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Partial use of coffee waste flour in cupcakes in Peru

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Abstract

Coffee husks are a promising raw material for the development of eco-friendly by-products. Therefore, the objective of the study was to determine the shelf life of coffee husk cupcakes through accelerated testing. The coffee husk was dehydrated at room temperature for 3 days and subjected to grinding for obtaining flour. 11 formulations were developed and estimated by response surface to determine the optimal formulation, establishing the husk life at 3 storage temperatures (20, 30 and 40°C) and 4 days of evaluation (0, 5, 10 and 15 days). The optimum formulation achieved was a 12% substitution of wheat flour for coffee husk flour and 1.14% of yeast: optimum pH values of 6.35 and b of 41.19. The preferred formulation obtained shelf lifetimes of 18, 13, and 9 days of storage at 20, 30, and 40°C, respectively, because NTP 206.002 establishes as a requirement that the % of acidity should not exceed the value of 0.7%, expressed in lactic acid. Finally, it is concluded that the use of coffee husk flour in the formulation of cupcakes is viable because it allows obtaining products with a longer shelf life and is presented as a processing alternative in coffee industries through the use of its residues.*

Keywords: *muffin, shelf life, surface response, coffee residue, coffee waste.*

1. Introduction

Coffee and its derivatives are the most demanded and traded products in the world after black gold, with more than 80 producing countries (Mirani and Goli, 2021). In this regard, the United States Department of Agriculture (USDA, 2021) estimates that the volume of world production in coffee year 2021/22 will register 164.8 million bags, so it is inferred that every day, more than 2250 million cups of coffee are consumed worldwide., with more than 90% of coffee production taking place in developing countries, while consumption is mainly concentrated in industrialized economies (Puente, 2002).

Meanwhile, Peru ranks tenth in the world as an agro-exporting coffee power with a production of 227,600 tons by the year 2021, with the Villa Rica district among the areas with the highest production, which has 31 coffee processing plants that associate 40 to 50 coffee producers per plant, whose inhabitants (90% villarricenses) are linked directly or indirectly to the coffee sector (PROMPERÚ, 2021).

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Coffee processing generates waste that, if not treated or reused, would be disposed of in soils or bodies of water, generating negative impacts on the ecosystems (Torres et al., 2021). Among the residues generated by its industrialization is the husk, which covers the coffee beans, representing an average of 12% of the dry weight of the berry, obtaining an average of 0.18 tons of coffee husk residues for each ton of coffee produced (Torres et al., 2021). The composition of coffee hulls comprises 15% moisture, 72.3% carbohydrates, 7% protein, 5.4% ash, 0.3% lipids, 29.7% hemicellulose, 23.7% lignin, and 6.2% ash (Gouvea et al., 2009).

On the other hand, the bakery industry has been innovating with the production of functional foods, in which cupcakes are bakery products suitable for the enrichment and it is universal and easy to make. This global trend demands the development of healthier food products that contribute to the daily requirements and ensures their conservation in compliance with the desired characteristics, avoiding organoleptic, physicochemical, chemical, microbiological and functional modifications (Corradini, 2018) because all food by nature is perishable, being physically, chemically and biologically active substances (García & Molina, 2008); therefore, it is changeable and influences its quality attributes, which will determine the degree of acceptability of the product and shelf life of the food..

Thus, coffee husks in the bakery industry, under a circular economy approach, provide the opportunity to generate sustainable production (Anastopoulos & Pashalidis, 2019), For this purpose, it is necessary to optimize formulations using methodologies that establish mathematical models such as response surface designs.

Concerning the aforementioned, Abdel-Moemin (2016) determined the chemical and sensory properties of cupcakes formulated with Roselle calyx extract (Caleja et al., 2018) and the Melissa officinalis (lemon balm) and its extracts for cupcake preservation. Odorissi et al. (2018) investigated the addition of a water-soluble formulation of lutein as an ingredient in cupcake formulation; Mirani & Goli (2021) formulated cupcakes with the replacement of wheat flour by eggplant fiber using surface response methodology, among others. Faced with this propensity, the research aims to estimate the shelf life of cupcakes with coffee husk by accelerated testing.

