REFORMULATING TORTILLAS WITH ZERO-TRANS CRYSTALLIZED VEGETABLE FAT PRODUCED FROM PALM STEARIN AND HIGH OLEIC SAFFLOWER OIL BLEND

REFORMULACIÓN DE TORTILLAS CON GRASA VEGETAL CRISTALIZADA CERO-TRANS PRODUCIDA A PARTIR DE UNA MEZCLA DE ESTEARINA DE PALMA Y ACEITE DE CÁRTAMO ALTO OLEICO

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ABSTRACT

The effects of zero-*trans* crystallized vegetable fat produced from palm stearin and high oleic safflower oil (PS/HOSO, 65:35) blend on the texture and sensory properties of wheat flour tortillas (WFT) were studied. WFT were prepared with a (PS/HOSO, 65:35) crystallized blend, instant flour (hydrogenated commercial shortening/emulsifier blend) and hydrogenated commercial shortening (HCS). Firmness, rollability, and moisture loss were measured at different storage times (2, 24, 48, and 72 h). The blend (PS/HOSO, 65:35) had high proportion of palmitic (49.03%) and oleic acids (36.78%), without *trans* fatty acids (TFA), with the presence of the polymorphic form β. Tortillas manufacturing with (PS/HOSO, 65:35) blend showed lower firmness values than tortillas elaborated with instant flour, and HCS. The blend (PS/HOSO, 65:35) affected positively the quality of tortilla and sensory properties; showed this zero *trans* crystallized fat can be a potential alternative to HCS to reduce *trans* fats in cereal-based foods.

Keywords: *Firmness; polymorphism; rollability; zero-trans crystallized fat; wheat flour tortilla*

RESUMEN

Se estudiaron los efectos de la grasa vegetal cristalizada cero *trans* producida a partir de estearina de palma y aceite de cártamo alto oleico (EP/ACAO, 65:35) sobre la textura y propiedades sensoriales de las tortillas de harina de trigo (THT). Se prepararon THT con una mezcla cristalizada (PS/HOSO, 65:35), harina instantánea (mezcla de emulsificantes/manteca vegetal hidrogenada) y manteca comercial hidrogenada (MCH). Se midieron la firmeza, rollabilidad y la pérdida de humedad a diferentes tiempos de almacenamiento (2, 24, 48 y 72 h). La mezcla (EP/ACAO, 65:35) tenía una alta proporción de ácido palmítico (49.03%) y ácido oleico (36.78%), sin ácidos grasos *trans* (AGT), con la presencia de la forma polimórfica β. Las tortillas elaboradas con la mezcla (EP/ACAO, 65:35) mostraron valores de firmeza más bajos que las tortillas elaboradas con harina instantánea y MCH. La mezcla (EP/ACAO, 65:35) afectó positivamente la calidad de la tortilla y propiedades sensoriales; demostrando que esta grasa cero *trans* cristalizada puede ser una alternativa potencial para MCH para reducir las grasas *trans* en los alimentos a base de cereales.

Palabras clave: Firmeza, polimorfismo, rollabilidad, grasa cero cristalizada, tortilla de harina de trigo

