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Effect Of Formulation On The Fluffiness And Volume Of A Commercial Cake Premix In Relation To Its Acceptability

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Abstract

Making a commercial cake based on a premix is a matter of finding the balance of key ingredients that influence the uniform distribution and homogeneous size of the pockets in order to obtain an acceptable commercial sponginess in a premix. The objective of this work was to evaluate the formulation of a commercial premix in relation to its fluffiness and volume employing image analysis and its acceptability. Initially, a screening was performed with Taguchi's methodology evaluating statistical descriptors of texture by image analysis and volume. The sponginess was evaluated by means of the statistical descriptors of texture ASM, contrast, IDM, and entropy determined by the GLCM method. Two optimum formulations were obtained, formula A consisting of monoglyceride, egg, oil, sugar, xanthan gum, and baking powder, the values of 4.0, 80.0, 50.0, 70.0, 0.05, and 2.0 percent respectively, and formula B; monoglyceride, egg, oil, sugar, xanthan gum, and baking powder; the values of 7.0, 80.0, 30.0, 70.0, 0.05 and 5.0 percent respectively, which were subjected to an acceptability test with 80 consumers. In the result, according to the statistic $t = 0.375858 > \alpha$ (significance level=0.05), the null hypothesis is rejected and the alternative hypothesis is accepted, which means that there is no statistically significant difference between formulas A and B for consumers. This means that, in a cake, not only the volume is important, but also its sponginess (the latter is due to the correct size, distribution, and dispersion of alveoli, as well as its homogeneity in all the cut surface of the crumb of the cake).

Keywords: *cake premixing, volume, porosity, image analysis, Taguchi.*

1. Introduction

Bakery products[1] depend on quality and process adaptation; today's consumers demand value-added products with a customized seal, variety, segmentation, and nutrition to meet different

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market demands. For producers of cakes and premixes, the focus increases by adding maximum ingredient yield and cost. The production of cakes is present throughout the confectionery industry, whether small, medium, or large, becoming more competitive with the boom and growth of confectionery in Peru. According to INEI (2022), in the consumer goods industry, the production of bakery products contributed 17.24%, due to the increased production of cakes and instant desserts for domestic and foreign consumption.

Formula adjustment corresponds to solving a formulation design problem by correlating the results and their yield, based on the doses of the inputs and ingredients used (Villarroel et al. 2000). The sponginess and volume of a cake depends a lot on excellent aeration, which results in good dough stability, uniform cell structure and, most importantly, no impairment of structure and flavor, as well as pleasant sensation and moist crumb.

Another way to evaluate characteristic quality parameters of processed food products is image analysis (Zhang et al. 2014). An image analysis system involves acquiring an image of the product, processing that image, and extracting information about the inspected scene with the idea of obtaining information about the appearance of food products (Golnabi and Asadpour, cited by Gonzalez 2021).

The work registers a proposal for improvement in the development and redesign of the formulation of a commercial premix of the company GFPERU, based on its volume and digital texture (Grey Level Co-occurrence Matrix - GLCM) in relation to its commercial acceptability. Thus, the main objective of this study is to evaluate the formulation of a commercial cake premix in relation to its fluffiness, volume, and acceptability, and as secondary objectives, to determine the factors that significantly influence, doses of ingredients that have maximum effect and a formula of maximum acceptance by the consumer.

2. General Objective

Evaluate the formulation of a commercial cake premix concerning its fluffiness and volume through image analysis and its acceptability.

3. Methodology

3.1 Place of execution

The research work was carried out in the application laboratories of GFPerú S.A.C. and TTFoods, the Engineering Laboratory of the Image Acquisition Section of the Professional School of Agroindustrial Engineering of the Universidad Nacional del Altiplano and the Sensory Evaluation Laboratory of the Faculty of Food Industries - UNALM.

3.2 Materials and Equipment

3.2.1 Inputs

- Alicorp® vegetable cooking oil
- Boiled water
- Refined white sugar
- Glodamix Vanillin

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- Xanthan gum Glodamix Xanthan 200
- Unprepared wheat flour Nieve®
- Fresh eggs
- Skim milk powder (LPD)
- Glodamix Emul 300® distilled monoglyceride
- Royal® baking powder
- Glodamix flavored® butter flavor
- Demesa® salt ®

3.2.2 Materials

- Baking trays
- High-density polypropylene bags
- Serrated cutting blade
- Manual cutter
- 500 g rectangular aluminum molds
- Rubber spatula and tongs
- 150 ml PYREX® test tubes
- Cutting board

3.2.3 Equipment

- Analytical balance SORES® 250 g +/- 0.001 g
- SORES® Balance 10 kg +/- 0,5 g
- Oster® 5L blender
- STANLEY® 150mm digital caliper
- D7000 4F-S DX digital camera with micro-Nikkor 40 mm NIKON® lens.
- Computer I Core ™ i7-2600 CPU@3.40 GHz
- Digital stopwatch
- BOCH® stationary home oven with temperature control
- Manual sealer 30 cm
- LED lighting system (4) ALGUI103WCW of 3,1 W 220-240V with color temperature 6400 oK equivalent to
- Adapted camera support.

