Scientia Agropecuaria 8(4): 315 – 325 (2017)

Scientia Agropecuaria

Website: http://revistas.unitru.edu.pe/index.php/scientiaagrop

Facultad de Ciencias Agropecuarias

Universidad Nacional de Trujillo

Development of functional cookies with wheat flour, banana flour (*Musa paradisiaca*), sesame seeds (*Sesamum indicum*) and storage stability

Angélica Loza[1]; Merly Quispe[2]; Juan Villanueva[1]; Pedro P. Peláez[1, *]

[1] *Universidad Nacional Agraria de la Selva, Facultad de Ingeniería en Industrias Alimentarias. Av. Universitaria Km. 1.5, Leoncio Prado, Tingo María, Huánuco, Peru.*

[2] *AMDEPJ Sociedad de Responsabilidad Limitada, Av. Frank Potokar Mz C, L1, Leoncio Prado, Tingo María, Huánuco, Peru.*

Received Janeiro 21, 2017. Accepted September 25, 2017.

Abstract

Functional cookies were developed using banana flour (BF) and sesame seeds (SS). Protein, moisture and ash were determined, and farinographic analyzes of flours were performed. The attributes odor, color, flavor, crunch and the IC_{50} value of the cookies were determined. The results were evaluated with the Complete Randomized Design and the Tukey and Kruskall Wallis test. The flour mixture presented higher protein (10.2%), humidity (14.40%) than BF, but lower than wheat flour. Cookies with 10%, 15% and 20% BF and 8% sesame seeds were selected. Flours with 10%, 15% and 20% BF had similar values of water absorption (≤ 60%) and different values statistically ($p \leq 0.05$) for development time, mass stability and degree of softening. Cookies with 20% BF and 8% SS (SC) had $IC_{50} = 17.52 \pm 0.25$ mg / mL, with moisture, protein, fat, crude fiber, ash and carbohydrates of 1.88%, 10.65%, 22.01%, 1.01%, 1.54% and 62.91%, respectively. SC did not present sensorial statistical differences ($p \leq 0.05$) the first two months, the third month decreased the acceptability of the crunch and flavor. In ninety days of storage the IC50 value (29.07 ± 0.92 mg / mL), reducing sugars (1.20 ± 0.02) and pH (5.24 ± 0.01) decreased and humidity (3.83 ± 0.03) increased.

Keywords: functional cookies; wheat flour; banana flour; sesame seeds.

1. Introduction

Cookies are widely consumed and generally, they are rich in carbohydrates, fats and calories, but low in fiber, vitamins and minerals. Currently, fortification of cookies has evolved to improve its nutritional and functional quality (Awolu *et al*., 2016).

The banana is a fruit whose origin is from Southeast Asia, including North India, Burma, Cambodia and part of South China, as well as the major islands of Sumatra, Java, Borneo, the Philippines and Taiwan. Green banana is composed of the high amount of starch, around 70% of the fruit, dry basis (Agama-Acevedo *et al*., 2015), banana flour contains 6% - 15.5% total fiber, 2.6% - 3.5% ash 2.5% - 3.3% protein and 0.3% - 0.8% lipids. The flour obtained has beneficial physiological effects, as it acts in the form of fiber, due to the high content of starch resistant to digestion and provides better glycemic and insulinemic responses (Hernández, 2006; Patzi, 2007). Raw starches isolated from cooking varieties showed a higher resistant starch content (RS), the RS content in gelatinized plantain starches is considered to be high compared to that of uncooked cereal starches, with values ranging between 9.6% and 24%. Gelatinized starches from cereals showed a RS content between 3.9%

* Corresponding author
E-mail: pedro.pelaez@unas.edu.pe (P. Peláez).

DOI: 10.17268/sci.agropecu.2017.04.03

and 6.9% (Chávez-Salazar *et al*., 2017). The resistance to hydrolysis by digestive enzymes of banana starch, even after gelatinization, is related to the structural arrangement of the components of starch within the granule (Agama-Acevedo *et al*., 2015).

Sesame seeds are dried fruits of an oilseed plant, come from the countries of the Middle East, India and Africa and spread through the Americas with the arrival of African slaves, who used their seeds to thicken and flavor a great variety of dishes (Diezgranados, 2011; Farmani *et al*., 2016). It is a plant of warm and dry climates, its seeds contain up to 50% of oil, 20% of protein and 10% of carbohydrates. Once extracted the oil, a cake is obtained, rich in proteins for the human and animal consumption, being in them about 15 amino acids; Is used to a lesser extent in the preparation of antioxidants, cosmetics and medicines, is used in bakeries, pastry shops (Gharby *et al.*, 2017). Of its lipid content, 80% belongs to polyunsaturated fats mainly linoleic acid and less alpha-linolenic (omega 6 and 3), these essential fatty acids make possible the regulation of cholesterol levels in the blood, consumption of sesame oil can reduce the risk of coronary vascular, diabetes and hypertension disease (Lin *et al*., 2014). Sesame seeds are known to exhibit various health beneficial properties, including hypocholesterolaemic, hepatoprotective, and anti-mutagenic effects (Kim *et al*., 2014). Antiproliferative activity of sesame seeds may be explained by the combina-tion of the fat-soluble lignans (sesamol, sesamin, and sesamolin) and water soluble lignan (sesaminol triglucoside), which functioned additively or synergistically for the total antiproliferative activity of sesame seeds (Lin *et al*., 2017).

The reported scientific information supports the proposal to make salty cookies using banana flour and sesame seeds; in order to obtain cookies with functional properties.