INTRODUCTION

The wheat flour tortilla (WFT) is a food that is part of the diet of much of the population of Mexico, the southwestern United States, and parts of Central America (Wang and Flores, 1999). The WFT was the only bakery segment that experienced growth in 2012 and is projected to increase further (TIA, 2013). The WFT sales exceeded $6 billion in 2012 (Jondiko et al., 2016). The tortilla is a thin Mexican flatbread made from wheat flour with the versatility to be used in many dishes (Liu et al., 2016). The WFT in Mexico is elaborated with four major ingredients: flour, salt, water, and fat (Anton et al., 2009) (high content of lipids), mainly hydrogenated commercial shortenings (HCS) (Bejosano et al., 2006). The HCS are prepared by hydrogenation of vegetable oils and they are characterized by high *trans* fatty acid content (20-50%) (Jeyarani et al., 2003; Mayamol et al., 2009). Most of the WFT that are in the market are made with HCS incorporated into the gluten during mixing, and handling is improved because the fat decreases mass viscosity, providing WFT flavor and texture (Serna-Saldivar, 1988; Zoulias et al., 2002). All these effects are due to its lubricating property, an adequate level of HCS should be used to produce a good appearance and sensory qualities. However, the adverse effects of *trans* fatty acids on health have been reported (Dhaka et al., 2011; Kromhout et al., 2011; Hughes et al., 2013). Several clinical studies have been published showing that *trans* fatty acids have adverse health effects, increasing the bad cholesterol levels (LDL) in blood and decreasing good cholesterol (HDL). That is why *trans* fats are considered a risk factor for cardiovascular disease (Kromhout et al., 2011; Hughes et al., 2013).

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Currently, the demand for foods made with free or lower content of *trans* fatty acids (TFA) that impart texture properties similar to hydrogenated fats is growing, and it is important that in this process the amount of saturated fatty acids does not increase (AGS) (Bejosano et al., 2006). The health conscious consumer is also increasingly demanding the use of fewer additives (clean label), as well as healthier options (Jondiko et al., 2016), like cereal-based foods, zero *trans* fat (Dinç et al., 2014). Several authors have proposed replacing the HCS with blends of palm stearin/oil vegetable for application in products to cereal-based such as bread (Aini et al., 1996; Pavlovich-Abril et al., 2009). Bakery products elaborated with palm stearin-canola oil blend (50:50) produced bread with a softer texture similar the bread elaborated with HCS (Pavlovich-Abril et al., 2009). The inclusion of palm stearin-palm oil blend in the white bread formulation improved the volume of the final baked product (Aini et al., 1996). On the other hand, zero-*trans* fats produced from palm stearin and vegetable oil blend, represents an excellent and viable option to replace HCS in the elaboration of WFT. Therefore the aim of this study was to evaluate the effects of zero-*trans* crystallized vegetable fat produced from palm stearin and high oleic safflower oil blend (PS/HOSO, 65:35) on the texture and sensory properties of WFT.

MATERIALS AND METHODS

Process of Production of Zero-Trans Crystalized Vegetable Fat

The PS was melted in a temperature controller bath set at 60°C. The liquefied PS and HOSO were mixed (vertical Robot Coupe PVM, model RS110V) in mass ratio (PS/HOSO) of 65:35 (10 min, at 1500 rpm) at constant temperature of 70°C. The homogeneous fat blend was poured in 500 mL closed plastic containers. The PS/HOSO (65:35) blend was tempered and equilibrated at 30 ± 1°C for 5 d according to the method described by Buitimea-Cantúa et al., (2017). The blend was elaborated based on response surface study.

Preparation of Wheat Flour Tortilla

The WFT were obtained by hot press process with a semi-automatic Torcal brand equipment. To prepare tortillas it was used a commercial formulation, where all the ingredients: flour 100%, salt 2.0%, HCS 15%, are homogenized for 1 minute before mixing. The water absorption and mixing time of dough for tortillas was based on what the farinogram shows at 450 BU. After dough, laminate was passed and division to be dumplings by hand ball 40 ± 1 g, were allowed to stand for 30 min in conditions of relative humidity and then flour and shaped by a tortilla press (iron 45 °, a book type) at a temperature of 110 °C, tortillas made went directly to the section on baking this was done at a temperature of 240 °C, then cooled, packed in polyethylene bags, and stored for a period of 2, 24, 48 and 72 h (25 ± 0.5 ºC) for the completion of the analysis of physical and chemical properties, and texture measurement. For sensory analysis.

Characterization of Physical-Chemical of Zero-Trans Crystalized Vegetable Fat. The HCS and PS/HOSO (65:35) blend was analyzed in terms of color (Lovibond red) (method, Cc 13e-92), refractive index (method Cc 7-25), capillary melting point (method Cc-1-25), relative density (method Cc 10a-25), acidity (method Ca 5a-40), peroxide value (method Cd 8-53), moisture and volatile matter (method Ca 2d-25), and iodine value (method Cd 1c- 85) according to official AOCS, (2001) procedures.