3.2.4 Software

- Camera Control Pro 2 version 2.8.001
- MATLAB® version 7.14.0.739 (R2012a)
- STATGRAPHICS Centurion 8.1.

3.3 Methods of análisis

3.3.1 Volume

Volumetric method described by Gallegos L. (2002) where samples of 40 ml are taken and placed in test tubes of 3.55 cm of internal diameter of a capacity of 150 ml (obtained from 250 ml test tubes that were already cut with precision and previously). Then they are placed in the test tubes (3 repetitions) in the middle of the oven tray. Then, they are baked for 20 min at a constant temperature. The test tube is removed and allowed to cool for 15 min, and finally, the volume of the 40 g of baked dough is measured by the difference between the total volume of the test tube (150 ml) and the volume not occupied by the baked dough. It is possible to measure using kañigua seeds and it is rooted with the metal sheet. These grains are poured into another

test tube and thus it is possible to measure the volume of the cake (apparent volume) in indirect form by subtracting 150 ml from the volume of the grains.

3.3.2 Image analysis

The computational method described by Vilca (2013) consists of a black box with a support for the digital camera model NIKON D7000 with a micro Nikkor 40 mm lens, located vertically at a distance of 22.5 cm from the sample with an angle of 45° between the camera axis and the LED light sources (Figure 9). The camera is operated remotely using Camera Control Pro 2 software (version 2.8.001), connected to the USB port of the computer. The images were captured at their maximum resolution (4928 x 3264 pixels). The lighting system is composed of 4 LED lights 3.1W 220-240V 50-60Hz 14mA PF>0.43 6400K corresponding to 103.3 lumens.

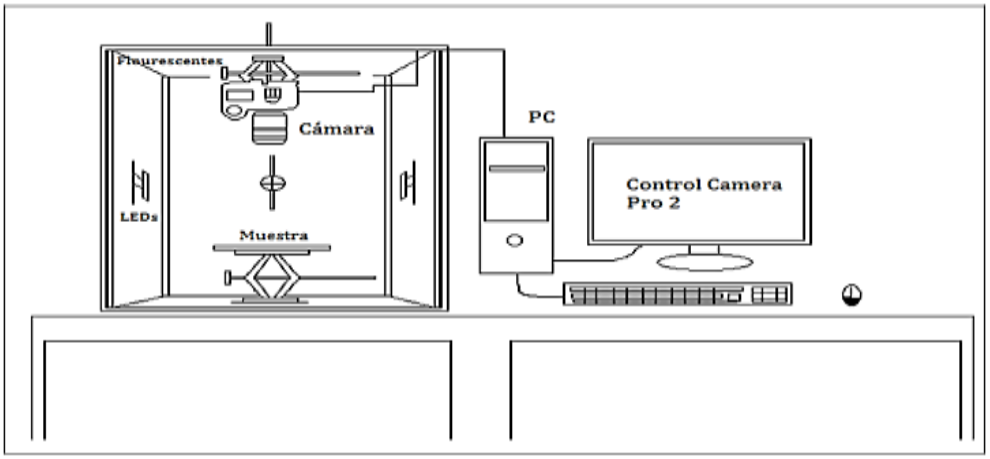


Figure 1. Image acquisition system

SOURCE: Vilca (2013)

The following are the trigger settings made on the camera in the image acquisition process:

- Flash: Off mandatory
- ISO Speed: ISO - 100
- Aperture: f/22
- Metering mode: Matrix
- AF Focus Mode - S
- Size/Quality: Good
- Focal Length: 40 mm

a) Preprocessing. Once the images are obtained, the quality of the images is improved, and for this purpose, digital filters are used to eliminate the noise in the image and can also increase the contrast and make it ready for segmentation. In the pre-processing, the original images (RGB format) are converted to grayscale (1-256) and black and white (0-1) using the respective Matlab code.

b) Image segmentation. The preprocessed image is segmented and is used as a routine developed in MATLAB software where the algorithms were programmed to simulate the process of biological vision. The segmentation is performed with the conversion to black and white using the Bim_segbau function (Mery, 2011), using the RGB channel and the G channel.