2. Methodology

2.1. Raw materials and place of execution

The coffee hulls were collected from the centralized wet mills - PBHC: APROCAFAE Association and air dried for 3 days in the district of Villa Rica, located in the province of Oxapampa in the department of Pasco, Peru. It is located at 1467 m.a.s.l. and is one of the largest coffee producers. The average temperature is 21°C, west longitude 75°,16',10" and south latitude 10°,43',10". The dehydrated husks were taken to the laboratories of the E.P. of Agroindustrial Engineering of the Faculty of Applied Sciences of the Universidad Nacional del Centro del Perú, Tarma branch, for grinding (IKA mill, M20) and sieving (ZONYTEST electric sieve, EJR2000) with a 100 mesh, to obtain coffee husk flour with a fineness module in the range of 0 to 2 (fine flour) (INDECOPI, 1986).

2.2. Obtaining cupcakes with coffee husk flour

The raw material and inputs were received with the proper hygiene and quality controls to be formulated according to Table 1. With this, mixing, molding, baking, cooling, packaging, and storage operations were carried out. Mixing 1 consisted of beating the eggs and sugar for 10 minutes until an almost white and foamy color was obtained. This was followed by the second mixing, which consisted of adding the milk and oil to beat for 6 minutes until a homogeneous mixture was obtained. Then, the third mixing was carried out, where the raw materials and all the dry ingredients were added to the second mixing, mixing the flour according to the formulation, water was also added and mixed for 10 minutes until the dough was completely homogenized. They were quickly poured into molds 5 cm in diameter by 1.5 cm high, in each one approximately 15 g of dough was added with the help of a stainless-steel spoon. They were baked in an electric oven (WOV-KONVEKT30). The equipment was heated for 4 minutes to reach the desired baking temperature of 176 °C for a baking time of 17 minutes, then the product was unmolded to be cooled at room temperature for 45 minutes. They were packed in high-density polypropylene bags to be hermetically sealed.

Finally, stored at room temperature (approximately 18 to 20°C) in a cool, dry place.

Table 1 Formulations established in the research.

Raw material and insumos	Formulación (%)
Wheat flour	9.00 – 17.00
Coffee husk flour	12.00 – 20.00
Yeast	1.00 – 2.00
Sugar	23.58
Egg	17.17
Milk	8.00
Oil	10.00
Water	10
Salt	0.25
Total	100

Note: The percentages established in the different substitutions are based on the substitution of wheat flour for coffee husk flour; and yeast levels detailed in Table 2.

2.3. Cupcake formulation by response surface

A) Experimental design response surface

For its study, the response surface methodology was used: central compound of 22+ 3 central points, obtaining 11 total trials. Establishing the relationship of the independent variables: levels of partial substitution of coffee husk flour ranging from 12 to 20% and the levels of yeast ranging from 1 to 2%. As response variables, the % acidity, pH, % humidity, uniformity, symmetry, brightness, a*, b*, and general acceptability were evaluated.

In the response surface design, the linear equation was established, allowing the construction of an empirical model that correlates the response variables with the independent variables, according to eq. (1):

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_{12} + \varepsilon$$

Where:

Y: Result of the response variable (% acidity, pH, % humidity, uniformity, symmetry, brightness, a*, b* and general acceptability).

X_1 : Independent variable, levels of partial substitution of wheat flour for coffee husk flour.

X_2 : Independent variable, yeast level

β : It is the intercept coefficient of the model; β_0 β_1, β_2 and β_{12} are interaction coefficients of the linear and quadratic terms, respectively.

Table 2 Treatments proposed by the 22+3 center composite response surface design for the different response variables

Treatment	Levels of wheat flour substitution by coffee husk flour (%)	Yeast levels (%)
F1	16.0	2.0
F2	20.0	2.0
F3	12.0	1.5
F4	12.0	2.0
F5	16.0	1.0
F6	20.0	1.5
F7	12.0	1.0
F8	20.0	1.0
F9	16.0	1.5
F10	16.0	1.5
F11	16.0	1.5

For the validation of the model, the Central Composite Design was used with an ANVA that assesses the variability of the variable responses due to the effect of the partial substitution of wheat flour by coffee flour and the levels of yeast in which the statistical significance of each effect was evaluated by comparing its mean square against an estimate of the experimental error, in addition to obtaining adjusted R2 values for each of the responses. This together with the Durbin-Watson (DW) statistic contrasts the presence of serial autocorrelation in the regression residuals to determine significance with a p-value of 0.05 and determine an equation that predicts values of the response variable.