Fatty Acid Profile. The fatty acid profile (FAP) of HCS and PS/HOSO (65:35) blend was determined by gas chromatography as described by Medina-Juárez et al. (2000).

Polymorphism. The polymorphic forms of HCS and PS/HOSO (65:35) blend were determined by X-ray diffraction (XRD) according to the methodology described by Mayamol et al. (2009), using a Broker Model D8 ADVANCE X-ray diffractometer emitting Cu α radiation.

Consistency. The consistency of HCS and PS/HOSO (65:35) blend was tested with a cone penetrometer (KOEHLER Model Instrument Company INC) in samples tempered at three different temperatures (12, 20, or 30°C) according to method Cc 16-60 (AOCS, 2001).

Texture Analysis of Tortillas.

The firmness and rollability in the tortilla were evaluated at different times of storage: 2, 24, 48, and 72 h. Each batch of WFT developed with HCS, PS/HOSO (65:35) blend, and instant flour was packed five tortillas in polyethylene bags and stored at room temperature (25 °C) until analysis. The firmness of the tortilla is expressed as the maximum force curve of force-distance (Yufeng et al., 2002). We used a texturometer (Instron brand, model 4465, Canton, MA, USA). We used the load cell compression and tension of 500 kg, the speed of the head was 50 mm/min. Firmness is expressed as the maximum load in N/g of sample.

The rollability which presents the tortilla was assessed, cutting strips of 2 cm wide, each strip of tortilla was rolled into a cylinder of wood of 2 cm in diameter and was noted the degree of rupture, which established a scale of 1 a 5; (1) extremely strong, (2) rigid, (3) inflexible, is very soft and (5) flexible (Waniska et al., 2002).

Physical and Chemical Evaluations of Tortillas.

In the tortillas were measured the diameter, thickness, and weigh. The diameter was reported as the average of four measurements (cm). The thickness was measured individually with a caliper on four different parts, the thickness that was reported was the average of 4 measurements (mm). The tortillas were weighed individually and record the weight (g). Moisture loss was determined by measuring the moisture content from time zero (2 hours after cooking) and during the time of storage (2, 24, 48, and 72 h). Values were reported as means of percentage of loss. The moisture content was determined by the method 44-15A (AACC, 2001).

Sensory Evaluation of Tortillas

Sensory evaluation tests were performed on WFT produced by 34 different untrained panelists. Each panelist was simultaneously given four coded samples along with a ballot paper and was asked to rate tortilla color, consistency, flavor, odor, and overall quality on a 9-point hedonic scale. All sensory evaluation tests were conducted in a sensory evaluation laboratory with temperature and relative humidity controls (Meilgaard, Civille, and Carr, 2007).

Experimental Design and Statistical Analysis

A completely randomized experiment was performed. The fat type (PS/HOSO, 65:35 blend, HCS, and instant flour and storage times (2, 24, 48, and 72 h) were the factors considered. ANOVA comparison of means by Tukey (significance level of 95%). Data were reported as means and standard deviations. Analyses were performed by using the JMP 5.0.1 program (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSIONS

Physicals Properties of Zero-Trans Crystallized Vegetable Fat

Table 1 shows that the color, melting point, relative density, and iodine values of the (PS/HOSO, 65:35) crystallized blend were higher compared to HCS. The color value of the PS/HOSO blend, 65:35, was 2.9. This is above what is required (1.5 red), so it does not meet the standards of HCS. This color is attributed to the fact that palm stearin has a high amount of antioxidants such as β-carotene (Mayamol et al., 2009). The high melting point (48 °C) in the (PS/HOSO, 65:35) crystallized blend is due to the concentration of palm stearin (65%). The melting point of palm stearin is 52 °C due to the high amount of solid glycerides, which gives it consistency (Pyler, 1988; Buitimea-Cantúa et al., 2017).