The threshold value during the segmentation process is generated based on the results of the histogram analysis of the grayscale image and is constant for all samples. Dilation and erosion operations are also performed to determine more clearly the sectors of interest (area and porosity).

c) Measurement or extraction of characteristics. In this stage, the measurement of the characteristics of the area proportion of the cake, and textural characteristics is performed. The matlab code works on the whole sample, after the segmentation process it determines the sector of interest through the calculation of the area, and the porosity and subtracting the sectors that do not correspond to the sample itself (external edges, etc.), and the porosity of the sample).

d) Interpretation of results. Finally, the characteristics extracted from each cut of cake according to the experimental design are interpreted.

4. Results and discussion

4.1 Determination of the factors ($p<0.05$) influencing the volume and sponginess of the cake

The factors (independent variables of the process) that significantly influence the volume of the cake were determined. The Taguchi method was applied, where 12 proposed formulations are presented as shown in Table 1.

	MD90	Egg	Oil	Sugar	Xanthan Gum	Baking powder
Formulation	F_1	F_2	F_3	F_4	F_5	F_6
1	4	30	30	40	0,05	2
2	4	30	30	70	0,1	5
3	4	30	50	40	0,05	5
4	4	80	50	40	0,1	5
5	4	80	30	70	0,1	2
6	4	80	30	70	0,05	2
7	7	30	50	40	0,1	2
8	7	30	50	70	0,05	5
9	7	30	30	70	0,1	2
10	7	80	30	40	0,1	5
11	7	80	50	40	0,05	5
12	7	80	50	40	0,05	2

Table 1. Cake formulations for evaluation according to Taguchi

Table 2 shows the analysis criteria for each factor.

Factor	**Criteria**
Volume	More is Better
ASM – Uniformity	More is Better
Contrast	Less is Better

IDM – Homogeneity	More is Better
Entropy	Less is Better

Table 2. Analysis criteria for each factor analyzed

4.1.1 Determination of volume

Table 3 shows the volume results obtained for the 12 formulations according to the experimental design under study.

F_n	Volume (g)
F1	64.00 ± 1.00
F2	76.00 ±2.00
F3	76.00 ± 1.00
F4	84.00 ± 2.00
F5	88.00 ± 2.00
F6	68.67 ± 0.58
F7	77.00 ± 0.58
F8	79.67 ± 0.58
F9	60.00 ± 1.00
F10	90.00 ± 1.00
F11	100.00 ± 1.00
F12	100.00 ± 1.00

Table 3. Volumes obtained from the study formulations

Table 4 presents the ANOVA results, showing that the factors: monoglycerides, egg, oil, sugar, xanthan gum, and baking powder exert significant effects on volume, all these ingredients contribute in one way or another in providing volume, the monoglyceride in facilitating fat emulsification and improving the aeration of the dough and thus improving volume (Corke et al. 2008). Similarly, xanthan gum improves gas retention and texture, as well as stability, moisture, and less crumbling (Miller and Hoseney 1993). There is also the egg which gives structure and has emulsifying action helping the incorporation of air in the oven, gluten, starch, and egg become stiff and the subdivided air bubbles become more inflated (Potter and Hotchkiss 1999), which when coupled with oil as a fat source helps to improve the emulsion with the ingredients covering the need for air absorption creating a water/oil emulsion that in baking stabilizes the gas cells through small crystals distributed around them contributing to volume and fluffiness (Wilderjans et al. 2013). Sugar helps with its hygroscopic property in maintaining softness, also promoting the aggregation of fat crystals and thus improving air entrainment during beating and its stabilization in baking (Beesley 1995). Finally, baking powder also contributes to volume through its property of releasing carbon dioxide in the reaction of acid and a weak base, conferring sponginess (Gallegos 2002). Likewise, the

interactions between the ingredients also significantly influenced the volume of the baking powder.