2. Material and methods

2.1 Materials and reagents

Materials: wheat flour, banana meal variety "Stick", sesame seeds, butter, milk powder, salt, water, butter essence, baking powder, calcium propionate. Reagents: 2,2-diphenyl-1-picrihydrayl (DPPH), Trolox, 0.1 N Sodium Hydroxide, Phenolphthalein, Sulfuric Acid, 1.6% Oxalic Acid, Hexane, Ethyl Ether, Copper Sulphate, Potassium Sulphate, 50% Caustic Soda, 0.1 N Hydrochloric Acid, Red Methyl Indicator, Sodium Potassium Tartrate, Glucose, 3,5-Dinitrosalicylate (DNS), Phenol, Sodium Metabisulfite.

2.2 Physicochemical analysis of cookies

Humidity, method No 930.04, pH method No 930.08, protein method No 930.07, total fat, method No 930.09; Ash, method No. 930.05 (AOAC, 2000). Carbohydrates were determined by difference (Kira *et al*., 1996), IRAM method 15855 (2000), quantification of reducing sugars (Miller, 1959; Gusakov, 2011), antioxidant capacity, Radical 2,2-diphenyl-1-pycrylhydrazyl DPPH) (Brand-Williams *et al*., 1995). Digital analytical balance H.W. Kessel S.A., Muffle brand CIMATEC SAC; Protein digester for semimicro Kjeldal model BUCHI k-438; Kjeldahl semimicro protein distiller, model BUCHI k-350, reflux equipment for determination of raw fiber model 30001, 30002 brand LABCONCO equipment was used.

2.3 Sensory analysis of cookies

It was performed at zero days and each month for three months, considering the color, smell, taste and crisp attributes with a structured hedonic scale of nine points (Demirkesen, 2016). The randomized complete design and the Kruskal-Wallis test allowed the analysis of the results; twelve panelists conducted the evaluations (Ertaş, 2015; Berlanga and Rubio, 2012). The results of the sensory tests were analyzed using the software STATGRAPHICS Centurión XV, version 15.2.06

2.4 Making Cookies

In an industrial mixer the cremating was done, mixing butter and sugar; Then the other dry ingredients, minus the flour, then the water was added. This process lasted about 3 minutes. The mixture obtained was uniform and without lumps. The creamer, wheat flour and banana flour were added to the kneading mixer according to the formulations in Table 1.

It was kneaded for a time of 7 minutes until a granular and almost dry mass was obtained. Then the molding was carried out, the dough was weighed and added to the cookie machine, which made the rolling and molding operations, the cookies were received in cans; which were baked at 160 °C for 12 minutes in an oven brand NOVA MAX 1000. It was cooled for 2 hours at room temperature, then packed in polyethylene bags; the selected cookies were stored for 3 months. Three formulations of Table 1 were selected by sensory evaluation; then formulations were tested by adding sesame 4%, 8% and 12% according to Table 2.

2.5 Flours and cookies characterization

In wheat flour, banana flour and in the mixture with 20% banana flour; the contents of moisture, protein, ash, pH and the farinographic parameter were analyzed. In the samples of cookies with wheat flour and cookies with 20% of banana flour, 8% of sesame seeds, moisture, protein, ash and fat were analyzed.

2.6 Stability of cookies during storage

Cookies made with 20% banana flour and 8% sesame seeds were stored for three months. These were analyzed at the beginning and every 15 days, the moisture content, pH, reducing sugars and the inhibition capacity of the DPPH radical were determined.

Table 1
Cookies formulations with variation of banana flour content (%)

Ingredients	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9
Wheat flour	69.34	64.84	61.84	59.34	56.84	54.34	51.84	49.34	46.84	44.34
Banana flour	0.00	5.00	7.05	10.00	12.05	15.00	17.05	20.00	22.50	25.00
Chuño	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Vegetable shortening	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Milk powder	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Water	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
Salt	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Sugar	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Eggs	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Essence of butter	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Calcium propionate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Baking powder	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 2
Cookies formulations with variation in banana flour and sesame seeds content (%)

Ingredients	FA1	FA2	FA3	FB1	FB2	FB3	FC1	FC2	FC3
Wheat flour	56.43	52.43	48.43	51.43	47.43	43.43	46.43	42.43	38.43
Banana flour	10.00	10.00	10.00	15.00	15.00	15.00	20.00	20.00	20.00
Sesame seeds	4.00	8.00	12.00	4.00	8.00	12.00	4.00	8.00	12.00
Vegetable shortening	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Milk powder	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Chuño	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Essence of butter	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Calcium propionate	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Sugar	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Salt	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Eggs	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Water	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60	9.60
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The values represent the mean ± SEM, with n = 3. Values of the same column with different superscripts presented statistical differences ($p \leq 0.01$).

3. Results and discussion

3.1 Chemical characterization of banana flour, wheat flour and selected flour mixture

Table 3 shows the protein, moisture and ash contents of wheat flour, banana flour and the selected flour mixture. The results indicate that there was a statistical difference between the contents. The table shows that wheat flour presented a higher protein and moisture content, it is known that banana flour has lower protein content compared to wheat flour. The protein content of 4.40% was like the value of 3.16 ± 0.10 % reported; the ash content was of 1.37%, this value is similar to the value of 1.92 ± 0.10 % reported (Pelissari *et al*., 2012).

