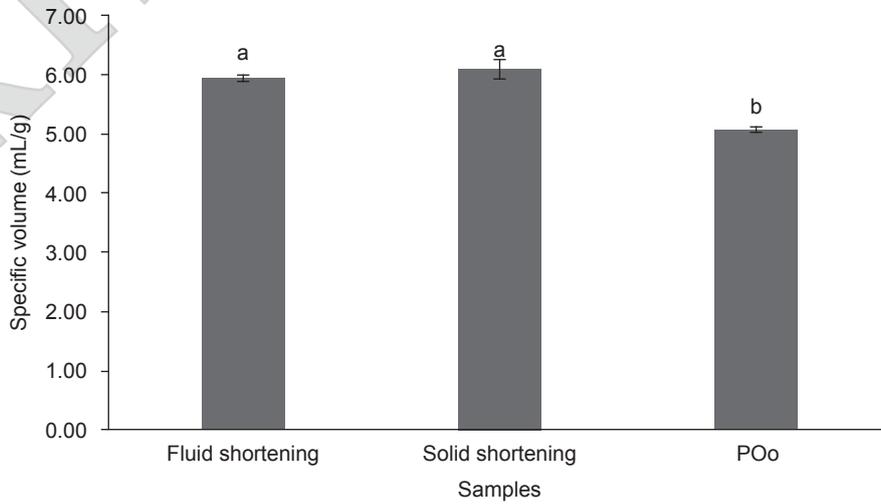

Figure 4. Specific volume of bread made with fluid shortening, solid shortening and palm olein at 25℃.

Artan *et al.* (2010) reported that the volume of bread made with shortening containing POs (hard fraction of PO) increased with an increase in the POs content in the shortening formulation. Osuna *et al.* (2018) described that the addition of canola oil into the bread produced a negative impact on the bread volume compared to the bread made with bovine fat which had higher SFC. The fluid shortening used in this study had an SFC of 15% at 25°C and 4% at 40°C. However, the solid shortening had SFC of 25.53% at 25°C and 9.31% at 40°C, which are within the specifications for an optimum bakery shortening. Ghotra *et al.* (2002) and Smith and Johansson (2004) reported that adequate SFC in the shortening can prevent air cells (produced by yeast from the dough) from being released by enclosing them within protein-lipid films. This process is crucial at the beginning of baking to make the dough rise. A higher amount of SFC in shortening produced a higher loaf volume due to this process (Osuna *et al.*, 2018). Notwithstanding this, the shortening itself has also a good leavening ability as it can mix homogeneously in the flour, providing a sufficiently aerated structure. Calligaris *et al.* (2013) explained that liquid oil did not homogeneously disperse throughout the flour, which prohibits the development of a sufficiently aerated structure. This showed that the SFC of fluid and solid shortenings has a good leavening ability.

Colour

The colour attributes of the breadcrumbs and crusts made with fluid shortening, solid shortening and POo are tabulated in *Table 2*. The a* value of bread crust made with fluid shortening was higher (*p*<0.05) compared to other samples, showing that the crust is redder than the other samples and this might be due to the difference in the colour of the PO and POo. Almeida *et al.* (2019) reported variation of colour in RBD palm oil and POo upon storage at various temperatures. The colour of all the bread crusts was similar (*p*>0.05) in terms of L*, b* and δE values. These findings are similar to what was reported by Aguilar *et al.* (2015), of which the shortening levels did not affect the lightness of the crust although the levels of shortening were different in their studies. The type of oils and fats used in the bread also had no significant effect (*p*>0.05) on the colour of the breadcrumbs. The crumbs from all bread had similar whitish colour, with L*, a* and δE values ranging from 72.24 to 73.75, -0.87 to -0.82 and 28.08 to 29.36, respectively. However, the b* of the crumb showed variation between fluid and solid shortenings with those made with POo. The crumb of bread made POo was yellower than the other samples.

Firmness

Firmness is the important criterion that contributes to the perception of bread with good quality (Majeed *et al.*, 2017). Firmness is described as the force required to bite into the bread, with a low force indicating a soft bread crumb texture (Ulziijargal *et al.*, 2013). The firmness of the bread made with fluid shortening, solid shortening and POo at 25°C are presented in *Table 2*.

The bread made with fluid shortening had the softest crumbs, followed by the bread made with solid shortening. The bread made with POo had the firmest crumbs. The crumbs of the bread made with POo was 1.6 and 1.2 firmer than the crumbs of bread made with fluid shortening and solid shortening, respectively, which was due to the absence of any solid fat in the bread formulation. A previous report by Chin *et al.* (2010) stated that bread made with shortening had a softer crumb. This has been related to the lubricating and tenderising effect of fat, as well as better aeration and breaking up the gluten network. Shortening also helps to reduce moisture migration from the core of the loaf to the drier outside crust region, which would otherwise result in the loaf losing its crispness later in the baking process.