Factor	SC	g.l.	CM	F	p
{1}MD	47.4747	1	47.4747	3388.01	5.216E-157
{2}EGG	218.4834	1	218.4834	15591.98	7.217E-245
{3}MD-EGG	0.1038	1	0.1038	7.41	0.00690237
{4}OIL	27.0329	1	27.0329	1929.19	1.445E-126
{5}OIL-MD	2.9806	1	2.9806	212.71	4.1295E-36
{6}OIL-EGG	10.3872	1	10.3872	741.28	3.6987E-80
{7}AZUCAR	3.1005	1	3.1005	221.27	3.7222E-37
{8}AZUCAR-MD	2.8946	1	2.8946	206.57	2.385E-35
{9}XANTAN	14.6582	1	14.6582	1046.08	6.9744E-96
{10}XANTAN-MD	120.5687	1	120.5687	8604.34	4.468E-210
{11}POLVO HORNEAR	65.4204	1	65.4204	4668.70	5.592E-175
Residual	3.8675	276	0.0140		

Table 4. Analysis of Variance of the Effect of Ingredients on Volume

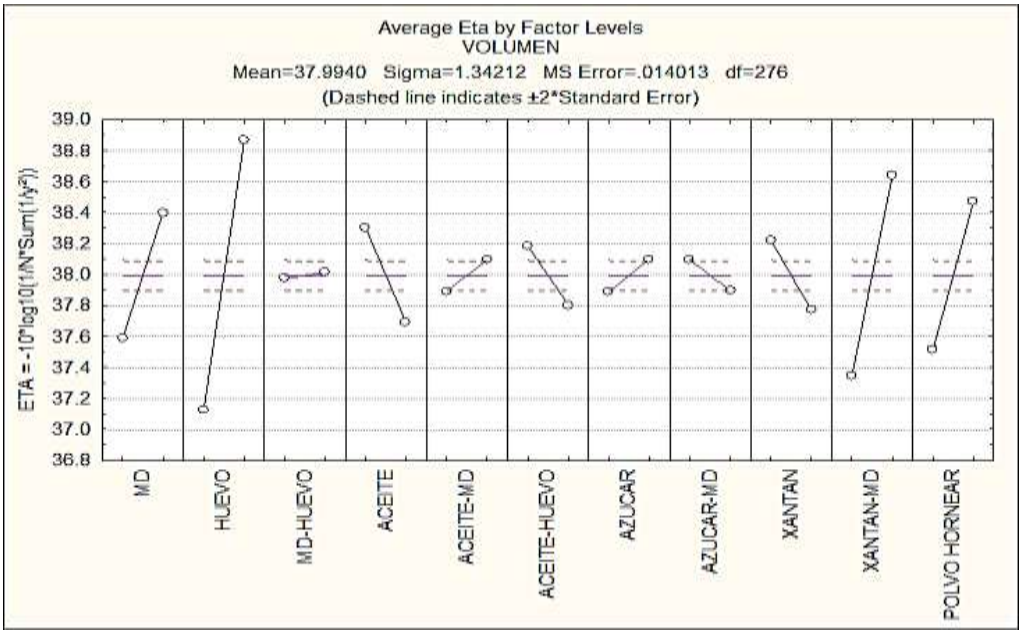


Figure 2. Signal Noise Values for Volume

Figure 2 shows that the factors with the highest slope, such as egg and baking powder and the xanthan gum-monoglyceride interaction, maximize the S/R robustness, influencing the volume

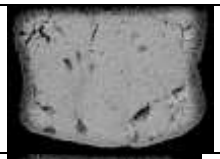
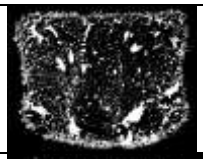
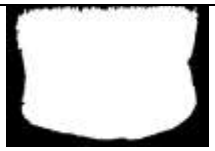
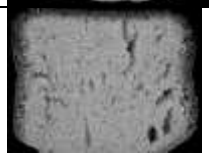
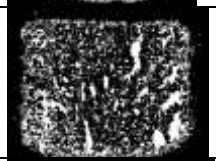
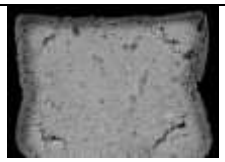
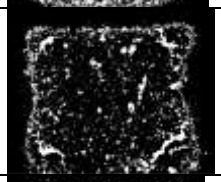
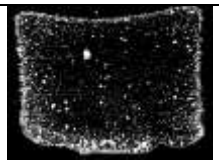
of the cake. The proposed formula to maximize the robustness recommends using the monoglyceride, egg, baking powder, and sugar factors at a high level and the oil and xanthan gum factors at a low level, which is concretized with an optimum proposal in Table 5.

Ingredient / Descriptor	Volume %
Analysis criteria	More is better
Egg	80
Oil	30
Sugar:	70
Xanthan Gum	0.05
Baking Powder	5

Table 5. Optimal combination for volume with the more-is-better criterion

4.1.2 Determination of statistical descriptors of texture

The changes in the texture characteristics were evaluated according to the variation of the grayscale of the images of the 12 formulations according to Hernán (1996), as shown in Figure 3.