B) Cupcake optimization using the response surface method

Finally, the cupcake formulation was optimized through the interaction of the response variables that presented significant differences, obtaining the desirability (D), % of wheat flour substitution by coffee husk flour, and % of yeast, as well as the expected optimal response variables.

2.4. Characterization of cupcakes at different % substitution of wheat flour by coffee husk flour and yeast levels.

A. Physical analysis of the cupcake at different % substitution of wheat flour for coffee husk flour and yeast levels.

The quality parameters of the cupcake volume measurement were determined. For the symmetry index (mm) and uniformity index (mm) the cupcake was cut in half and determined by AACC method 19-91.01, using a transparent ruler (AACC, 2000a). Finally, crumb color was determined, with the colorimeter (LC 100, Germany), in values of three L* (lightness) stimuli from 0 to 100, 0 being a perfect absorber and 100 for a perfect diffuser, a* (yellow-blue) and b* (magenta-green).

B. Physicochemical analysis of the cupcake at different % substitution of wheat flour by coffee husk flour and yeast levels.

The acidity content (%) was determined using the titration method established by AACC 02-31.01 (AACC, 2000c) (considering lactic acid as the predominant acid) and in pH values with the potentiometric method established by AACC 02-52.01 (AACC, 2000b), using a potentiometer (SCHOTT, PH11).

C. Proximal chemical analysis of cupcakes with different % substitution of wheat flour for coffee husk flour and yeast levels.

The moisture content (%) was determined, five grams of dough and cake crumb were separated and thoroughly mixed, and their moisture content was measured by the hot oven drying method (105°C) until a constant weight was reached according to the standard method of NTP 206.011 (1981).

D. Análisis sensorial del cupcake con diferentes niveles de sustitución de harina de trigo y tarwi

The sensory analysis of cupcakes substituted with coffee husk was carried out at the Faculty of Applied Sciences of the Universidad Nacional del Centro del Perú with a panel of 30 students from the professional career in Agroindustrial Engineering, aged 18 to 25 years old. The panelists entered a suitable environment, and each panelist received the 11 samples and a glass of water to rinse their mouths between samples. An evaluation booklet was also provided to assess overall acceptability. The purpose of the test was to determine the degree of acceptability of the cupcake samples by establishing 5-point hedonic scale, from I dislike it (1 point) to I like it very much (5 points) (ISO, 2007).

2.5. Shelf-life analysis of optimized cupcakes at different storage conditions

The optimized cupcake was prepared as detailed in section 2.2. and packaged in polypropylene bags for shelf-life evaluation by accelerated testing. For this, the cupcakes were stored at 20, 30, and 40°C and evaluated at different storage times of 0, 5, 10, and 15 days (Nuñez et al., 2018). The results were modeled with the Arrhenius equation based on the obtained acidity content; a control parameter established by NTP 206.002 (2018), which states that the product is suitable for consumption when it does not exceed the value of 0.7% acidity expressed as lactic acid.

2.6. Data analysis

The data processing and respective analysis of the evaluated factors: % substitution of wheat flour by coffee husk flour and the selected yeast levels for each factor expressed in Table 2 were processed with Statgraphics Centurion software, version XVI with the central composite response surface design of 22+ 3 central points for the different response variables: % acidity, pH, % humidity, uniformity, symmetry, brightness, a*, b* and general acceptability. The results are presented in tables and figures according to the descriptive and inferential statistics obtained from the ANOVA with a significance level of 5%.

3. Results

3.1. Characterization of cupcakes formulated using response surface design.

The cupcakes formulated at different levels of partial substitution of wheat flour for coffee husk flour and levels of yeast using the 22+ 3 central points central composite response surface design, presented effects in the response variables: % acidity, pH, % moisture, uniformity, symmetry, brightness, a*, b* and general acceptability expressed in Table 3.