A certain amount of solid fat is needed in bread as high melting crystals contribute to the higher gas development of the air cells during baking (Pehlivanoglu *et al.*, 2018). The findings also align with those of Farmani *et al.* (2016) who discovered that bread with a higher addition of oil was firmer. In addition, the incorporation of shortening containing solid fats in a bread formulation formed a thin and expandable gluten film in the dough, while liquid oil caused gluten aggregation (Scheuer *et al.*, 2014; Watanabe *et al.*, 2003). Gluten in the bread dough made with liquid oil contained a large number of holes that cause a fragile and easily ruptured structure. Smith and Johansson (2004) clarified that liquid oil cannot attach to the air cells, and therefore, specific concentrations of solid fats are necessary for a good shortening. Bread with lower firmness values showed lower chewiness values, indicating that a lower effort is required to break down the bread to the state ready for swallowing. Although solid shortening in the present study had recommended levels of SFC for a good bakery shortening, fluid shortening produced a much softer crumb texture than solid shortening.

Sensory Analyses

The mean scores attributed to appearance, texture, taste, colour, aroma and overall acceptability of the bread are shown in *Table 3*. The bread made with solid and fluid shortenings received mean scores above 6.0 for all the attributes,

TABLE 3. MEAN SCORES FOR SENSORY ATTRIBUTES OF THE BREAD MADE WITH FLUID SHORTENING, SOLID SHORTENING AND PALM OLEIN

Attribute	Sample		
	Fluid shortening	Solid shortening	POo
Appearance	$6.63^a \pm 1.28$	$6.59^a \pm 1.73$	$5.25^b \pm 1.45$
Texture	$6.19^b \pm 1.17$	$7.09^a \pm 1.35$	$4.78^c \pm 1.45$
Taste	$6.50^a \pm 1.24$	$6.84^a \pm 1.24$	$5.47^b \pm 1.50$
Colour	$6.78^a \pm 1.18$	$6.84^a \pm 1.24$	$5.47^b \pm 1.50$
Aroma	$6.59^a \pm 1.07$	$6.84^a \pm 1.19$	$5.31^b \pm 1.28$
Overall acceptability	$6.98^a \pm 1.11$	$6.84^a \pm 1.19$	$5.47^b \pm 1.19$

Note: *Means within each row bearing different superscript letters differ significantly ($p<0.05$) from one another.

indicating that the breadwere well accepted by the panellists. The bread made with solid shortening received the highest scores for all the attributes except for appearance and overall acceptability, but these were not significantly different ($p>0.05$) from the scores for the bread made with fluid shortening, except for texture. As a result, it can be suggested that customers are unable to identify any differences in appearance, taste and aroma between the bread made with fluid shortening and solid shortening. Bread made with fluid shortening, despite its outstanding softness was less preferred in terms of texture compared to the bread made with solid shortening. However, bread made with fluid shortening received the highest score for overall acceptability. The texture of bread made with POo received the lowest score indicating that the panellists slightly dislike the texture of the bread as the bread was the firmest. The bread made with POo was the least accepted by the panellists, as shown by its lower scores, with mean scores below 5.56 for all the sensory attributes. Lowest volume and hard texture as well as appearance scores appear to be the factors that contribute to panellists rating POo bread as the least preferred. The highest b* value (yellowness) of the bread made with POo might affect the perception of the panellists resulting lower score of appearance of this sample.

CONCLUSION

In conclusion, bread made with fluid shortening had comparable qualities in terms of volume, specific volume and density with those made of solid shortening, while bread made with POo had significantly ($p<0.05$) lower volume, specific volume and density. Crumbs of the bread made with fluid shortening were the softest while bread made with POo had the firmest crumb. Different types of fats used in the bread had no significant effects ($p>0.05$) on the L* and b* of the crusts and L* and a* of the crumbs of all the breads. The bread made with fluid and solid shortening received comparable sensory scores for taste, colour, aroma and overall acceptability, except for texture. It was discovered in this study that the softest texture does not always imply the most preferred in terms of texture. The results indicate that bread made with fluid shortening had comparable physical, textural and sensory properties to bread made with solid shortening. This evaluation does not recommend POo for bread making as the use of POo resulted in bread with inferior physical, textural and sensory qualities. The findings of this study may provide researchers and the bakery industry with vital information on shortenings. Future work on this research could include baking tests with different sorts of bakery products using fluid shortenings.

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