The high iodine value of the (PS/HOSO, 65:35) crystallized blend (46.45 gr. I_2/100 gr.) was due to that the palm stearin has a low iodine value (32.23 gr.) by the high levels of solid glycerides, but when it mixed with high oleic safflower oil the iodine value increases. Since oils have a high iodine index (125-200 gr. of I_2/100 gr.) At differences of saturated fats that have low iodine values (30-70 gr. of I_2/100gr.) (Kirk et al., 1996; Pyler et al., 1988). With respect to the refractive index, acidity (Oleic %), peroxides (Meq O_2/kg), density, humidity and volatile matter (%) complied with the quality standards (Pyler, 1988).

Binary blend of palm stearin-canola oil (50:50) was used for baking and it was observed that it presented higher values of color (3.0), melting point (49 °C) and iodine index (63 gr. I_2/100 gr) compared to the HCS that showed lower values of color (2.0), melting point (45 °C) and iodine value (43 gr. I_2/100 gr) (Pavlovich-Abril et al., 2009). Recently Buitimea-Cantúa et al., (2017), elaborated blends of palm oil-oleic high oleic safflower oil (50:50) obtaining color results (2.7), melting point (46 °C), and iodine value (52.45 gr. I_2/ 100 g) lower compared with the binary blend of palm stearin-canola oil. This behavior may be due to differences in the chemical composition of vegetable oils.

Tabla 1. Propiedades físicas, composición de ácidos grasos, formas polimórficas y consistencia de manteca comercial hidrogenada y mezcla (estearina de palma y aceite de cártamo de alto oleico) [1,2].
Table 1. Physical properties, fatty acids composition, polymorphic forms, and consistencies of hydrogenated commercial shortening and blend (palm stearin -high oleic safflower oil) [1,2].

Characteristics	Shortenings	
	Hydrogenated comercial shortening	Blend PS/HOSO (65:35)[3]
Colour (lovibond red)	2.0 b	2.9 a
Refractive index (50/25˚C)	1.4590 a	1.4595 a
Melting point (°C)	45.00 b	48.00 a
Relative density (60/25°C; g/ml)	0.810 b	0.931 a
Acidity (Oleic %)	0.015 a	0.015 a
Peroxides (Meq O2/Kg)	0.55 a	0.60 a
Moisture and volatile matter (%)	0.40 a	0.50 b
Iodine value (gr. I2/100 gr)	43.00 b	46.45 a
Fatty acids composition (%) †		
Myristic (C:14)	ND	1.88 a
Palmitic (16:0)	23.00 b	46.20 a
Stearic (18:0)	18.75 a	4.81 b
ΣSFA4	41.03 b	52.89 a
Palmitoleic (16:1 n-7)	ND	0.33 a
Oleic (18:1 n-9)	37.56 b	40.71 a
ΣMUFA5	37.56 b	41.04 a
Linoleic (18:2 n-6)	3.81 b	5.55 a
Linolenic (18:3 n-3)	ND	ND
ΣPUFA6	3.81 b	5.92 a
Fatty acids trans	17.00 a	*ND
Polymorphic forms	β´	β
Short spacing (Å)	4.46	4.50
	4.10	3.83
	3.70	3.72
Consistency (mm/10 g) to:		
12°C	80.00 b	156.00 a
20°C	125.00 b	296.00 a
30°C	220.00 b	385.00 a

[1] Means with a different letter (s) within rows are statistically different ($p < 0.05$).
[2] Values are the mean of three replicates; 3 PS/HOSO = palm stearin high oleic safflower oil blends; 4 SFA = saturated fatty acids; 5 MUFA = monounsaturated fatty acids; 6 PUFA = polyunsaturated fatty acids; † weight percentage;
*ND: not detectable.