It is observed that the formulations that obtain higher values in the response variables are indistinct. In the case of % acidity, formulations 3, 9, and 11 (0.20%). In pH value, formulation 4 (6.42). In the % of humidity the formulation 9 (24.89%). For the uniformity index the formulation 3 (82.33 mm), symmetry the formulation 1 (8.67 mm), luminosity the formulation 4 (29.41), value of a* formulation 2 (17.72), value of b* formulation (41.5) and general acceptability the formulation 6 (5 points); evidencing the great variability of results leading to the analysis of the response surface methodology for the determination of an optimal formulation of the product.

Table 3 Variable responses of the different cupcake formulations were obtained from the response surface design

Formulation	Coffee husk flour (%)	Yeast levels (%)	Descriptive statistics	Acidity%	pH	Humidity (%)	Uniformity (mm)	Symmetry (mm)	*L**	a*	b*	Acceptability
F1	16.00	2.00	Media	0.15	6.31	18.84	76.33	8.67	22.37	16.35	40.51	3.20
			± SD.	±0.02	±0.21	±1.23	±0.85	±0.15	±0.57	±0.37	±0.55	±0.26
F2	20.00	2.00	Media	0.15	6.12	20.07	80.67	7.67	24.5	17.72	39.24	3.00
			± SD	±0.01	±0.34	±1.65	±0.75	±0.11	±1.15	±0.69	±0.90	±0.15
F3	12.00	1.50	Media	0.20	6.37	20.30	82.33	4.67	20.96	14.47	41.50	4.00
			± SD	±0.01	±0.18	±1.02	±0.64	±0.91	±0.86	±0.80	±0.84	±0.21
F4	12.00	2.00	Media	0.12	6.42	22.58	79.67	5.33	29.41	14.58	35.94	3.4
			± SD	±0.04	±0.36	±0.98	±0.79	±1.02	±0.93	±0.94	±0.27	±0.10
F5	16.00	1.00	Media	0.15	6.28	20.05	76.00	5.00	26.59	15.80	38.14	3.00
			± SD	±0.09	±0.42	±1.35	±0.82	±0.99	±0.88	±0.45	±0.64	±0.06
F6	20.00	1.50	Media	0.17	6.13	23.36	75.33	8.00	25.42	16.53	37.01	5.00
			± SD	±0.05	±0.53	±0.87	±0.59	±0.87	±0.42	±0.52	±0.58	±0.07
F7	12.00	1.00	Media	0.15	6.41	22.47	75.67	6.33	26.46	15.25	36.73	3.00
			± SD	±0.01	±0.27	±0.72	±0.75	±0.79	±0.96	±0.94	±0.91	±0.11
F8	20.00	1.00	Media	0.12	6.27	4.43	70.33	6.00	22.05	17.09	36.48	3.00
			± SD	±0.06	±0.82	±0.96	±0.87	±0.95	±0.37	±0.63	±0.85	±0.04
F9	16.00	1.50	Media	0.2	6.28	24.89	79.00	5.00	23.6	16.29	36.75	4.10
			± SD	±0.04	±0.60	±1.05	±0.91	±0.99	±0.52	±0.70	±0.58	±0.02
F10	16.00	1.50	Media	0.17	6.27	20.03	74.33	6.67	18.52	15.75	34.71	3.90
			± SD	±0.02	±0.54	±1.24	±0.93	±0.60	±0.74	±0.28	±0.79	±0.07
F11	16.00	1.50	Media	0.20	6.28	24.13	75.33	7.33	27.95	15.72	37.71	4.00
			± SD	±0.07	±0.37	±1.46	±0.83	±0.76	±0.70	±0.92	±0.80	±0.09

3.2. Effect of partial substitution of wheat flour by coffee husk flour and different levels of yeast on cupcake response variables by response surface.

To establish the optimization of the levels of partial substitution of wheat flour by coffee husk flour and levels of yeast on the effect of the parameters of % acidity, pH, % moisture, uniformity, symmetry, brightness, a*, b*, and overall acceptability (Table 3), ANOVA was performed to assess their linear, quadratic and interaction effects at a value of $p < 0.05$ as detailed in Figure 1.

