J Food Sci Technol (November 2019) 56(11):5046–5055
https://doi.org/10.1007/s13197-019-03977-2

ORIGINAL ARTICLE

Pancake ready mix enriched with dehydrated squash pulp (*Cucurbita moschata*): formulation and shelf life

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Revised: 13 July 2019 / Accepted: 24 July 2019 / Published online: 1 August 2019
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Abstract The objective of this study was to evaluate the physicochemical, sensory and texture characteristics of pancakes which contained dehydrated squash pulp (10 and 30 g/100 g of ready mix pancake). For this, first the physicochemical characteristics as well as the thermal and functional properties of dehydrated squash pulp (DSP) were determined. Then, the stability of the pancake ready mix was evaluated, through its physical–chemical and microbiological properties, during a storage period of 3 weeks, at 25, 40 and 50 °C. Finally, shelf life was estimated by means of two predictive methods (reaction kinetics and microbiological method). Results showed that DSP presented a high dietary fiber content (30.02 g/100 g), total carotenoids (452.04 µg/g), and phenolic compounds (415 ± 9.19 mg GAE/100 g), high swelling power, low solubility and emulsifying capacity. The formulation with the highest acceptance was that containing 10% dehydrated squash pulp (DSP-10), which obtained a shelf life of 5.39 weeks (28 °C) (reaction kinetics) and 33.51 weeks (microbiological method).

Keywords Pancakes · Squash · Functional properties · Total carotenoids · Dietary fiber

Introduction

Gluten is the protein present in cereals such as wheat, barley and rye, which are found with starch in the endosperm. This consists of a set of proteins classified in two groups, gliadins (soluble) and glutenins (insoluble), both fractions are important for the rheological properties of dough. The gliadins give the dough viscosity and extensibility; hydrated glutenins give the dough cohesiveness and elasticity (Lamacchia et al. 2014). The partial replacement of raw materials containing gluten by those rich in dietary fiber and antioxidants is a growing trend in the food industry due to the need to cover the demand for nutraceutical foods in the population to prevent diversity of diseases. The total or partial substitution of gluten sources affects some of their properties such as texture, therefore the formulation must be adjusted in order to improve sensorial quality (adhesiveness and firmness).

Due to its protein contents, dietary fiber, β-Carotene, minerals, and attractive orange color, dehydrated squash pulp is being used in products such as bread (Aly and Seleem 2015), cakes and spaghetti (Padalino et al. 2013), among others. However, the palatability of these foods continues to be a challenge in the development of products with sensorial characteristics which guarantee its acceptance by the consumer. When you innovate in the formulation of a food product which you want to place in the market, the estimation of shelf life is fundamental; therefore, the aim of this study was to evaluate the properties and composition of dehydrated squash pulp, as well as analyzing the effect of its incorporation over the

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s13197-019-03977-2) contains supplementary material, which is available to authorized users.

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chemical–physical and sensory properties of ready mix pancakes (RMP). Furthermore, this study aimed to estimate the shelf life of the formulation with highest sensorial acceptance.

Materials and methods

Raw materials

Fresh squashes (*Curcubita moschata* var. Bolo verde) were purchased in a local market (CAVASA, Candelaria, Colombia) and processed to obtain dehydrated pulp. They were conditioned and dried (55 °C/7 m s^{-1}/24 h) in accordance with the Potosí-Calvache et al. (2017) methodology in a convective oven (DIDACONTROL, Colombia, 2016). Subsequently, the pulp was ground (DIDACONTROL, Colombia, 2016) and sifted according to the granulometry required (≤ 210 µm). This raw material (DSP) was stored at refrigeration temperature (10 ± 0.5 °C) until its use. Laminated material composed by bioriented polypropylene, nylon and aluminum (200 ± 0.36 µm) was purchased by Alico S.A. (Cali, Colombia) and used to store the ready mixes for pancakes (RMP). The physical properties of this material were evaluated before its use obtaining a resistance to rupture = 33.01 ± 3.66 MPa; maximum deformation = 34.48 ± 6.49% and the module of Young = 382.39 ± 36.59 MPa. The permeability to water vapor was determined at 25 °C/68% HR (0.08545 g/m^2 dia).