Fatty Acids Profile

The fatty acid profile of the (PS/HOSO, 65:35) crystallized blend showed that had a higher concentration of palmitic and oleic acids compared to the HCS (Table 1). The components in order of abundance were palmitic acid (46.20%), oleic acid (40.71%), linoleic acid (5.55%), stearic acid (4.81%), myristic acid (1.88%), and palmitoleic acid (0.33%). This blend did not presented TFA. Similar results have been reported in binary blend (50:50) of palm stearin with rice bran oil, canola oil and high oleic safflower oil (Mayamol et al., 2004; Pavlovich-Abril et al., 2009; Buitimea-Cantúa et al., 2017). In these blends, palmitic acids and oleic acid were the most abundant (36.80 to 41.1%) and (34.4 to 42.90%), respectively.

The fatty acid composition of the HCS indicated that oleic acid (37.56%) was found in greater proportion, followed by SFA, especially palmitic acid (23%), stearic acid (18.75%) and linoleic acid. (3.81%). The HCS presented a high amount of TFA (17%). Generally, HCS contain 20-40% of AGT, which are mainly responsible for the polymorphic forms (α, β 'and β) of the fat crystals (Lida and Ali, 1998). Undoubtedly, *trans* fats have significant effects on the texture and appearance of food products, but they also cause health problems. In addition, HCS contains a high amount of TFA exceeding the daily intake (5 g/day of *trans* fat) recommended by the FDA (Wang, Wei, and Caswell, 2016).

Polymorphism. In the (PS/HOSO, 65:35) crystallized blend there were three peaks that corresponded to the values of interplanar spacing (4.50, 3.83 and 3.72 Å) characteristic of a polymorphic β form. In contrast, HCS showed three peaks of lower intensity (4.46, 4.10 and 3.70 Å), showing a tendency to a β' crystallinity pattern (Table 1) (O'Brien, 2009; Humphrey and Narine, 2004). The crystals β' delay the crystalline transformation of the solid fat product, which has a great influence on the texture properties. Fats that exhibit a stable β 'form appear to be softer and provide good aeration. On the other hand, the polymorphic form β tends to produce a granular product with poor aeration capacity (Lida and Ali, 1998; Mayamol et al., 2004; O'Brien, 2009). The presence of the polymorphic form β, has been reported in formulations of binary blends of palm stearin with oils of rice bran, sesame, soybean or high oleic safflower (50:50) and ternary blends of palm stearin-palm oil-palm olein (40:30:30) (Aini et al., 1999, Jeyarani et al., 2003, Mayamol et al., 2004, Berger et al., 2005, Pavlovich-Abril et al., 2009, Buitimea-Cantúa et al., 2017).

Consistency. The consistency values of the (PS/HOSO, 65:35) crystallized blend were higher compared to the HCS. The consistency of the blend increased as the temperature was augmented (Table 1). This is attributed to the fact that palm stearin has a high-melting triacylglycerides resulted in a hard consistency. However, the palm stearin mixed with vegetable oil produced a (PS/HOSO, 65:35) crystallized blend that a lower (12 °C) and higher temperatures (20 °C) showed comparable consistencies with HCS (150-300 mm/10 g) in spite of their modified fatty acid composition (high in saturated and unsaturated fatty acids with zero-TFA) (Table 1). The (PS/HOSO, 65:35) crystallized blend stored at 30 °C had a semi-solid state with consistency values higher than HCS. In blend of palm stearin with canola oil (50:50), the same trend was reported, exist an increase of the consistency as the temperature increased (Pavlovich-Abril et al., 2009, Buitimea-Cantúa et al., 2017).