Table 3
Protein, moisture and ash content in different flours

Sample	Proteín (%)	Humidity (%)	Ash (%)
Wheat flour	14.30 [c]	14.50 [c]	0,27 [a]
Banana flour	4.40 [a]	14.30 [a]	1.37 [c]
Mix with banana flour (20%)	10.20 [b]	14.40 [b]	0.83 [b]

3.2 Sensory selection of cookies made with banana flour and sesame seeds

The analysis of variance of the results did not present statistical differences for the attributes smell, color, flavor and crisp. The results coincide with the research in amaranth, where it was determined no significant change in color, aroma, and texture of cookies prepared from blend containing amaranth flour up to 100% level. In terms of taste, significant increase in mean scores was noted up to 60% addition of amaranth flour into the composite cookies (Chauhan *et al.*, 2016). The score obtained on all attributes was found between 5.17 and 6.75, which meant that all cookies were rated between "I do not like or dislike" and "I like lightly". The most acceptable biscuits, on average, were with contents of 10%, 15% and 20% of banana flour, to these formulations was incorporated sesame seeds.

The cookies elaborated with different percentages of sesame did not present statistical differences for the attributes odor, color, flavor, crunchiness. The score obtained on all attributes was found between 5.00 and 6.42, which meant that all cookies were rated between "I do not like or dislike" and "I like lightly". The most acceptable biscuits on average were with 10%, 15% and 20% banana flour and 8% sesame. It is known that the highest percentage of sesame gives a definite odor to commercial cookies, especially the cookies with 20% sesame (Hernández-Monzón *et al*., 2014). The selection of these three formulations allowed to determine the antioxidant capacity of the cookies.

3.3 Farinographical parameters of selected flours and flour mixtures

A laboratory dough model LAB 2500 was used for analysis. It is known that water absorption is the amount of water required by a flour to form a mass that reaches a consistency of 500 UB (De la Horra *et al.*, 2012). The farinograph determines dough and gluten properties of a flour sample by measuring the resistance of a dough against the mixing action of paddles (blades), results include absorption, arrival time, stability time, peak time, departure time, and mixing tolerance index (Abdel *et al*., 2016; Sun *et al*., 2015). The water absorption results of Table 4, indicated statistical differences between treatments ($p \leq 0.01$) and according to the Tukey test the treatment with wheat flour had 64.97 ± 0.03% of water absorption and treatment with banana flour 54.56 ± 0.01% absorption, results coinciding with reported theoretical data for water absorption in wheat flour with 62.1 ± 0.14 (Boita *et al.*, 2016).

Flour with substitutions of 10%, 15% and 20% with banana flour did not present statistical differences, it was reported in cookies made with corn flour with 5%, 8% and 12% a water absorption percentage of 52%, concluding that these mixtures of flours will have the same production yield as wheat flour, since they presented a similar percentage of water absorption (Nuñez, 2009).

It is known that the time of development or kneading is the time necessary to reach the maximum consistency, that is to say immediately before the pharinographical curve begins to descend; it is here where the gluten of the mass is conditioned (Abdel *et al*., 2016). In the results presented in Table 4, among the treatments there was a statistical difference ($p \leq 0.01$) and according to the Tukey test comparing the treatments averages, the wheat flour mass obtained a longer development time with 7.27 ± 0.01 minutes and the banana flour mass a shorter time with 1.53 ± 0.00 minutes. Such time varies in the different flours, with the strong flours can be relatively long. It is possible that a time of prolonged mass development, related to the quality and quantity of gluten, a flour with higher gluten content will present a longer development time and vice versa (Pagani *et al*., 2014). Flour with 10%, 15% and 20% of banana flour presented development times of 2.15 ± 0.01, 1.80 ± 0.00 and 2.07 ± 0.01, respectively; these times were lower than that of wheat flour. The development time and kneading time for wheat flour varies from 3.5 minutes to 7.5 minutes (Pavlovich-Abril *et al*., 2014), values within this range show that it is acceptable for the good development of gluten.

Stability is the time interval during which the mass maintains the maximum consistency, indicates how the mass supports kneading. A strong wheat flour takes longer to develop before reaching 500 BU, where it remains for some time at good stability and shows only a minor decline in consistency. A weak wheat flour reaches 500 BU quickly and undergoes a considerable decline in consistency showing little or no stability (Pagani *et al*., 2014). The results presented in Table 4 show that between the treatments there was statistical difference ($p \leq 0.01$) and according to Tukey the highest average corresponded to the wheat flour with 10.10 ± 0.01 minutes and the lowest to the banana flour with 1.20 ± 0.01. At higher stability, the dough will be able to withstand longer mixing times and will have a longer fermentation time as well as a large gas retention capacity, since the gluten reticular structure is quite strong, which brings about a greater spontaneous mass (Duncan, 1983). The results indicate that as the substitution increases, the stability time of the mass decreased, with values of 6.97 ± 0.03, 5.77 ± 0.03 and 6.10 for the substitutions with 10%, 15% and 20% respectively. It is known that in times of 1.6 and 1.4 minutes, respectively, in 8% and 12% substituted cookies with maize flour; Which indicates that the masses with substituted flours are not to be fermented, since it will not favor the retention of carbonic gas for the swelling and do not withstand a lot of time of mixing, this was not a problem since cookies were made using hard dough.

Table 4
Farinographic parameters of the evaluated flours

Samples	Water absorption (%)	Time of development (Min)	Stability of mass (min)	Degree of softening (PU)
Wheat flour	64.97 ± 0.03^{c}	7.27 ± 0.01^{e}	10.10 ± 0.01^{e}	88.64 ± 0.01^{a}
Banana flour	54.56 ± 0.01^{a}	1.53 ± 0.00^{a}	1.20 ± 0.01^{a}	127.30 ± 0.01^{e}
Banana flour 10%	59.97 ± 0.03^{b}	2.15 ± 0.01^{d}	6.97 ± 0.03^{d}	109.45 ± 0.01^{b}
Banana flour 15%	60.00 ± 0.00^{b}	1.80 ± 0.00^{b}	5.77 ± 0.03^{b}	124.44 ± 0.00^{d}
Banana flour 20%	59.97 ± 0.03^{b}	2.07 ± 0.01^{c}	6.10 ± 0.00^{c}	118.22 ± 0.01^{c}

The values represent (mean ± SEM), n = 3. Values of the same column with different superscripts are statistically different ($p \leq 0.05$).