	Original image (a)	**Gray image (b)**	**Binary image (c)**	**Total area (d)**
F1				
F2				
F3				
F4				
F5				

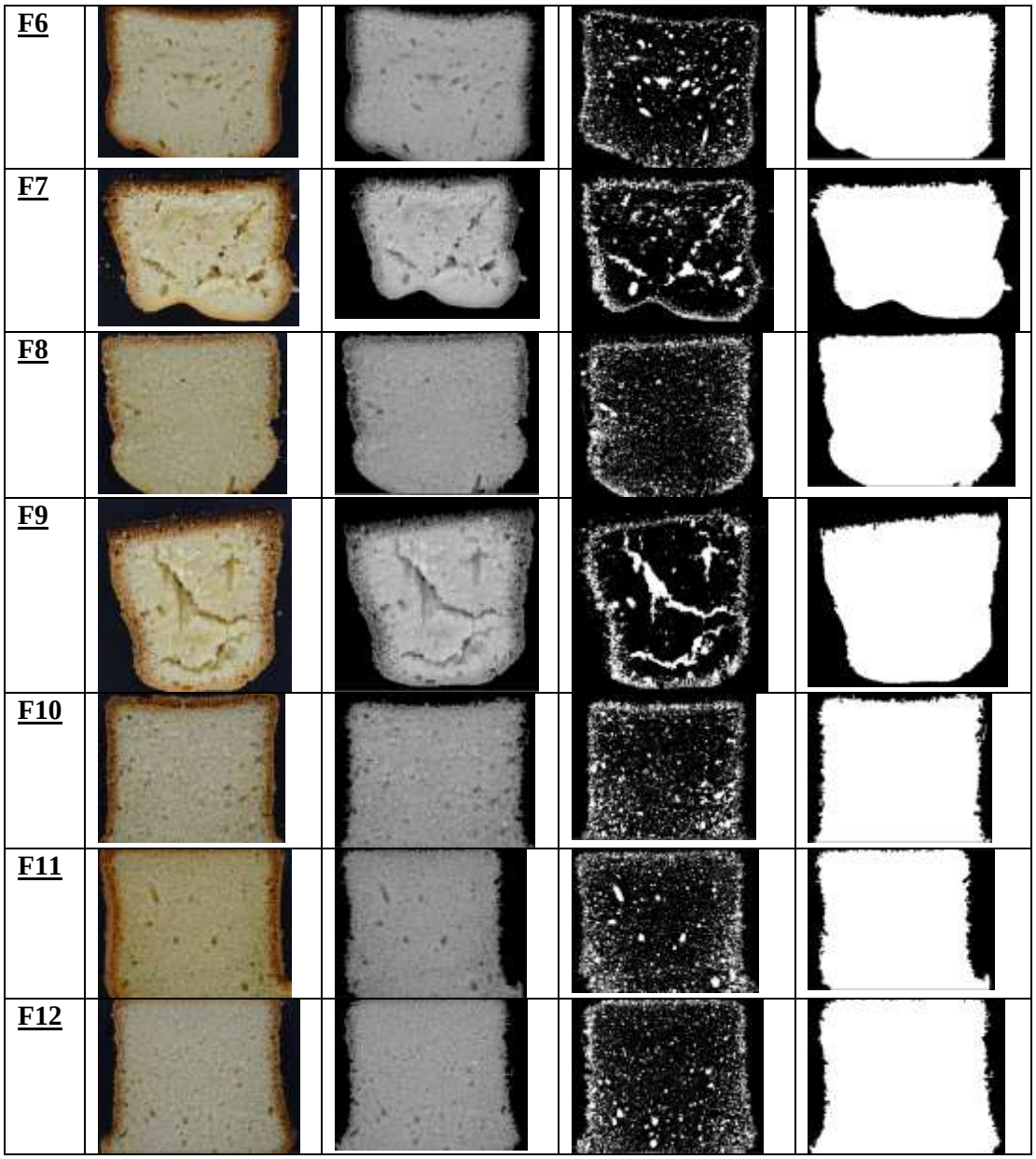


Figure 3. Results of the determination of the proportions of the cake

Next, the statistical descriptors of texture are determined, such as ASM (uniformity), contrast (heterogeneity), IDM (homogeneity), and entropy: ASM (uniformity), contrast (heterogeneity), IDM (homogeneity) and entropy as shown in Table 6.