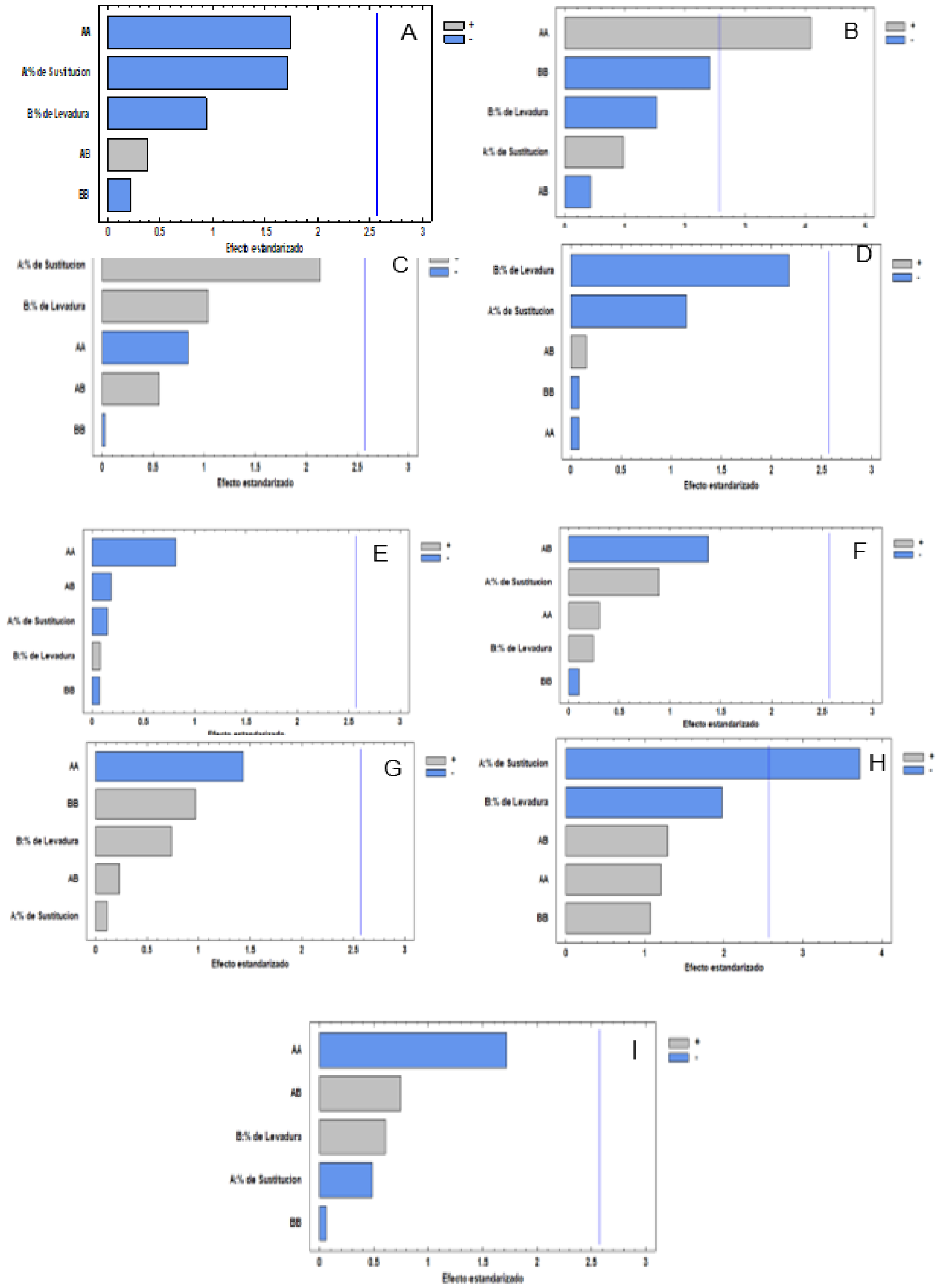

Figure 1 Pareto plot for each of the estimated effects on each response variable assessed on cupcakes with different levels of partial substitution of wheat flour for coffee husk flour and levels of yeast.

Note: (A) % acidity; (B) pH; (C) % moisture; (D) uniformity; (E) symmetry; (F) L*; (G) a*; (H) b* and (I) general acceptability.

Figure 1 represents in separate bars each of the effects of each response variable. Thus, it is evident that for the response variables of % acidity, % moisture, uniformity index, symmetry, lightness (L), a*, and acceptability, each of their effects does not present statistically significant differences in the levels of partial substitution of wheat flour for coffee husk flour and levels of yeast.