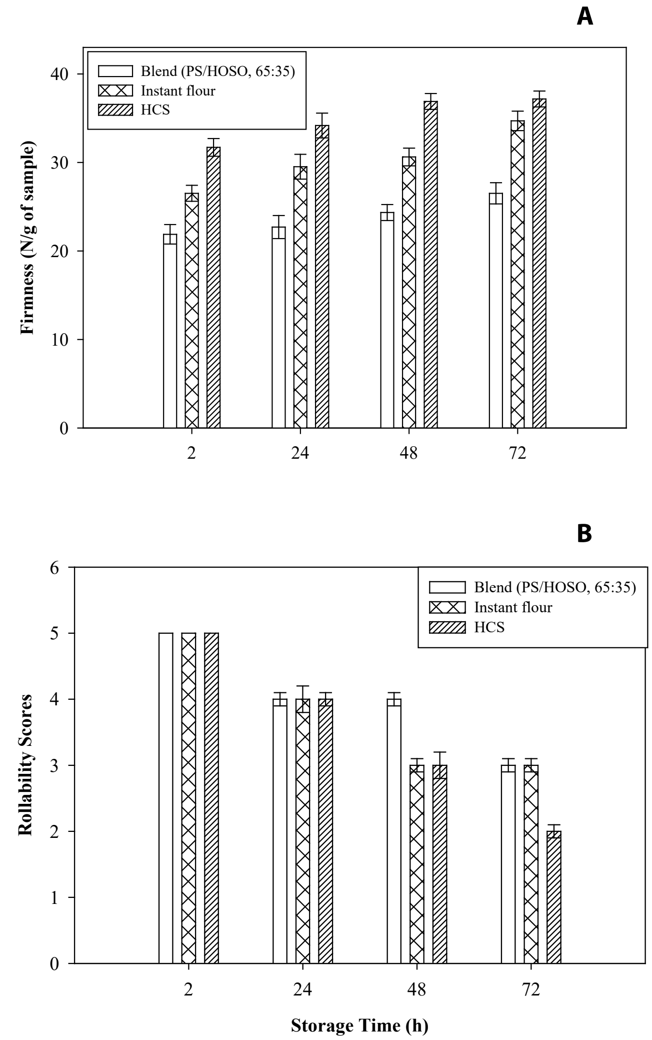

Figura 1. Efecto del tiempo de almacenamiento sobre la firmeza (A) y rollabilidad (B) de las tortillas de harina de trigo elaborada con varios tipos de grasa.
Figure 1. Effect of storage time on firmness (A) and rollability (B) of wheat flour tortillas elaborated with various types of fat.

Texture Analysis of Tortillas.

The type of fat (HCS, PS/HOSO, 65:35 crystallized blend) and instant flour had a significant effect ($p < 0.05$) on the firmness of the tortillas. The tortillas made with the (PS/HOSO, 65:35) crystallized blend were softer (21.88 to 26.51 N/g of sample) compared with the tortillas made with instant flour (26.51 to 34.70 N/g of sample) and HCS (31.70 to 37.17 N/g of sample) (Figure 1A). Zero-*trans* shortenings, made with blend of palm stearin and canola oil (50:50), have been used in the preparation of bread, and these are softer compared to bread where HCS was used (Pavlovich-Abril et al., 2009).

The fat-storage time interaction showed significant differences ($p < 0.05$) in the firmness of the wheat tortillas. In Figure 1A, it is observed that, regardless of the type of fat used, the firmness had a lower value in the freshly made tortillas (2 h), because when the tortilla is fresh, it is more extensible, soft, flexible, and rollable. At 24, 48 and 72 h of storage the firmness gradually increased, indicating that, as storage time passes, the flexibility of the wheat tortilla decreases (Yufeng et al., 2002, Waniska et al., 2002, Bejosano et al., 2006; Salazar-García et al., 2008). Aging caused crisp and hard tortillas, resulting in a decrease in the quality of the wheat tortilla; this could be due to the retrogradation of the starch and to the moisture loss (Srinivasan et al., 2000).

Additionally, during the elaboration of WFT the effect of the added level of fat (15% based on the weight of the flour) is important. Due that HCS interact with the starch fraction in a similar way as the emulsifiers, favoring the formation of amylose-lipid complex during processing. This is important because tortillas prepared with low-fat (5%) is firmer than tortillas made with HCS (15%). Furthermore, the HCS enhanced the characteristics of plasticity and produced tortillas with textural characteristics of softness (Yufeng et al., 2000).