Physicochemical analysis

Moisture content (MC), protein (PC), dietary fiber (DF), fat (FC), ashes (AC) and pH were determined in DSP and RMP using the methods of the AOAC (2000). The quantification of total carotenoids (TC) was done in both products according to the method modified by Ordoñez-Santos et al. (2017). The quantification of total polyphenols (TCP) and antioxidant activity (AA) were only determined in DSP. For the quantification of TCP and AA, samples of 5 g were submitted to an extraction process by means of Soxhlet technology (REF) using 200 mL of ethanol as solvent, at 80 °C/5 h. The extract was totally roto evaporated at 53 °C under a vacuum with a yield of 28.93 g of dry extract/100 g of sample. Dilutions of 3 mg of dry extract/mL of ethanol were prepared in flask volumetric with capacity 25 mL (stock solution) which were used for TCP and AA. The content of TCP was quantified using the Folin–Chocalteu reactive, following the procedure described by Martinez-Correa et al. (2011). The results were expressed in equivalents of gallic acid (mg GAE/g dry extract). The antioxidant activity was determined by using two methodologies. The first one by spectrophotometric analysis according to the methodology reported by Martinez-Correa et al. (2011), using the reactive 1.1-difenil-2-picryhidrazil (DPPH) and the second ABTS as a reactive (Machado et al. 2015). AA was expressed as µmol equivalent trolox (mg TE)/g of fresh residual.

The color parameters $CIE_{L^*a^*b^*}$ were determined following the method reported by Ordoñez-Santos et al. (2017). For this, a colorimeter (Konica Minolta, CR-400, Japan) was previously calibrated (Y = 89.5. X = 0.3166 and Y = 0.3347) (ASTM D2244-16, 2016). Additionally, other parameters were calculated, such as Chroma (c) (Eq. 1), tone angle (h°) (Eq. 2) and color difference ΔE (Eq. 3). For the finished pancake, the reading was taken on the surface (dark and light zones), and in the core of the product.

$$C = \sqrt{a^{*2} + b^{*2}} \quad (1)$$

$$h = arctg\frac{b^*}{a^*} \quad (2)$$

$$\Delta E = \sqrt{\left(a^* - a_0^*\right)^2 + \left(b^* - b_0^*\right)^2 + \left(L^* - L_0^*\right)^2} \quad (3)$$

where L* = lightness (0–100); b* = color coordinate which indicates yellow (+) and blue (−); a* = color coordinate which indicates red (+) and green (−); a^*_0, b^*_0 and L^*_0 = measured parameters in the week 0 and a*, b* and L* = measured parameters in the week 3. ΔE = color difference.

Scanning differential calorimetry (DSC) and thermogravimetric analysis (TGA)

The gelatinization temperature (T_p) was determined in 12 ± 0.50 mg of DSP using a scanning differential calorimeter (DSC 2STAR SYSTEM, Mettler Toledo), at 10 °C/min for a temperature in a range from 28 to 90 °C, in a nitrogen atmosphere (flow rate 20 mL/min). The thermal decomposition was analyzed using the TGA technic (TGA 2STAR SYSTEM, Mettler Toledo) in a temperature range from 28 to 700 °C (ASTM E794-06 2012).

Functional properties

Swelling power (SP) and solubility (S) were determined in DSP following the method proposed by Yu et al. (2012). Oil holding capacity (OHC) was measured with the method reported by Wani et al. (2013). Additionally, the emulsifying capacity (EC) and stability of the emulsion was evaluated with the method described by Kaur and Singh (2005).

Ready mixes for pancakes (RMP)

Formulation

Two formulations of RMP by DSP addition were evaluated (Table 1). Components like wheat flour (WF) (Haz de oro®), ultrapasteurized pulverized egg (Ovopacific, Duty free Zone Cauca, Colombia), sucrose (Manuelita®), sodium bicarbonate ($NaHCO_3$) (Royal®) and sodium chloride (NaCl) (Refisal®).

Whole milk was added in the preparation of the pancakes (3% fat) in a proportion of 160 g/100 g of mix approximately. Subsequently, melted margarine was added in a proportion of 4.81 g/100 g. The components were mixed manually, homogenized for 2 min and the mix was cooked in a little oil on both sides at 150 °C for 2 min.

Texture analysis

The parameters, such as the hardness and elasticity of the cooked pancakes (600 mm × 30 mm), were determined using a texturometer (Shimadzu, EZ test, Japan). The parameters were measured 4 times on each sample and the average value was reported, using a fixed plate (fixing base 346-51819-01), a compression cylinder (diameter = 36 mm, 346-51687-02), and a 500 N charging cell. A maximum deformation percentage of 50% and a speed of 100 mm/min (AACCI 74-09.01 1999).

Sensorial analysis

Pancakes DSP-10 and DSP-30 were sensorially evaluated by means of structured hedonic test (numeric) of five points. The level acceptance of attributes as: color, taste, odor, softness, touch adhesiveness and global acceptability. Samples of 25 g of product was supplied to 10 people (not trained), with ages ranging between 21 and 56, for the corresponding sensorial evaluation. Each formulation was evaluated independently.

Microbiological analysis

An aerobic mesophilic, *E. coli*, molds, yeasts, coagulase-positive *Staphylococcus aereus* and *Bacillus cereus* were analyzed in RMP with a higher sensorial acceptance, to the different storing conditions (25, 40 and 50 °C), in 0 to 3 weeks, by an accredited laboratory: $NULAB_{LTDA}$ (Bogotá, Colombia).