In relation to the response variables of pH in the AA effect with a p-value of 0.0094 and in the A effect: % of substitution of the response variable b* with a p-value of 0.0137, results show the existence of significant statistical differences in the levels of partial substitution of wheat flour by coffee husk flour and levels of yeast, which is why these response variables will be taken for the optimization of the cupcake formulation.

3.3. Optimization of cupcake formulation

The optimization of the cupcake formulation at different levels of partial substitution of wheat flour for coffee husk flour and yeast levels through the response surface methodology as a function of the response variables pH and b* are shown in Figure 2.

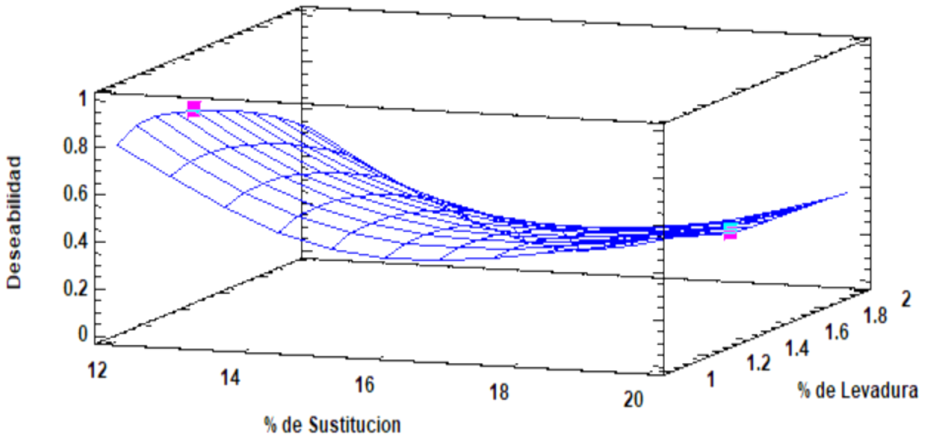

Figure 2 Estimated response surface for the effects of the level of partial substitution of wheat flour by coffee husk flour and yeast levels on the desirability function for optimizing the pH and b*.

Thus, the optimization of the cupcake is given through the maximization of the desirability function (D), finding an optimal desirability value of 0.86 (Figure 2) (Table 4).

Table 4 shows the optimum values for the cupcake formulation and the optimum results that would be achieved with this formulation in the response variables pH and b*.

Table 4 Optimal values for cupcake formulation with partial substitution of wheat flour by coffee husk flour and yeast levels in the desirability function for the optimal expected responses variables pH and b*

Optimal desirability	Optimum formulation		Variables expected optimal response	
	% of Substitution	% of Yeast	pH	b
0.86	12.00	1.14	6.35	41.19

3.4. Optimized cupcake shelf life

From the optimal formulation obtained (Table 4), the shelf life is determined by accelerated tests, considering as variables the days of storage (0, 5, 10, and 15 days) and temperatures (20, 30, and 40 °C) to predict the increase in acidity content (%) expressed as lactic acid (Table 5).

Table 5 Acidity content (%) of the optimized cupcake at different storage conditions

Days	0			5			10			15		
Temperature	20	30	40	20	30	40	20	30	40	20	30	40
% acidity	0.15	0.15	0.15	0.29	0.34	0.38	0.42	0.47	0.51	0.66	0.7	0.78
± SD	± 0.04	± 0.02	± 0.04	± 0.05	± 0.04	± 0.03	± 0.03	± 0.04	± 0.05	± 0.03	± 0.03	± 0.01

Note: n=3 repetitions. SD: standard deviation.

Figure 3-A shows that the acidity content (%) at different temperatures increases as the days of storage elapse. From this, equations (2, 3, and 4) are denoted to facilitate the prediction of the acidity content in days after 15 days of cupcake storage.

$$\% \text{ acidity}_{20°C} = 0.1310 + 0.0332T \qquad (2)$$

$$\% \text{ acidity}_{30°C} = 0.1480 + 0.0356T \qquad (3)$$

$$\% \text{ acidity}_{40°C} = 0.3567 + 0.0400T \qquad (4)$$

With the equations expressed, the Arrhenius equation is developed (Figure 3-B), based on equation (5).