F_n	ASM Uniformity	Contrast Heterogeneity	IDM Homogeneity	Entropy
F1	0.30741 ± 0.067	0.19515 ±0.038	0.92364 ± 0.014	1.84362 ± 0.181
F2	0.29634 ± 0.052	0.17677 ±0.029	0.92871 ± 0.011	1.80525 ± 0.197
F3	0.32650 ± 0.056	0.16897 ± 0.025	0.93080 ± 0.010	1.70433 ± 0.150
F4	0.37526 ± 0.056	0.15251 ± 0.028	0.93503 ± 0.012	1.45922 ± 0.229

F5	0.39037 ± 0.041	0.15152 ± 0.030	0.93614 ± 0.013	1.47915 ± 0.092
F6	0.41700 ± 0.072	0.13447 ± 0.029	0.94272 ± 0.013	1.42007 ± 0.180
F7	0.29444 ± 0.032	0.18303 ± 0.039	0.93181 ± 0.013	1.83580 ± 0.113
F8	0.31375 ± 0.028	0.18352 ± 0.028	0.92297 ± 0.012	1.63254 ± 0.054
F9	0.24186 ± 0.048	0.19229 ± 0.025	0.92491 ± 0.009	1.99903 ± 0.134
F10	0.29231 ± 0.053	0.17830 ± 0.032	0.92646 ± 0.012	1.73467 ± 0.243
F11	0.30931 ± 0.039	0.17467 ± 0.021	0.92754 ± 0.008	1.62193 ± 0.177
F12	0.33834 ± 0.062	0.17212 ± 0.030	0.92679 ± 0.013	1.56649 ± 0.210

Table 6. Results of the statistical descriptors of texture

The results of ANOVA on CSA (Table 7) showed that the most significant factors with the highest criterion are monoglyceride, egg, sugar, and xanthan gum, which occur when the gray level distribution has a constant or periodic shape and their values are high (Gadkari 2004) while oil and baking powder do not significantly influence. In addition, the interactions of monoglycerides with egg and sugar also significantly influenced the ASM. With this information, there could be an inversely proportional relationship between the inclusion of monoglycerides and xanthan gum with oil as proposed by Corke et al. (2008) as a total or partial replacement of fats, in substitute products and/or fat extenders.

Factor	SC	g.l.	CM	F	p
{1}MD	140.1769	1	140.1769	69.22464	0.000000
{2}EGG	163.4725	1	163.4725	80.72889	0.000000
{3}MD-EGG	43.1697	1	43.1697	21.31883	0.000006
{4}OIL	0.0795	1	0.0795	0.03925	0.843100
{5}OIL-MD	6.7104	1	6.7104	3.31384	0.069782
{6}OIL-EGG	0.4061	1	0.4061	0.20056	0.654623
{7}SUGAR	45.2874	1	45.2874	22.36462	0.000004
{8}SUGAR-MD	25.2344	1	25.2344	12.46169	0.000487
{9}XANTHAN	15.8654	1	15.8654	7.83494	0.005486
{10}XANTHAN-MD	1.9583	1	1.9583	0.96709	0.326269
{11}BAKING POWDER	2.9582	1	2.9582	1.46087	0.227826
Residual	558.8879	276	2.0250		

Table 7. Analysis of Variance of the Effect of Ingredients on ASM

The results of the ANOVA on the contrast (CT) and MDI indicate that the factors monoglyceride, egg, oil, and sugar have a significant influence, while oil and baking powder do not (Tables 8 and 9). In Annex 12 and 13, it can be seen that monoglyceride, egg, oil, and sugar exert significant effects on the IDM which has maximum value when all elements in the

image are equal and decreases if the contrast increases while the ASM remains constant (Gadkari 2004), a characteristic that coincides with the properties of monoglyceride in reduction of the size of the alveolus (Tejero 2018), but not the homogeneity of the size of the crumb (DANISCO 2006). Likewise, the interaction of monoglyceride with egg also significantly influenced Homogeneity.