Shelf life

For shelf life estimation of RMP with the greatest sensorial acceptation, the deterioration index (DI) was determined. For this, physicochemical variables were measured during 3 weeks in RMP stored at 25 and 40 °C, in which the determination of color difference (ΔE) was included. These two properties, which registered higher, significant differences over time ($P < 0.05$), were established as DI, which were also quantified in RMP stored at 50 °C. Subsequently, reaction kinetics were elaborated through which the degradation (k) speed of the ID was obtained (Eq. 4). With this information the k dependency with temperature was studied by the Arrhenius (Eq. 5) and the shelf life (t_s) was determined at 28 °C (environment temperature). Additionally, the microbiological method described by McMeekin and Ross (1996) was used to find t_s, using Eq. (6).

$$\pm\frac{dA}{dt} = k[A]^n \tag{4}$$

$$k = A\ exp\frac{-E_a}{RT} \tag{5}$$

where k = reaction speed constant (concentration/week) = ; A = quantity of the attribute to be evaluated in time t (weeks); n = reaction order (0, 1, 2); E_a = activation energy (J/mol); R = constant of ideal gases (J/mol K) and T = absolute temperature (K).

$$t_s = \frac{logN_s - logN_0}{log2} * tg \tag{6}$$

where t_s = shelf life (weeks); N_s = security population (maximum permitted value before considering the product altered) (UFC/g mL^{-1}); N_0 = initial population present in the product (UFC/g mL^{-1}) and t_g is the generation time of the specific altering population (weeks).

Table 1 Pancake ready mix formulations with different proportions of dehydrated squash pulp

F	WF	DSP	Saccharose	Egg powder	Sodium bicarbonate	Sodium chloride
DSP-0 (control)	72.78	0.00	15.00	7.24	4.49	0.49
DSP-10	65.51	7.28	15.00	7.24	4.49	0.49
DSP-30	50.95	21.84	15.00	7.24	4.49	0.49

The proportions equal to g/100 g of mix

F formulation, *WF* wheat flour, *DSP* dehydrated squash pulp

Experimental design and statistical analysis

Unifactorial designs were used to study the incorporation effect of DSP (0, 10 and 30 g/100 g flour) in the characteristics of the pancakes mix (RMP) and baked pancakes, as well as the storing stability at different temperatures (25 and 40 °C) during 3 weeks. ANOVA was performed with Tukey test to identify significant differences with significance level $P < 0.05$. To study the reaction kinetics one more temperature level was considered (50 °C). The kinetics reaction and the used models were done by Excel v.2013. The model adjustments were evaluated by starting with R^2 (> 0.9).

Results and discussion

Dehydrated squash pulp (DSP)

Physicochemical analysis

The results of the physicochemical parameters obtained for DSP showed high contents of DF (30.02 g/100 g), PC (13.87 ± 0.05 g/100 g) and AC (8.89 ± 0.10 g/100 g) on respect to the evidenced for DSP of other varieties (De Escalada Pla et al. 2007; Aziah and Komathi 2009) and for WF (PC = 7.17 g/100 g, AC = 0.97 ± 0.06 g/100 g and DF = 0.03 ± 0.01 g/100 g) (Aziah and Komathi 2009). TC contents of DSP obtained in the present study (452.04 µg/g) was similar to that one reported by De Carvalho et al. (2012) (TC = 404.98 ± 17.37 µg/g) and higher to the one reported for WF (0.46 ± 0.054 µg/g) (Kandlakunta et al. 2008). The presence of carotenoids in DSP gives it an orange color which coordinates $CIE_{L^*a^*b^*}$ were L* = 71.50 ± 0.03, a* = 13.60 ± 0.30 and b* = 34.72 ± 0.16.

The TCP contents in DSP (415 ± 9.19 mg GAE/100 g) was lower to the one reported by Aydin and Gocmen (2015) while the AA values were higher (15.55 ± 0.47 µmol trolox/g DPPH and 30.02 µmol trolox/g ABTS). This is due to the existence of other compounds that give AA as pigments (β-carotene), tocopherols and organic acids (Tang et al. 2015). When comparing TCP of DSP with other flours like plantain (TCP = 220.30 ± 0.59 mg GAE/100 g) (Sarawong et al. 2014) and wheat (TCP = 4.34 mg GAE/100 g) (Žilić et al. 2012).

Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA)

On Online Resource Fig. 1 the endothermic gelatinization peak (T_p) of DSP is shown 71.59 °C, higher than the ones reported by Przetaczek-Rożnowska (2017) (T_p = 68.9 °C) for DSP. On Fig. 1b the thermic decomposition of the thermogram is shown DSP and its derivate (DTG). Zone 1 corresponds to the weight loss represented by the moisture present in the sample (8.66%). This diminishing was present between 28 and 119.60 °C; Showing its greatest peak around 78 °C. The most representative weight loss was observed in zone 2 between 119.60 and 328.98 °C, losing 51.10% of its weight; corresponding to carbohydrates and proteins. In zone 3, between 329 and 530 °C, weight loss was 25.06% corresponding to high molecular weight polysaccharides, proteins and lipids among other organic compounds. The percentage of residues according to the thermogram is high and corresponds to 15.18% which indicates that DSP contains a high concentration of minerals.