$$lnk = -0.5068 - 851.74\left(\frac{1}{T}\right) \qquad (5)$$

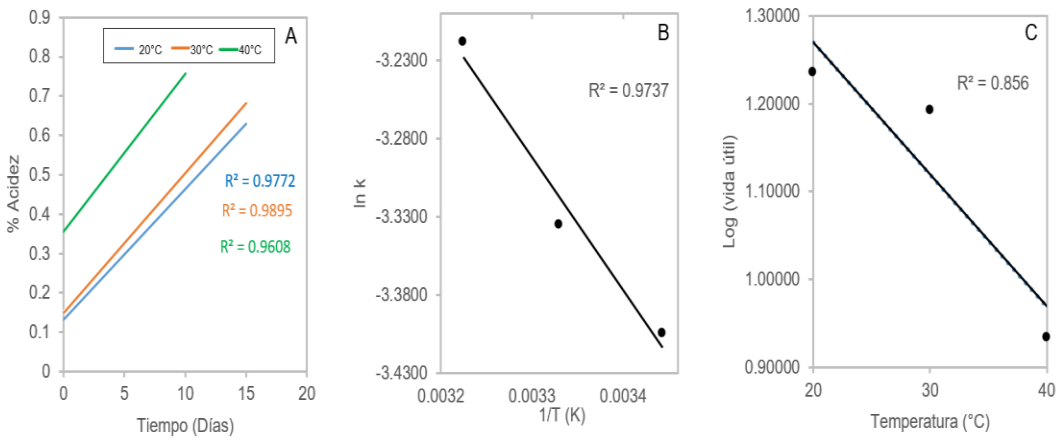

Figure 3 Determination of optimized cupcake shelf life by accelerated testing.

Note: (A) % acidity in relation to storage temperatures (20 °C, 30 °C and 40 °C); (B) Arrhenius equation of the optimized cupcake; and (C) Logarithm of the shelf life of the optimized cupcake.

In this regard, NTP 206.002 (2018) refers that, as a physicochemical requirement, the acidity content must have a maximum value of 0.7%, a control parameter to be considered to estimate the shelf life of the product. Thus, equations 2, 3, and 4 are used to determine the shelf life of the cupcakes at 20, 30, and 40°C of storage. These results were then converted to logarithms in base 10 for the development of linear regression and an equation to estimate the shelf life at different storage temperatures (eqs. 6 and 7).

$$Log_{vida\ útil} = 1.5699 - 0.015T \qquad (6)$$

$$vida\ útil = 10^{(1.5699-0.015T)} \qquad (7)$$

With equation 7, the predicted shelf life of the cupcake at 20°C storage was 18 days, for 30°C it was 13 days and for 40°C it was 9 days.

4. DISCUSSIONS

The different cupcake formulations showed favorable results for consumption. Such is the case of acidity content (%), the formulations have between 0.12 to 0.20% lactic acid, a requirement that complies with NTP 206.002 (2018), where it establishes not to exceed 0.7% of acidity content expressed in lactic. When comparing with research on cupcakes with red palm olein, it has 0.09±0.01 % of acidity (Loganathan et al., 2020), a lower value than the research. Contrary case to that reported by Liubych et al. (2022) in the cupcake enriched with pumpkin slices, which obtains 1.5 to 1.7 % acidity, and Abdel-Moemin (2016) who obtains 1.2% acidity in Roselle cupcakes. This could be justified by the differentiated composition of the raw materials.

With respect to pH values the cupcakes obtained from 6.12 to 6.42 when contrasted with studies by Caleja et al. (2018) in cupcakes with lemon balm extract (7.3 to 7.5), Abdel-Moemin (2016) in Roselle cupcakes (7.9) and Moemin AR (2016) in the cupcake with Rosella calyxes (5.5 to 7.7), certain approximations would be differentiated by the raw materials.

In % moisture, the results show 18.84 to 24.89%, values that are within the requirements established by NTP 206.002 (2018), which establishes a maximum value of 40% moisture. Likewise, the values are close to those obtained by Ahmadi et al. (2022) in the cupcake with apricot kernel flour (16 to 19%), Jabeen et al. (2022) with the gluten-free cupcake enriched with almond, flaxseed, and chickpea flours (18.89 to 23.15%) and Abdel-Moemin (2016) in Roselle cupcakes (29.2%), but different from the cupcake with almond and coconut flours (32.2 to 42.0%). This could be due to their formulation and that they evaluated at 40 hours of storage (Hopkin et al., 2022).