The degree of softening or weakening of mass represents the difference between maximum consistency and that obtained after 10 - 20 minutes; is expressed in pharynographic units (PU), high softeners indicate that the gluten network is bad or that the flour possesses a lot of damaged starch (Quaglia, 1991). The results of Table 4 indicate that a statistical difference ($p \leq 0.01$) was found between the treatments and according to Tukey's test, the highest degree of softening was obtained by banana flour with 127.30 ± 0.01 UB and the lowest wheat flour with 88.64 ± 0.01 UB, it is known that wheat flour will always present a lower degree of softening compared to other cereal flours due to the greater presence of gluten in its composition (Quaglia, 1991). Flour substituted with 10%, 15% and 20% banana flour presented values of 109.45 ± 0.01, 124.44 ± 0.00 and 118.22 ± 0.01, respectively. It is known that high values of degree of softening would influence the process of making cookies, so it must be taken into account that once the mixing time has passed, it must be passed directly to the rolling step, in order to avoid that the mass is damaged and loses its spongyness (Nuñez, 2009).

3.4 Determination of antioxidant capacity (DPPH) of cookies

Spectrophotometer. Model Genesys 10S UV-UVIS (Thermo) was used for analysis. In Table 5, the results of the capacities to inhibit the DPPH radical of the elaborated cookies are presented. The statistical evaluation determined that there was a difference ($p \leq 0.05$) between the types of cookies, the Tukey test showed that the highest efficiency against the DPPH radical was presented by the cookies with 20% substitution with banana flour and 8% of sesame with an IC_{50} value of 17.52 ± 0.25 mg / mL, this value is better than the one presented by cookies made with wheat flour. It has been reported that chocolate chip cookies presented IC_{50} values of 2.461 ± 5.47 mg/mL and chocolate cake IC_{50} of 2.951 ± 0.46 mg/mL, baked goods such as cakes and cookies decrease their antioxidant activity due to baking since high temperatures cause a negative effect.

Furthermore, it is known that the high starch content (about 74%, dry basis) is important because it is resistant to hydrolysis by digestive enzymes, making acting in roles fiber (Aparicio-Saguilán *et al.*, 2005; Ovando-Martinez *et al.*, 2009). It has been cited that the antioxidant activity of the phenolic compounds is due largely to its redox properties, which play an important role in adsorbing and neutralizing free radicals (Quiñones *et al.*, 2013). It is further known that high temperatures baking and short favor stability of polyphenols and that not all products cooked or baked retain the same level of antioxidant activity (Cheung *et al.*, 2003; Hurst *et al*., 2006).

Table 5
Results of IC_{50} of DPPH radical cookies with different substitution percentages of banana flour

Samples	DPPH IC_{50} (mg/ml)
Cookie with wheat flour	24.115 ± 0.55 ^{c}
Cookie 10% banana flour and 8% sesame	32.54 ± 0.25 ^{d}
Cookie 15% banana flour and 8% sesame	19.38 ± 0.20 ^{b}
Cookie 20% banana flour and 8% sesame	17.52 ± 0.25

Values represent mean ± SEM. n = 3. Values of the same column with different superscripts are significant ($p \leq 0.05$).

3.5 Chemical characterization and stability of cookies in storage

3.5.1 Chemical Characterization of Cookies

The contents of moisture, protein, fat, crude fiber, ash and carbohydrates were (%): 1.88 ± 0.00, 10.65 ± 0.00, 22.01 ± 0.001, 1.01 ± 0.00, 1.54 and 62.91, respectively. The contents of moisture, fat, fiber and ash were higher than that of wheat flour; the content of protein and carbohydrates was higher in wheat flour with values of 13.42% and 64.56% respectively. It is known that the permitted humidity in the biscuit industry is 12% (MINSA, 2010), the values found conform to this tolerance range. Moisture content is an important quality factor for the preservation, convenience in packaging and transport. In addition to it, moisture content also constitutes an identity standard (Kaur *et al*., 2017). The increase of fat in the elaborated cookies was due to the incorporation of 8% of sesame in the cookie, but this value is within the normal range according to different investigations for commercial cookies, with ranges of values between 8.7% - 25.6% (Robinson *et al*., 2007). It has reported a fat content of 19.59% in biscuits with 10% addition of sesame (Hernandez *et al*., 2014). More than 80% of the fats present in sesame seeds are polyunsaturated fats that help regulate blood cholesterol levels. The decrease in protein content was due to the fact that banana flour has no gluten and its protein content is lower than wheat flour. In similar works, low levels of crude protein have also been obtained when wheat flour is substituted for flour from sources other than cereals (García and Pacheco, 2007). The crude fiber content in the cookies increased, this was due to the greater amount of fiber provided by the green banana flour 22.91±0.11% (Bezerra *et al*., 2013). The starch content obtained is similar to that found in cookies flour substituted pijuayo *(Bactris gasipaes)* and native cassava starch (*Manihot esculenta*) was 61.09% and 63.27 % respectively, which represents an energy product and attractive (Hernández and Díaz, 2012).