Functional properties

Results regarding the swelling power (SP) and solubility (S) of DSP were obtained in the temperature range between 50 and 90 °C. It was shown that at 60 °C solubility increased 4.93%. Starting at 71.59 °C (T_p), solubility decreased slightly until a level of 5.55 ± 1.39 g/100 g. At 80 °C, SP and S were 21.82 ± 2.34 g/g and 5.75 ± 0.41 g/100 g respectively. Similar results of the SP were reported by De Escalada Pla et al. (2007) (24.0 ± 0.20 g/g).

In this research it was evidenced that DSP presented less solubility than the reported for rice flour (S = 6.15 ± 4.00 g/100 g) (Mir and Bosco 2014). This result could be related with a higher content of amylose in the starch granule of DSP, which plays an important role in preserving the grain structure, making it more compact as well as making more difficult the loss of particles to the exterior (Seguchi et al. 2003).

For DSP the oil holding capacity (OHC) was of 0.72 g/g, less than the one reported by Aziah and Komathi (2009) (1.07 ± 0.01 g/g) though equal to the one reported for WF (0.70 ± 0.03 g/g). Factors such as dietary fiber and protein contents have an influence in the obtained value for this property. Thus, the higher the fiber proportion, the higher the fat absorption (Fuentes-Alventosa et al. 2009). Finally, the emulsifying capacity (EC) of DSP was of 0.49 ± 0.04 mL/mL with a stability (SE) of 100%. These values were relatively low compared to the ones reported by Martínez et al. (2014) for WF (CE = 0.83 mL/mL and SE = 115.18%).

Mixes ready for pancakes (RMP)

Physicochemical analysis

The physicochemical analyses of the RMP are shown in Table 2, with DSP-0, DSP-10 and DSP-30. It was