Factor	SC	g.l.	CM	F	p
{1}MD	68.1404	1	68.1404	27.99647	0.000000
{2}EGG	103.7442	1	103.7442	42.62482	0.000000
{3}MD-EGG	24.9171	1	24.9171	10.23756	0.001537
{4}OIL	14.4017	1	14.4017	5.91714	0.015630
{5}OIL-MD	1.3857	1	1.3857	0.56935	0.451162
{6}OIL-EGG	7.5753	1	7.5753	3.11243	0.078803
{7}SUGAR	21.0287	1	21.0287	8.63995	0.003567
{8}SUGAR-MD	0.2400	1	0.2400	0.09863	0.753721
{9}XANTHAN	1.4432	1	1.4432	0.59295	0.441938
{10}XANTHAN-MD	0.0046	1	0.0046	0.00188	0.965447
{11}BAKING POWDER	1.9112	1	1.9112	0.78524	0.376314
Residual	671.7543	276	2.4339		

Table 8. Analysis of Variance on the Effect of Ingredients on Contrast

Factor	SC	g.l.	CM	F	p
{1}MD	0.231551	1	0.231551	19.38491	0.000015
{2}EGG	0.175964	1	0.175964	14.73131	0.000154
{3}MD-EGG	0.101765	1	0.101765	8.51949	0.003803
{4}OIL	0.138559	1	0.138559	11.59982	0.000758
{5}OIL-MD	0.003012	1	0.003012	0.25217	0.615950
{6}OIL-EGG	0.012402	1	0.012402	1.,03824	0.309124
{7}SUGAR	0.059141	1	0.059141	4.95112	0.026882
{8}SUGAR-MD	0.013102	1	0.013102	1.09683	0.295880
{9}XANTHAN	0.001910	1	0.001910	0.15993	0.689526
{10}XANTHAN-MD	0.006723	1	0.006723	0.56283	0.453759
{11}BAKING POWDER	0.035534	1	0.035534	2.97482	0.085689

Residual	3.296795	276	0.011945		

Table 19. Analysis of Variance of the Effect of Ingredients on the WDI

For entropy, it is shown that monoglycerides, egg, sugar, and xanthan gum exert significant effects. On the other hand, the interactions of monoglycerides with egg, oil, and sugar significantly influenced.

Factor	SC	g.l.	CM	F	p
{1}MD	27.2235	1	27.2235	32.8879	0.000000
{2}EGG	135.5696	1	135.5696	163.7776	0.000000
{3}MD-EGG	10.8289	1	10.8289	13.0821	0.000354
{4}OIL	0.2194	1	0.2194	0.2651	0.607063
{5}OIL-MD	9.7357	1	9.7357	11.7614	0.000697
{6}OIL-EGG	2.0006	1	2.0006	2.4168	0.121182
{7}SUGAR	24.9664	1	24.9664	30.1612	0.000000
{8}SUGAR-MD	12.8709	1	12.8709	15.5489	0.000102
{9}XANTHAN	5.5602	1	5.5602	6.7171	0.010058
{10}XANTHAN-MD	0.0190	1	0.0190	0.0230	0.879539
{11}BAKING POWDER	1.0856	1	1.0856	1.3115	0.253113

Table 10. Analysis of Variance of the Effect of Ingredients on Entropy

From Figure 4, the factors with the highest slope maximize the S/R robustness, which can be observed when the formula proposal is made, where it is recommended to use the egg, oil, and sugar factors at their high level and the monoglyceride factors at their low level. For the case of the ASM factors, xanthan gum delivers its maximum S/R robustness at its low level, while for the case of the IDM factor, baking powder obtains its maximum S/R robustness at its minimum level, although it has no significant effect against the texture statistical factors, while they do have significance on volume (Miller and Hoseney 1993; Picas and Vigata 1997 and Lee et al. 2014).

Table 11 presents the summary of the optimal combinations according to the best ASM, Contrast, IDM, and Entropy conditions. The overall optimal combination is also presented in the last column, which is chosen for convenience with the company.

Ingredient / Statistical descriptors	ASM %	Contrast %	IDM %	Entropy %	Optimum %
Analysis criteria	More is better	Less is better	More is better	Less is better	
Monoglyceride	4	4	4	4	4
Egg	80	80	80	80	80
Oil	30	50	50	30	50

Sugar	70	70	70	70	70
Xanthan Gum	0,05	0.05	0.05	0.05	0.05
Baking Powder	2	2	2	5	2

Table 11. Summary of the optimal combination of the statistical texture descriptors

After statistically evaluating the volume and texture descriptors observed in Tables 5 and 11, a summary table can be obtained (Table 12) showing the significant ingredients in the cake formula studied, where it is observed that monoglycerides, egg, and sugar have a significant effect on the uniformity, heterogeneity, homogeneity, entropy, and volume of the crumb of commercial cakes. This does not occur at all for oil, xanthan gum, and baking powder.