3.5.2. Stability of cookies in storage

The direct method to access the acceptability of cookies is through sensory evaluation. Sensory evaluation methods are more effective, require a small sample size, less time and do not require a trained panel (Kaur e*t al*., 2017). The biscuit elaborated with the formulation of 20% of banana flour and 8% of sesame was evaluated every 30 days during storage of 3 months, considering odor, color, flavor and crunchiness (Fig. 1).

According to Figure 1, the overall score for all attributes falls within a range of averages between 5.8 and 6.8, which means that the cookies throughout the storage time were graded with the level of liking "Like Slightly "by the panelists.

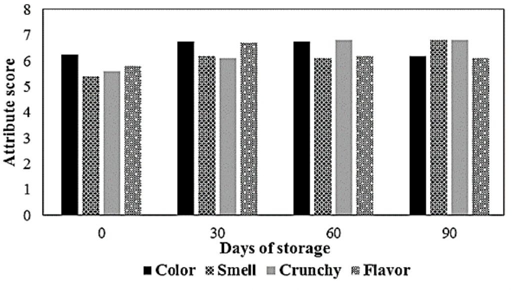

Figure 1. Sensory profile for each attribute of the cookies made with 20% banana flour and sesame 8%, during storage.

In a research conducted it was reported that the highest ratings of general acceptability (7.66) were for biscuits with 15% flaxseed and after this level of substitution a decrease in acceptability scores was observed (Kaur *et al*., 2017).

The statistical analysis ($p \leq 0.05$) of the results evidenced that there was no difference in the results during storage, being verified stability in the evaluated attributes, during the first two months and a slight decrease in the acceptability with respect to crunch and flavor, In the last month; this is linked to a slight increase in the moisture of the cookies due to the permeability of the medium density polypropylene used as packaging. It is known that, over time, different sensory attributes decrease their score, as well as it is known that, at a higher storage temperature, more deterioration occurs (Sanhueza, 2007). The theoretical reference indicates that if it is necessary to prolong the useful life in cookies, snacks and cereals; selecting the best packaging is metallised biaxially oriented polypropylene (BOPP) since this container has an excellent barrier to water vapor, light, oxygen and mechanically (Hernandez *et al*., 2000).

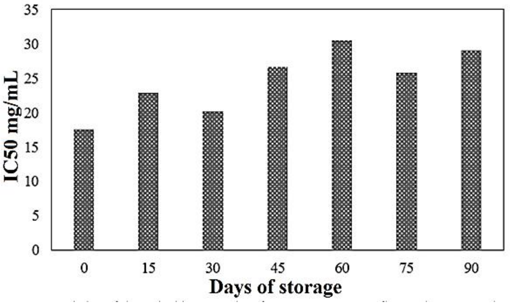

Figure 2. Variation of the antioxidant capacity of cookies with banana flour and sesame seeds on the DPPH radical expressed as IC_{50} (mg/mL), during storage.

Figure 2 shows the antioxidant capacity against the radical DPPH, expressed as IC_{50}, these values presented statistical difference ($p \leq 0.05$) through storage time. The Tukey's test ($p \leq 0.05$) indicated that the cookies showed a higher antioxidant capacity against the DPPH radical at the beginning of storage, with an IC_{50} equal to 17.52 ± 0.29 mg/mL. Thereafter, the IC_{50} value decreased nonuniformly. These results coincide with those obtained in buckwheat, gluten-free biscuits where the antioxidant capacity measured using the DPPH test showed a decreasing tendency during storage in all samples of biscuits investigated (Sakač *et al.*, 2016). The results of similar investigations carried out on tuna marmalade coincided with this behavior of the antioxidant capacity against the DPPH radical on the first day of processing with an IC_{50} of 19.36 mg/mL; however, at the second month of storage there was a decrease in the IC_{50} value to 20.33 mg/mL (Alvares and Cardenas, 2010). These results of improved antioxidant capacity in the product were also achieved by mixing wheat flour with buckwheat flour, in addition to achieving improvements in the physicochemical properties of the mixture (Jan *et al.*, 2015). It was shown that a high phenolic content leads to a high antioxidant activity (Awolu *et al.*, 2016), it is known that banana flour contains these compounds.

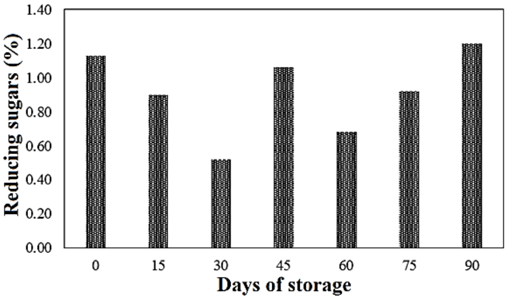

Figure 3. Variation of the content of reducing sugars of the cookies, during the time of storage.

Figure 3 also shows that the values of reducing sugars had a statistical difference ($p \leq 0.05$) during storage and, according to the Tukey test ($p \leq 0.05$), the minimum value was 0.52 ± 0.01%, for the beginning of storage and the highest value was presented at three months with 1.20 ± 0.02%. Reducing sugars values of 3.11% were found for chocolate cookies with wheat flour and 3.19% for cookies substituted in 7% with banana flour; these values are higher because they are sweet cookies. It is important to note that the existence of high concentrations of sugars significantly affect the properties of cookies and are fundamental factors in establishing the interactions of the components within the food matrix (Marlett and Longacre, 1996).