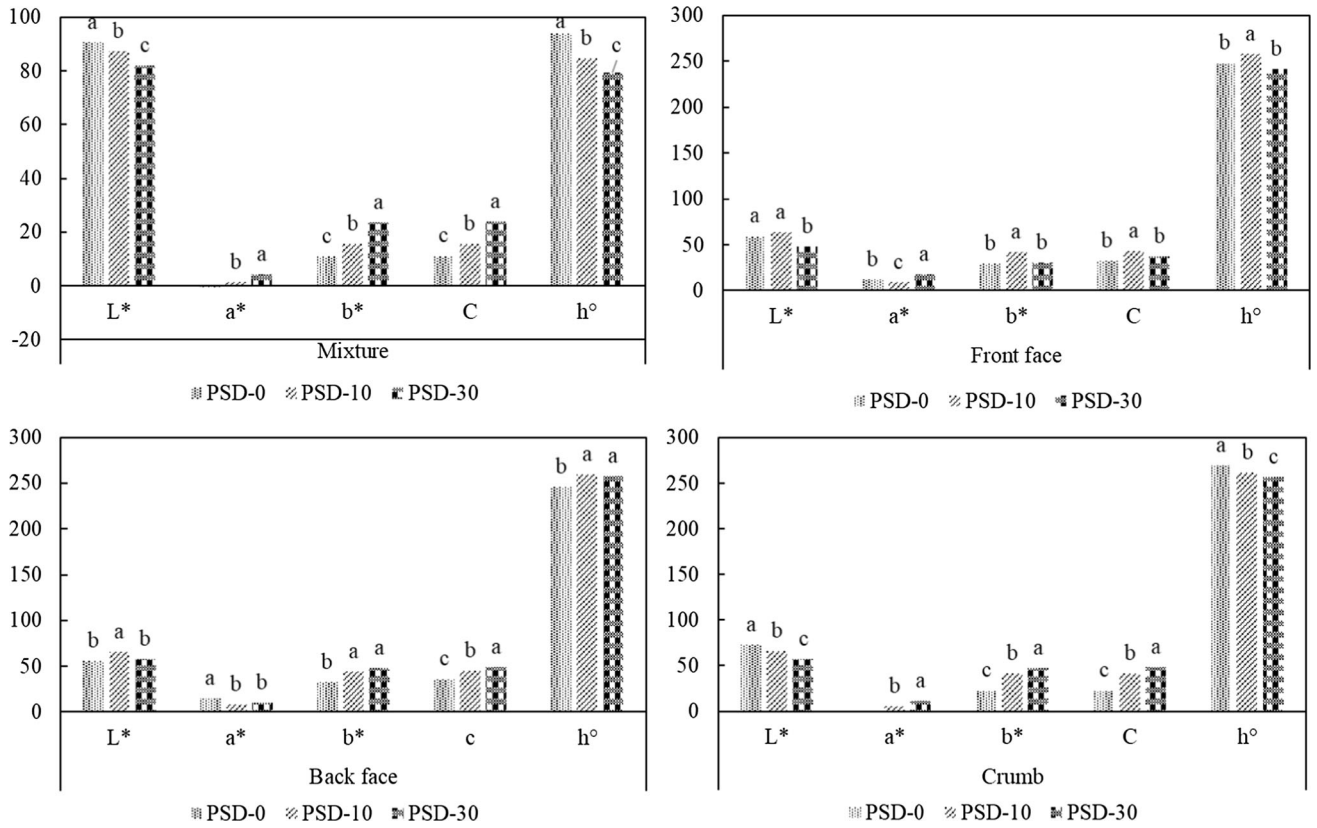

Fig. 1 Effect of the dehydrated squash pulp (DSP) incorporation on the color of pancake ready mix; cooked pancake frontal face; cooked pancake posterior face and pancake crumbs. Data are expressed as the mean ± standard deviation (n = 3). Different letters for each evaluated parameter correspond to significant differences ($P < 0.05$)

Table 2 Chemical composition of different formulations developed from panckake ready mix

Property	DSP-0 (control)	DSP-10	DSP-30
MC (g/100 g)	9.06 ± 0.05^{a}	9.07 ± 0.06^{a}	8.96 ± 0.05^{a}
a_w	0.57 ± 0.00^{a}	0.54 ± 0.00^{b}	0.48 ± 0.00^{c}
pH	6.87 ± 0.00^{a}	6.86 ± 0.00^{a}	6.88 ± 0.00^{a}
PC (g/100 g)	11.84 ± 1.21^{c}	14.10 ± 0.28^{b}	18.50 ± 0.53^{a}
FC (g/100 g)	1.64 ± 0.10^{c}	2.15 ± 0.06^{b}	2.39 ± 0.049^{a}
AC (g/100 g)	3.53 ± 0.07^{c}	3.80 ± 0.04^{b}	4.61 ± 0.03^{a}
TC (μg/g)	37.03 ± 0.01^{c}	111.07 ± 0.03^{b}	286.21 ± 0.06^{a}

MC moisture content, *PC* protein content, *FC* fat content, *AC* ash content, *TC* total carotenoids

Data are expressed as the mean ± standard deviation (n = 3). Different letters in the same row correspond to significant differences ($P < 0.05$, Tukey)

evidenced that DSP didn't have statistically significant effects ($P < 0.05$) in MC and pH but it did in a_w, CP, FC, AC and TC; observing the nutritional enrichment that DSP gives to the formulation.

On the other side, Fig. 1, shows how the addition of DSP in different proportions had a significant effect ($P < 0.05$) in the color of RMP and of the cooked pancakes (Fig. 1b, c, d). Figure 1a it was evidenced that when the proportion of DSP in RMP increases, the lightness decreased due to the orange pigmentation the squash's pulp confers to it. Also, it was observed that the parameters a*, b* and chroma increased, while the parameter h° (pitch angle) decreased. The same behavior was evidenced in Fig. 1d, in which the cooked pancake parameters $CIE_{L^*a^*b^*}$ are shown.

On Fig. 1b the parameters $CIE_{L^*a^*b^*}$ are shown measured on the frontal surface of the pancake. The pancake with DSP-10 didn't show significant differences on lightness (L*) on respect to the control. On the other side it was observed that the values L* a* and b* for pancakes with DSP-30 were higher on respect to control, evidencing darkening, due to the enrichment with carotenoid pigments that DSP provides. The same behavior was evidenced for the chrome parameter and the tone angle (h°).

In Fig. 1c color parameters were observed measured on the posterior surface of the boiled pancake samples with DSP-10 and DSP-30, which didn't show significant differences on the parameters a*, b* and h°, with respect to the control. On the chrome (C) a significant increase is evidenced ($P < 0.05$), due to the incorporation of DSP,

taking in account that it conferred more purity and intensity to the color of the product.

Texture analysis

Figure 2 shows the results of hardness and elasticity obtained for cooked pancakes in function of the DSP contents. The hardness of pancakes with DSP-10 didn't present a significant difference ($P < 0.05$) with respect to the control. On the contrary, the hardness registered for pancakes containing DSP-30 was significantly higher. The elasticity diminished in 54% when increasing the contents of DSP in RMP. The reduction of gluten contents in the formulation contributes to a diminish formation of gluten–starch bonds. Additionally, texture properties become affected by the increase in the fiber contents present in DSP. Similar results were obtained by Tsatsaragkou et al. (2016), for dehydrated squash enriched bread.