	Image analysis				Volume
Ingredients	**ASM**	**Contrast**	**IDM**	**Entropy**	**Volume**
MD	X	X	X	X	X
Egg	X	X	X	X	X
Oil	-	X	X	-	X
Sugar	X	X	X	X	X
Xanthan gum	X	-	-	X	X
Baking powder	-	-	-	-	X

Table 11. Summary of formulation ingredients that have a significant effect

Each ingredient used has an effect on the volume, height, and shrinkage in the crumb of the cake (Miller and Hoseney 1993) but the relationship between them and their doses can increase or delay their performance, as in the case of replacing the oil; which contributes to mix the ingredients and change texture, by competing with the monoglyceride for its softening effect (Picas & Vigata 1997). Xanthan gum is related to eggs, due to its functional properties such as water binding, emulsifying capacity, and texture improvement (Lee et al. 2014). The significance of sugar is due to its softening and hygroscopic capacity (Quaglia 1991).

4.1.3 Determination of factors by acceptability test

Table 12 shows the optimal combinations of image and volume analysis obtained from Table 8 and Table 10, respectively.

	Image analysis % Formulation A	**Volume % Formulation B**
Monoglyceride	4	7
Egg	80	80
Oil	50	30
Sugar:	70	70
Xanthan Gum	0.05	0.05
Baking Powder	2	5

Table 12. Summary of the optimal combinations of Taguchi analysis

The cakes made from formulations A and B shown in Figure 4 were subjected to sensory evaluation using a panel of 80 potential consumers for each sample. The consumers were of different ages (16-66 years) with a predominance of young people (16-30 years).

Sample A

Sample B

Table 4. Sample A and B for sensory evaluation of consumer acceptability

	Sample A	Sample B
No. of samples	88	91
Average	13.2057	12.6857
Standard deviation	8.51225	9.91682
Coefficient of variation	64.459	78.1731
Minimum	0.6	4
Maximum	87	102
Range	86.4	98
Standardized bias	28.981	32.156
Standardized kurtosis	127.442	146.183

Table 13. Results of sensory evaluation of acceptability of samples A and B

Table 13 presents the results obtained, where the average score of samples A and B is 13.2057 and 12.6857 respectively. The results were high, indicating high acceptability. For being close to the extreme "I like it very much" in the evaluation card.

The result according to the t statistic = 0.375858 > α (significance level=0.05) the null hypothesis is rejected and the alternative hypothesis is accepted, this means that there is no statistically significant difference between formulae A and B for consumers. Indicating a clear inverse relationship between monoglyceride and oil (Picas and Vigata 1997; Tejero 2018).

5. Conclusions

- It was determined that all the ingredients of the formulation have a significant effect on volume.
- Two formulations of the commercial premix for cakes were obtained through the Taguchi methodology that improved the sponginess and volume of the product, the first from image analysis, consisting of monoglyceride (4.0%), egg (80.0%), oil (50.0%), sugar (70.0%), xanthan gum (0.05%) and baking powder (2.0%), which improved the sponginess and

volume of cakes. The second by volume measurement, constituted by: monoglyceride (7.0%), egg (80.0%), oil (30.0%), sugar (70.0%), xanthan gum (0.05%), and baking powder (5.0%), which improved the fluffiness and volume of cupcakes.

- It is confirmed that the duality of oil and monoglyceride contribute to obtaining the best texture of the cake, mixing different ingredients in the first one and softening the second one, showing an inversely proportional relationship when comparing the two optimal formulations and generating an application range of 4.0 - 7.0% of monoglyceride and 30 - 50% of oil.
- The same amount of xanthan gum, egg, and sugar in both optimal formulations makes them contributing factors in fluffiness and volume.
- Baking powder had a significant effect on obtaining the optimum formulation that maximizes the volume of the cake and not on the one obtained from the image analysis.
- Applying the image analysis, it was determined that the ingredients monoglyceride, egg, and sugar have a significant effect on the uniformity, heterogeneity homogeneity and entropy of the cake.
- By the statistical contrasts found in the screening, there are 2 formulations A and B, which were submitted to an acceptability evaluation with 80 consumers where the result according to the t statistic = 0.375858 > α (significance level=0.05) the null hypothesis is rejected and the alternative hypothesis is accepted, this means that there is no statistically significant difference between formulas A and B for consumers.

6. Recommendations

- Determine porosity by image analysis and correlate it with direct porosity, seeking a methodology that eliminates bias.
- Evaluate wheat flour for the improvement of textural characteristics and porosity.
- To correlate the data obtained by image analysis with TPI and Uniaxial physical texture analysis.
- Identify a statistical texture descriptor that evaluates freshness.
- Evaluate the effect of monoglyceride levels on the optimal formulation obtained versus the size of the generated cells.

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