Figure 4 also shows that the moisture content of the stored cookies was statistically different ($p \leq 0.01$) and the Tukey test ($p \leq 0.05$) indicated that the lowest value was 1.88% at the beginning of storage and 3.98 ± 0.05% in the third month. In Peru, it was established that the maximum allowable moisture content in cookies at 12% (MINSA, 2010), the values obtained are below the maximum limit. It is known that moisture biscuits made with potato flour with 30%, 40% and 50% at 60 days of storage reached 13.4% moisture (Ceron *et al.*, 2014), similar results to those found in research with cookies made with arracacha flour (García and Pacheco, 2007).

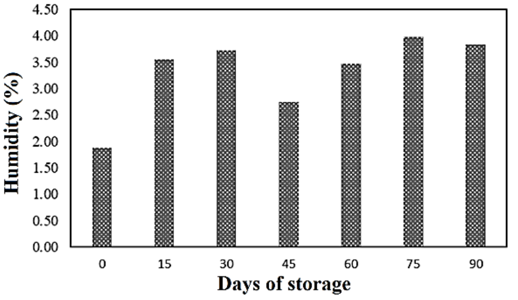

Figure 4. Moisture variation of cookies with banana flour and sesame seeds in storage.

Figure 5 shows that the pH values varied during storage, leading to a decrease; these values were statistically different ($p \leq 0.01$) and according to the Tukey test ($p \leq 0.05$), the lowest value was 5.24 ± 0.01, at the third month of storage and 6.44 ± 0.02 at the beginning. It is known that commercial crackers have a pH range of 5.65 - 7.32 (FDA, 2007), so it can be said that the pH value at the end of storage fell below the minimum value. The control of the pH has the purpose of verifying if there was a formulation with excessive bicarbonate of sodium which exerts on the cookies a regulating effect on the hydrophobicity during the kneading process. In research with cookies made with potato flour (Ceron *et al*., 2014), the pH after 60 days of storage came to 6.83, in biscuits with arracacha flour the pH at the third month was pH 5.75 (García and Pacheco, 2007).

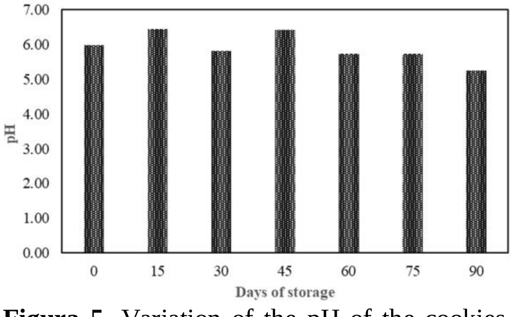

Figura 5. Variation of the pH of the cookies, during the time of storage.

4. Conclusions

It was determined that the protein content (10.2%), moisture (14.40%) of the flour mixture was higher than that of the banana cookies, but lower than that of wheat flour, the ash content (0.83%) was lower than that of the banana flour. Sensory evaluations of the odor, color, flavor and crisp attributes of the cookies allowed to select those with contents of banana flour with 10%, 15% and 20% and with an aggregate of 8% of sesame seeds. The farinographic test determined that the flours with 10%, 15% and 20% of banana flour presented similar values of water absorption (59.97 ± 0.03, 60.00 ± 0.00, 59.97 ± 0.03) and statistically different values for the development time, stability of mass and degree of softening.

Cookies made with formulation 20% banana flour and sesame 8% had higher antioxidant capacity with an IC_{50} equal to 17.52 ± 0.25 mg/mL and according to the proximal chemical analysis the contents of moisture, protein, fat, crude fiber, ash and carbohydrates were: 1.88% ± 0.00, 10.65% ± 0.001, 22.01% ± 0.001, 1.01% ± 0.001, 1.54% and 62.91%, respectively.

The evaluation of sensory storage stability of cookies showed that there were no statistically significant differences ($p \leq 0.05$) in the results, with stability in terms of the attributes evaluated during the first two months and a decrease in crunchiness and flavor in the last month. Ninety days of storage decreased antioxidant capacity (IC_{50} = 29.07 ± 0.92 mg/mL), reducing sugars (1.20 ± 0.02%) and pH (5.24 ± 0.01) and increased humidity (3.83 ± 0.03%), these results were statistically different ($p \leq 0.05$). The results obtained show that it is possible to develop cookies with improved functional characteristics using banana flour and sesame seeds, with good stability in storage time, depending on the type of packaging used, temperature and storage time.

Acknowledgments

The authors would like to thank Innovate Peru and the Ministry of Production of Peru for research funding.

References

Abdel, M.E.S.; Wisal, A.M.B.; Sirekhatim, B.E.; Elamin, A.E.; Vajid, N.V. 2016. Influence of Enrichment of Wheat Bread with Pomegranate (Punica granatum L) Peels by-Products. International Journal of Food Science and Nutrition Engineering 6(1): 9-13.

Agama-Acevedo, E.; Nuñez-Santiago, M.C.; Alvarez-Ramirez, J.; Bello-Pérez, L.A. 2015. Physicochemical, digestibility and structural characteristics of starch isolated from banana cultivars. Carbohydrate Polymers 124: 17–24.

Alvares, P.; Cardenas, V. 2010. Application of the chemical DPPH method to determine the antioxidant capacity present in a tuna jam. Thesis of Chemical Engineer. Faculty of Chemical Engineering. University of Guayaquil, Guayaquil, Ecuador.

AOAC - Association of Official Analytical Chemists. 2000. Official Methods of Analysis, seventeenth ed. (Maryland, USA).

Aparicio-Saguilán, A.; Flores-Huicochea, E.; Tovar, J.; García-Suárez, F.; Gutiérrez-Meraz, F.; Bello-Pérez, L. A. 2005. Resistant Starch-rich Powders Prepared by Autoclaving of Native and Lintnerized Banana Starch: Partial Characterization. Starch - Stärke 57(9): 405–412.