Sensorial analysis

Sensorial analysis results made to the formulations of RMP are shown on Table 3, which showed that, of all the evaluated attributes, the only one that presented significant differences ($P < 0.05$) with respect to the control formulation was odor, registering higher acceptance in PSD-10 and PSD-30, with the latter presenting a higher score. The acceptance degree of attributes such as color and adhesiveness was higher in pancakes containing DSP-10. The attributes with the greatest qualifications were odor and softness. Though pancakes containing DSP-10 had a higher global acceptance than pancakes containing DSP-30, the difference between both products were of only decimals in the qualification. This indicates that the incorporation of DSP may be considered in a proportion of 30 g/100 g in RMP, taking in account that pancakes will be less consistent and adhesive.

Microbiological analysis

The results of the microbiologic analysis made in the ready mix pancake stored at 25, 40 and 50 °C, on week 0 and 3rd showed that the product satisfied with what was stipulated on the current normativity, even on the 3rd week of storage. However, aerobial mesofile microorganisms which may alter the product, were detected (week 0 = 40 UFC/g mL^{-1}, week 3 = 8500 UFC/g mL^{-1}), when the maximum permitted is 200,000 to 300,000 UFC/g mL^{-1} according to NTC 267 (NTC 2007). This microbiological parameter was selected to estimate the shelf life of RMP according to the predictive method described by McMeekin and Ross (1996).

Shelf life

The chemical properties of the RMP are shown in Fig. 3, which were measured during the storage period with two temperature conditions (25 and 40 °C). Among the evaluated properties, MC (Fig. 3a), pH (Fig. 3c), AC (Fig. 3f), total carotenoids degradation (TCD) and color (Online Resource Fig. 2) showed significant changes during storage ($P < 0.05$). For this reason, MC and TCD were used as deterioration indexes.

The MC parameter increased by 6.57% during storage in the mixtures stored at 25 °C and increased by 13.16% in the mixtures stored at 40 °C, which was observed until the second week of storage; subsequently, the MC remained constant. The increase in the MC was due to the tendency towards equilibrium in the samples with a lower moisture content and a higher humidity medium (air humidity) and due to the hygroscopic properties of the material. The

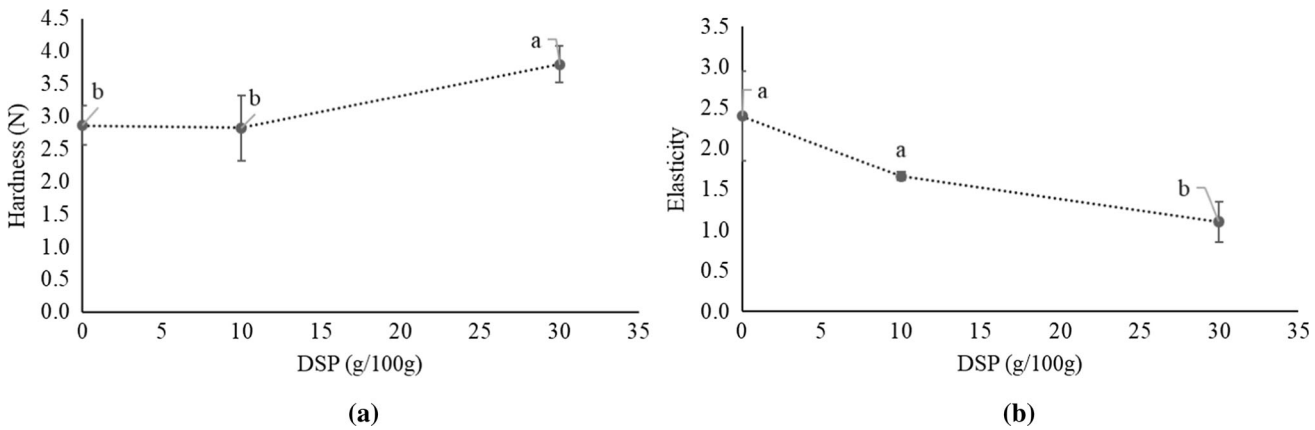

Fig. 2 Pancake texture analysis in function of the addition of DSP percentage (0, 10 and 30 g/100 g). **a** Hardness and **b** elasticity. Data are expressed as media ± standard deviation (n = 4). Different letters indicate significant differences due to DSP effect ($P < 0.05$)

Table 3 Average values of sensorial analysis made for pancakes with different proportion of dehydrated squash pulp

F	Color	Odor	Softness	Adhesiveness to the touch	Taste	Global acceptance
PSD-0 (control)	3.57 ± 0.51[a]	3.13 ± 0.42[b]	4.83 ± 0.29[a]	4.50 ± 0.44[a]	4.17 ± 0.19[a]	4.67 ± 0.31[a]
PSD-10	4.60 ± 0.52[a]	4.70 ± 0.48[a]	4.80 ± 0.63[a]	4.50 ± 0.53[a]	4.50 ± 0.53[a]	4.60 ± 0.52[a]
PSD-30	3.40 ± 0.84[a]	4.10 ± 0.88[a]	4.00 ± 0.47[a]	3.90 ± 1.37[a]	4.10 ± 0.57[a]	4.20 ± 0.42[a]