Table 3 shows values between 70.33 and 82.33 mm for the uniformity index. Ferrari et al. (2015) establish that this measure is the difference of the ends of the product and that the growth of the dough in the baking and cooling stage was uniform, the reason with which the quality of the cupcake can be guaranteed. As well as the importance of adding liquids to the formulation because they help to obtain a foaming dough and this affects the volume and uniformity of the bubbles achieving a better structure, lightness, softness, and increased dispersion of air cells during baking and this is valued according to its uniformity index (Gupta et al., 2009).

The Cupcake Symmetry Index of the 11 formulas presents a variability ranging from 4.67 to 8.67 mm, in addition to being positive values. De Souza et al. (2018) state that positive symmetry index values affirm that the product has a superior center which allows for maintaining its structure. In line, Almeida et al. (2013) refer that values higher than 0 indicate that cupcakes have a higher center than their ends, which is formed during baking. Gómez et al. (2012) point out that if the values of the symmetry index had been negative, the center of the cake falls because there is little protein fraction during baking. Also, when comparing with research, the values are similar to those reported by Ferrari et al. (2015) (5.58 ± 0.72 to 6.33 ± 1.04 mm) in the cupcake with chia mucilage, but different in the cupcake with apricot kernel flour (0.05 to 0.10 mm) (Ahmadi et al., 2022). This could be a consequence of the baking time, the longer the baking time and the longer the storage time, the symmetry index decreases (Karaoğlu & Kotancilar, 2009).

Regarding the color of the crumb (L*), this attribute is often valued by the consumer and, in this regard, Paucar-Menacho et al. (2016) point out that a very pale or extremely dark color can cause rejection of the final product. In the different samples, it is evident that the values of L* are between 18 and 29.41 evidencing that this tends to lose luminosity due to the effect of the substitution of coffee husk flour, that when contrasting with their research of a cupcake with substitution of wheat flour for soy flour present greater luminosity; in the same way, the cupcake with apricot kernel flour (a* from 50 to 65) (Ahmadi et al., 2022) but similar to the cupcake with Jamaican calyx extract, due to its pigmentation (Abdel-Moemin, 2016). At the same time, an intense golden color is perceived due to the effect of the Maillard reaction and those formulations with a higher protein content intensify this color, and present a lower a* value. For the cupcake of Paucar-Menacho et al. (2016), it was from 1 to 3, contrary to the cupcake of the research, which has values from 14.47 to 17.72.

For the overall acceptability of the cupcakes of the 11 treatments, the total scores range from 3 to 5 points, on a rating scale from dislike (1 point) to like very much (5 points). The evaluation of general acceptability allows inferring the acceptability of attributes such as smell, taste, color, and texture of the food.

In the optimization of the cupcake using the response surface methodology, it was determined that the optimum formulation is a 12% substitution of wheat flour for coffee husk flour and 1.14% yeast with a desirability of 0.86, which allows obtaining a pH of 6.35 and a b* value of 41.49. So, based on this formulation, the shelf life of the cupcake was estimated where the shelf life for 20°C was 18 days, 30°C it was 13 days, and for 40°C it was 9 days. Results that are close to the research of Gómez & Colina (2019) on gluten-free cupcakes formulated with hydrocolloids for celiacs, which were stored at 28°C an estimated 14 days of shelf life

5. Conclusions

The cupcakes with the substitution of wheat flour for coffee husk flour at different levels of yeast showed physical, physicochemical, chemical, proximal, and sensory characteristics suitable for consumption. Likewise, employing the response surface methodology, the formulation was optimized with a 12% substitution of wheat flour for coffee husk flour and 1.14% of yeast, which when stored at different temperatures allows shelf lifetimes of 18 days at 20°C, 13 days for 30°C and 9 days for 40°C. With this, the development of by-products based on coffee husk, agro-industrial waste that causes high levels of pollution in ecosystems, can be used to obtain cupcakes differentiated from conventional ones in their nutritional contribution with appreciable shelf lifetime in compliance with regulations and generation of alternative sources of work in the coffee industry.

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