Awolu, O.O.; Omoba, O.; Olawoye, O.; Dairo, M. 2016. Optimization of production and quality evaluation of maize-based snack supplemented with soybean and tiger-nut (*Cyperus esculenta*) flour. Food Science & Nutrition 5(1): 3–13.

Bezerra, C.V.; Amante, E.R.; de Oliveira, D.C.; Rodrigues, A.M.C.; da Silva, L.H.M. 2013. Green banana (Musa cavendishii) flour obtained in spouted bed – Effect of drying on physico-chemical, functional and morphological characteristics of the starch. Industrial Crops and Products 41: 241–249.

Berlanga, S.; Rubio, H. 2012. How to apply bivariate Student's t-tests and ANOVA in SPSS. Case study. Online REIRE, Revista d'Innovació i Recerca en Educació 5(2): 83-100.

Boita, E.R.F.; Oro, T.; Bressiani, J.; Santetti, G.S.; Bertolin, T.E.; Gutkoski, L.C. 2016. Rheological properties of wheat flour dough and pan bread with wheat bran. Journal of Cereal Science 71: 177–182.

Brand-Williams; Cuvelier, M.; Berset, C. 1995. Use of free radical method to evaluate antioxidant activity. Lebensm. Wiss Technol. 28: 25-30.

Cerón, C.; Bucheli, J.; Osorio M. 2014. Elaboration of biscuits based on potato flour of the variety Parda Pastusa (*Solanum tuberosum*). Acta Agronómica 63(2): 104-112

Chauhan, A.; Saxena, D.; Singh, S. 2016. Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. Cogent Food & Agriculture 2: 1125773

Chávez-Salazar, A.; Bello-Pérez, L. A.; Agama-Acevedo, E.; Castellanos-Galeano, F. J.; Álvarez-Barreto, C. I. 2017. Isolation and partial characterization of starch from banana cultivars grown in Colombia. International Journal of Biological Macromolecules 98: 240-246.

Cheung, L.; Cheung, P.; Ooi, V. 2003. Antioxidant activity and total phenolics of edible mushroom extracts. Food Chemistry 81(2): 249–255.

De la Horra, A.E.; Seghezzo, M.L.; Molfese, E.; Ribotta, P.D.; León, A. E. 2012. Indicadores de calidad de las harinas de trigo: índice de calidad industrial y su relación con ensayos predictivos. Agriscientia 29(2): 81-89.

Demirkesen, I. 2016. Formulation of Chestnut Cookies and their Rheological and Quality Characteristics. Journal of Food Quality 39(4): 264–273.

Diezgranados, G. 2011. Milk (horchata) of sesame or sesame in replacement of cow's milk. International Clinic of Biological Medicine. Foundation in Good Hands. Cartagena de Indias.

Duncan, J. 1983. Technology of the biscuit industry. Ed. Acribia. Saragossa. Spain. 483 pp.

Ertaş, N. 2015. Effect of Wheat Bran Stabilization Methods on Nutritional and Physico-Mechanical Characteristics of Cookies. Journal of Food Quality 38(3): 184–191.

Farmani, J.; Edalatkhah, M.; Motamedzadegan, A.; Mardani, M. 2016. Production of set yoghurt analogue through replacement of milk fat with canola and sesame oil. International Journal of Dairy Technology 69(3): 433–440.

FDA. 2007. US Food and Drug Administration, Center for Food Safety and Applied Nutrition. PH values of food products. Journal of Food Engineering 34 (3): 98-99.

García, A.; Pacheco, E. 2007. Evaluation of sweet wafer cookies based on arracacha flour (*Arracacia xanthorriza* B.). Journal Faculty. National Agrarian. Medellin 60(2): 4195-4212.

Gharby, S.; Harhar, H.; Bouzoubaa, Z.; Asdadi, A.; El Yadini, A.; Charrouf, Z. 2017. Chemical characterization and oxidative stability of seeds and oil of sesame grown in Morocco. Journal of the Saudi Society of Agricultural Sciences 16(2): 105–111.

Gusakov, A.V. 2011. Alternatives to biofuel production in Trichoderma reesei. Trends in Biotechnology 29: 419-435.

Hernández, R. 2006. Elaboration of spaghetti added with banana starch: physical, chemical, nutritional and quality characterization. Master Thesis. National Polytechnic Institute. Center for the development of biotic products. Morelos, Mexico.

Hernandez, R.; Selke, S.; Culter, J. 2000. Plastics packaging properties, processing, applications, and regulations. Cincinati Hanser Publications, Inc. 425 pp.

Hernández-Monzón, A.; García-Pedroso, D.; Calle-Dominguez, J.; Duarte, C. 2014. Develop of a sweet cookie with toasted sesame and ground. Tecnología Química 34(3): 240-250.

Hernández, G.; Dias O. 2012. Elaboration of cookies as an alternative for food sovereignty in the Colombian Amazon region. University of Antioquia, Medellín-Colombia.

Hurst, W.; Miller, B.; Stuart, A.; Smith, L.; Lee, Y.; Mchale, L.; Flanagan, A.; Ou, B. 2006. Antioxidant activity and polyphenols and procyanidin content Products containing commercially available cocoa and chocolate selected in the United States. Journal of Agricultural and Food Chemistry 54(4): 4062-4068.

Iram (Argentine Institute for Rationalization of Materials). IRAM standard 15855, 2000. Wheat flour. Physical characteristics of the masses. Determination of water absorption and rheological properties, using a farinograph. Buenos Aires, Argentina.