F formulation

Data are expressed as the mean ± standard deviation (n = 10). Different letters in the same column correspond to significant differences ($P < 0.05$, Tukey)

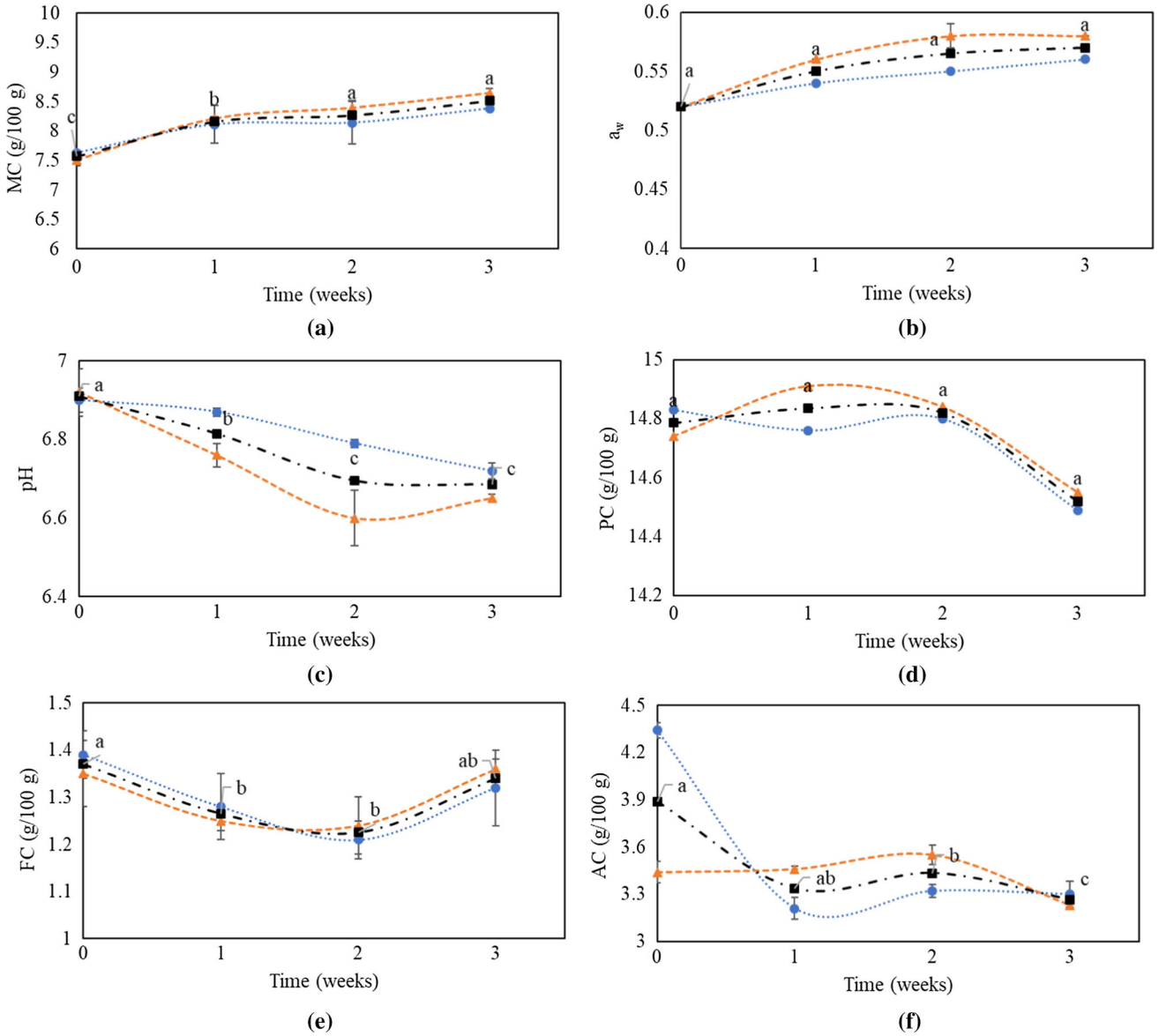

Fig. 3 The chemical properties of the pancake ready mixes, stored at two temperature conditions. **a** Moisture content, **b** water activity, **c** pH, **d** protein content, **e** fat and **f** ashes. Results expressed as the media ± standard deviation (n = 3). Different letters indicate significant differences due to the effect of storage time ($P < 0.05$)

significant effect of storage time and temperature on the MC has already been reported for other flours (Paciulli et al. 2016).