In general, the firmness in the tortillas made with the (PS/HOSO, 65:35) crystallized blend, HCS and instant flour, increased with the storage time. This behavior coincides with the research of Bejosano et al. (2006) who observed that tortillas made with HCS are firmer compared to tortillas made with a blend of saturated fat-oil which are more extensible. Studies conducted by Berger et al. (2005); Aini et al. (1999); Mayamol et al. (2004); Jerayani et al. (2003) formulated blends of palm stearin with different oils in different proportions to obtain zero-*trans* shortenings and margarine, for the preparation of bakery products. The breads obtained presented lower firmness characteristics after 24 h of storage.

The type of fats used (HCS, PS/HOSO, 65:35 crystallized blend) and instant flour had a significant effect ($p < 0.05$) on the rollability or flexibility of WFT. Tortillas made with the (PS/HOSO, 65:35) crystallized blend were more flexible compared to tortillas made with HCS and instant flour (Figure 1B). The fat-storage time interaction showed significant differences ($p < 0.05$) on the rollability of WFT. A tendency to decrease the flexibility of the tortillas was observed as the storage time was increased. This behavior may be due to the moisture loss in the tortillas. These results agree with the results obtained in other investigations by Yufeng et al. (2002); Waniska et al. (2002); Bejosano et al. (2006); Salazar-García et al. (2008), where flexibility decreases in WFT made with baker wheat and commercial flour during storage. The type of fat also affects the flexibility of the tortillas. It has been reported that tortillas made with a mixture of saturated fat-vegetable oil are more flexible compared to those made with HCS (Bejosano et al., 2006).

Physical Determination

The type of fat did not show a significant effect ($p > 0.05$) in the diameter, weight, and thickness of the WFT (Table 2). As reported by Bejosano et al. (2006). The diameter of the tortillas with HCS, (PS/HOSO, 65:35) crystallized blend, and instant flour was from 16.45 to 16.56 cm, being within the range reported in WFT (15 to 18.4 cm) (Pascut et al., 2004; Waniska et al., 2004). The WFT diameter is the best quality parameter (Barros et al., 2010). However, it was found that

Tabla 2. Evaluación sensorial y propiedades físicas de las tortillas de harina de trigo [1,2].
Table 2. Sensorial evaluation and physical properties of wheat flour tortillas[1,2].

Tortilla Atribbute	Tortillas Blend PS/HOSO (65:35)	 Instant flour	 Hydrogenated commercial shortening
Physical Properties			
Diameter (cm)	16.45 a	16.50 a	16.56 a
Weight (g)	36.69 a	36.60 a	37.32 a
Thickness (mm)	1.64 a	1.62 a	1.66 a
Sensory Evaluation			
Odor	7.32 a	6.20 c	6.91 b
Texture	7.45 a	6.36 b	7.27 a,b
Flavor	7.18 a	6.24 c	6.82 b
Color	7.97 a	6.38 c	7.06 b
Overall acceptability	7.71 a	6.22 c	7.09 b

[1] Means with a different letter (s) within rows are statistically different ($p < 0.05$).
[2] Values are the mean of three replicates; [3] PS/HOSO = palm stearin high oleic safflower oil blends.

the thickness of the tortilla influences the rollability, due to the fact that tortillas with greater thickness require a greater force to be rolled and its effect is more noticeable when the tortillas are stored for 24 h, so that the tortillas with less thickness they present a lesser force to the winding, as well as a better rollability, which translates into a more flexible tortilla.