Jan, U.; Gani, A.; Ahmad, M.; Shah, U.; Baba, W.N.; Masoodi, F.A.; Wani, S.M. 2015. Characterization of cookies made from wheat flour blended with buckwheat flour and effect on antioxidant properties. Journal of Food Science and Technology 52(10): 6334–6344.

Kaur, M.; Singh, V.; Kaur, R. 2017. Effect of partial replacement of wheat flour with varying levels of flaxseed flour on physicochemical, antioxidant and sensory characteristics of cookies. Bioactive Carbohydrates and Dietary Fibre 9: 14–20.

Kim, J.H.; Seo, W.D.; Lee, S.K.; Lee, Y.B.; Park, C.H.; Ryu, H.W.; Lee, J.H. 2014. Comparative assessment of compositional components, antioxidant effects, and lignan extractions from Korean white and black sesame (*Sesamum indicum* L.) seeds for different crop years. Journal of Functional Foods 7: 495–505.

Kira, R; Sawyer, R.; Egan, H.1996. Composition and food analysis of Person. 2 ed. DF, Mexico, Continental SA 135 pp.

Lin, X.; Zhou, L.; Li, T.; Brennan, C.; Fu, X.; Liu, R. H. 2017. Phenolic content, antioxidant and antiproliferative activities of six varieties of white sesame seeds (*Sesamum indicum* L.). RSC Adv. 7(10): 5751–5758.

Lin, Y.C.; Thùy, T.D.; Wang, S.-Y.; Huang, P.-L. 2014. Type 1 Diabetes, Cardiovascular Complications and Sesame (芝麻 Zhī Má). Journal of Traditional and Complementary Medicine 4(1): 36–41.

Marlett, J.; Longacre, M. 1996. Comparison of in vitro and in vivo measures of resistant starch in selected grain products. Cereal Chemistry 73 (1): 63-68.

MINSA – Ministerio de Salud. 2010. Norma Sanitária para la Fabricación, Elaboración y Expendio de Productos de Panificación, Galletería y Pastelería. RM N° 1020-2010 / MINSA. Peru.

Miller, G.L. 1959. Use of dinitrosalicic acid reagent for determination of reducing sugar. Analytical Chemistry 31(1959): 426-428.

Nuñez, F.D. 2009. Study of the Technical and Economic Feasibility of a Partial Substitution of Wheat Flour for Flour of other Cereals applied in the Gallete Industry. Thesis Food engineer. Faculty of engineering in mechanics and production sciences. Polytechnic School of the Coast. Guayaquil, Ecuador.

Ovando-Martinez, M.; Sáyago-Ayerdi, S.; Agama-Acevedo, E.; Goñi, I.; Bello-Perez, L. 2009. Unripe banana flour as an ingredient to Increase the (indigestible carbohydrates of pasta. Food Chemistry 113: 121-128.

Pagani, M.A.; Marti, A.; Bottega, G. 2014. Wheat Milling and Flour Quality Evaluation. In Bakery Products Science and Technology, Second Edition (eds W. Zhou, Y.H. Hui, I. De Leyn, M.A. Pagani, C.M. Rosell, J. D. Selman and N. Therdthai), John Wiley & Sons, Ltd, Chichester, UK.

Pavlovich-Abril, A.: Rouzaud-Sández, O.; Romero-Baranzini, A.L.; Vidal-Quintanar, R.L.; Salazar-García, M.G. 2014. Relationships between Chemical Composition and Quality-Related Characteristics in Bread Making with Wheat Flour-Fine Bran Blends. Journal of Food Quality 38(1): 30–39.

Patzi, J. 2007. Determination of Thiamin and Riboflavin in wheat flour, soybean meal and banana flour by the fluorometric method. Tesina for bachelor's degree in biochemistry- Pharmacy. La Paz, Bolivia.Faculty of Pharmaceutical and biochemical sciences. University of San Andrés.

Pelissari, F.; Andrade-Mahecha, M.; Sobral, P.; Menegalli, F. 2012. Isolation and characterization of the flour and starch of plantain bananas (*Musa paradisiaca*). Starch - Stärke 64(5): 382–391.

Quaglia. O. 1991. Science and technology of baking. 2d ed. Zaragoza, Espeta Acribia SA. 485 pp.

Quiñones, G.J.; Trujillo, S.R.; Capdesuñer, R.Y.; Quirós, M.Y.; Hernández de la Torre, M. 2013. Potencial de actividad antioxidante de extractos fenólicos de *Theobroma cacao* L. (cacao). Revista Cubana de Plantas Medicinales 18(2): 201-215.

Robinson, J.; Singh, R.; Kays, S. 2007. Evaluation of an automated hydrolysis and extraction method for quantification of total fat, lipid classes and Tran's fat in cereal products. Food Chemistry 107: 1150.

Sakač, M.; Pestorić, M.; Mandić, A.; Mišan, A.; Nedeljković, N.; Jambrec, D.; Sedej, I. 2016. Shelf-life prediction of gluten-free rice-buckwheat cookies. Journal of Cereal Science 69: 336–343.

Sanhueza, P.F. 2007. Development of quinoa biscuit (*chenopodium quinoa* Willd) with walnut. Thesis. Food engineer. University of Chile. Santiago, Chile, p 65-97.

Sun, J.; Yang, W.; Liu, D.; Zhao, J.; Luo, G.; Li, X.; Zhang, A. 2015. Improvement on Mixograph test through water addition and parameter conversions. Journal of Integrative Agriculture 14(9): 1715–1722.