Figure 3c shows the decrease in pH for the storage time for both storage temperatures, which was higher at 40 °C. This decrease could have been due to many factors, including degradation of fatty acids through the action of lipases and lipoxygenases and the formation of other compounds, such as hydrogen resulting from deterioration. The pH obtained for this food product from day 1 facilitated the action of lipoxygenase, which shows higher activity at a pH of 4.5–6.0; however, higher moisture contents are needed (MC > 10 g/100 g) (Loiseau et al. 2001). Similar results have been reported by Goyal et al. (2017) for cereal flours and by Doblado-Maldonado et al. (2012) for wheat flour. On the other hand, the greatest increase at 40 °C could also have been due to Maillard reactions, which generate acid by-products (Shen et al. 2018), explaining the decrease in the FC parameter at week 2 of storage (Fig. 3e) because a loss of essential amino acids was generated.

The parameter AC decreased in storage time, registering the greatest loss of week 2. The difference of bioactive compounds (carotenoids), minerals are not destroyed by light, oxidizing agents or pH; Its destruction is due to other factors such as thermal treatments (Reddy and Love 1999).

During week 3, RMP presented total carotenoids degradation (TCD) values of 23, 47 and 49% when they were stored at temperatures of 25, 40 and 50 °C respectively. These results confirmed that the degradation percentage had a direct proportional relation with storing temperature, indicating the possible isomerization of carotenoid compounds, accelerated by the temperature of the medium, oxygen exposure, acidity, water content and enzymes (Graça et al. 2014). A similar behavior was reported by Doblado-Maldonado et al. (2012) for wheat flour, with a reduction of 11.5% in carotenoids during storage.

Online Resource Fig. 2a shows that the lightness diminished significantly due to the effect of time and storage temperature. The parameters a* (Online Resource Fig. 2b), b* (Online Resource Fig. 2c), c (Online Resource Fig. 2d) and h° (Online Resource Fig. 2e) of the samples of week 1 were significantly different ($P < 0.05$) with respect to control, which from that week on, remained constant. With respect to the color difference (ΔE), this one increased significantly ($P < 0.05$) during week 1, also due to the effect of temperature ($\Delta E_{25\ °C} = 3$, $\Delta E_{40\ °C} = 5.4$ and $\Delta E_{50\ °C} = 7.5$). Taking into account that the color degradation is perceptible by the human eye when the ΔE values are higher than or equal to 5 (Yuan et al. 2007), the color change is perceptible for those stored mixtures at 40 and 50 °C from week 1.

Online Resource Tables 1 and 2 show the parameters obtained in the mathematical modeling of reaction kinetics, and the Arrhenius equation. On Online Resource Table 1, the zero order kinetic parameters obtained for both deteriorating indexes are evidenced. These parameters are degradation speed (k) and corresponding adjustment degree, which were higher than 0.9. Degradation speed (k) of the ready mix pancake increase with the raise in temperature. This raise was higher in the kinetic obtained for TCD.

On Online Resource Table 2 the Arrhenius model of the obtained parameters are shown. The activation energy (E_a) obtained for MC, was higher than the one of TCD; which means, that TCD requires less energy for the degradation to take place. This was reflected in the shelf life which was 5.39 weeks (28 °C) (time during which the total carotenoid initial concentration was decreased in 50%) and of 18.13 weeks (time during which the critical moisture = 12 g/100 g was reached).

The predictive microbiologic model was used for each temperature condition. Through its use, the shelf life estimated of 40 weeks (10 months) was established, for RMP at 25 °C; 20 weeks (5 months) for the ones stored at 40 °C and 50 °C. The results were displayed in function of the temperature and a second order polynomic equation was obtained with an adjustment degree of $R^2 = 1$ ($t_s = 0.0101\ T^2 - 0.936\ T + 26.745$). With this equation the shelf life was estimated at 28 °C, $t_s = 33.51$ weeks (8.33 months). Commercially, t_s of RMP based on wheat flour (100%) is of 1 year. If it is compared with what was obtained using a deterioration index TCD, it is evident that the mix will not be commercially competitive ($t_s = 5.39$ weeks approximately). But if it is compared with the value for integral RMP (commercial), t_s is similar. This variable has to be analyzed during future studies, with the purpose of diminishing the carotenoids degradation in the RMP.

Conclusion

Dehydrated squash pulp is a promising raw material for the elaboration of food products due to its physicochemical, functional and nutritional properties. This is due to its high dietary fiber content, protein and ashes as compared to other types of flour. The presence of bioactive compounds such as carotenoids and phenolic compounds confers a nutritional value to this raw material which gives it an advantage over conventional flours. This is why the addition of DSP in the formulation of RMP in proportions of 10 and 30 g/100 g nutritionally enriches this kind of product. However, the texture may be affected in function of the DSP, content, mainly due to the increase in hardness and the decrease of elasticity. The formulation with the highest

sensorial acceptance was DSP-10, being color and odor the attributes of highest acceptance. Finally, this research estimates the shelf life of RMP with DSP-10, using parameters like the deterioration index, humidity content, total carotenoids content and alternant microbial content.

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