Moisture loss. The effect of fat type and storage time had a significant effect ($p < 0.05$) on moisture loss of WFT. The lowest moisture loss at 2 h of storage was in the tortillas made with HCS. However, the moisture loss of all the tortillas decreased after 24 h of storage; with the exception of tortillas made with a (PS/HOSO, 65:35) crystallized blend that maintained the moisture content until 24 h and decreased until 48 h of storage (Figure 2). The tortillas made with the HCS had the lowest humidity values during the storage time. The moisture content (21.78%) of the tortillas blend (PS/HOSO, 65:35) is within the moisture values reported for a commercial and traditional WFT (Yufeng et al. al., 2002; Waniska et al., 2004). A high moisture content is reflected in a change in the texture properties of the tortillas. The humidity change is a function of the formulation, this affects the tortilla due to the phenomenon of redistribution of humidity from the gluten to the starch, which causes a rigidity of the structure of the gluten in the tortilla in a similar way as in the bread , possibly the changes obtained in the tortilla due to the effect of the storage time are due to retrogradation of the starch, but also to a great extent to the redistribution of humidity and rigidity of the gluten structure (Serna-Saldivar, 1988).

Sensory evaluation

The sensory scores of the tortillas made with different types of fats (HCS, PS/HOSO, 65:35 crystallized blend, and instant flour) are shown in Table 2. The general acceptability

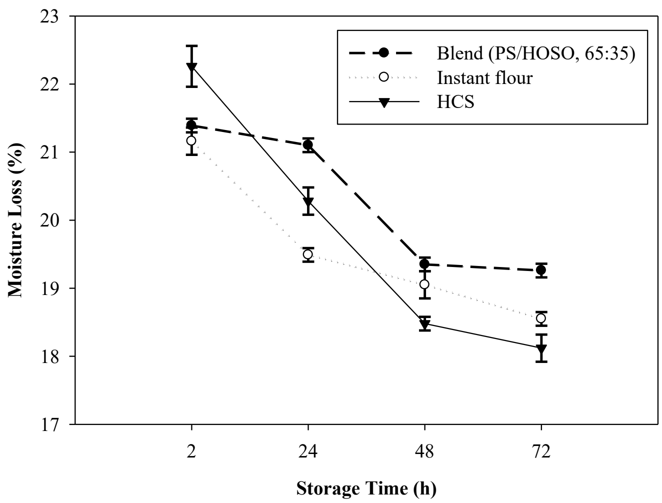

Figura 2. Efecto del tiempo de almacenamiento sobre la pérdida de humedad (%) de las tortillas de harina de trigo elaborada con varios tipos de grasa.
Figure 2. Effect of storage time on the moisture loss (%) of wheat flour tortillas elaborated with various types of fat.

of the tortillas manufacturing with (PS/HOSO, 65:35) crystallized blend was significantly higher ($p < 0.05$) than tortillas with HCS and tortillas made with instant flour. However, the panelists detected changes in the smell, texture, flavor, and color due to the effect of the type of fat that affected the general acceptance of the tortillas made with instant flour, these presented less acceptance. It has been reported that fat is one of the ingredients that effects each of the stages of the baking process (mixing, handling, and fermentation of the dough), as well as bread volume and sensory attributes (Baltasavias et al., 1999; Pavlovich-Abril et al., 2009).

CONCLUSIONS

The (PS/HOSO, 65:35) crystallized blend presented physicochemical properties similarly to HCS. The (PS/HOSO, 65:35) crystallized blend had an enhanced functionality and well-balanced fats rich in both omega 3 and omega 6 fatty acids without *trans* fatty acids (TFA). The presence of the polymorphic form β in the (PS/HOSO, 65:35) crystallized blend promoting the lower firmness values than tortillas elaborated with instant flour, and HCS. The (PS/HOSO, 65:35) crystallized blend showed an efficiency similar to HCS (structured fat) can replace 100% in the elaborated of wheat tortillas without compromising quality texture baking and flour tortillas. Sensorial analysis of WFT made with (PS/HOSO, 65:35) crystallized blend showed 100% of overall acceptance from panelist. The (PS/HOSO, 65:35) crystallized blend affected positively the quality of tortilla and sensory properties; showed this zero *trans* crystallized fat can be a potential alternative to HCS to reduce *trans* fats in cereal-based foods.

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