DRUM DRYING OF UNPEELED GREEN BANANA PULP (*MUSA CAVENDISHII*) FOR BAKE STABLE FRUIT FILLING PRODUCTION

MÁRIO JOSÉ MENDES[1]
AGNES DE PAULA SCHEER[2]
DAYANE ROSALYN IZIDORO[3]

Interest in consumer's market for the green banana has increased by its high starch content, low sugar and aromatic compounds. Considering these characteristics, production of flours with functional quality is an alternative for the growing industrialization of this fruit. This paper aims to present the study of unpeeled green banana pulp **(Musa cavendishii)** applications,dried using a single rotating drum, in cold process performed to obtain bake stable fruit filling. The unpeeled green banana flour showed physical and nutritional characteristics which enabled the development of a filling formula using a central composite design. The outcomes of this design, for unpeeled green banana flour, modified starches and other ingredients resulted in elastic, viscous and bake stable fruit filling. The use of this flour is viable considering its contribution of quantity fruit, therefore can be recommended in preparation of nutritious foods.

KEYWORDS: UNPEELED GREEN BANANA FLOUR; ROTATING DRUM DRIER; COLD PROCESS

1 Endereço para correspondência: [1]Programa de Pós-Graduação em Engenharia de Alimentos – UFPR, mendes.mja@gmail.com; [2]Coordenação de Pesquisa e Desenvolvimento – Empresa Nutrimental S/A, CEP 83005-900, São Caixa Postal 19011, Curitiba – Paraná/Brasil, fone/fax (041) 33613232; José dos Pinhais-Paraná/Brasil.
2 Texto texto texto texto texto.
3 Texto texto texto texto texto.

1 INTRODUCTION

The mellow banana is a usual component in Brazilians diet, due to its sensorial characteristics and nutritional value. Approximately two bananas can meet in about 25% the daily needs recommended ingestion of ascorbic acid, in addition to provide significant amounts of vitamins A and B, potassium and other minerals such as sodium. A factor that is also responsible for high levels of consumption is the facility of access and its ubiquity all over the country. The predilection is ascertained by the numbers, as approximately 99% of the national production supplied the domestic market in 2016. Medium crop of banana reached 7 million tons, in a medium area of 474 thousand hectares. The activity comprises about 800 thousand production units; most of them run by small-scale farmers or family farmers. (Carvalho *et al.*, 2017). However, only in the last few years, green banana has attracted interest in consumer's market, by its high starch content, about 55% to 93% of the total solids content (Ramos *et al.*, 2009), low sugar and aromatic compounds, neutral flavor and flavonoids richness.

For those characteristics, the production of flours with functional quality is an important alternative to increase the green banana production chain. (Travaglini *et al.*, 2001). Added value to the fruit's by-products, such as green banana pulp and flour, allows employment's generation and increased income in small rural properties. Consequently, green by-products are ensured alternatives to be used by the food industry.

The unpeeled green banana (*Musa cavendishii*) biomass transformed into flour by drum drying process, can stimulate industrial use and minimize the losses, after harvesting.

Drum drying is a continuous process heated by steam and with a constant speed rotation to dry the product. The material in paste form is applied under a rotating drum and the dried product is scrapped off it by knife blades, resulting in flour with physical-chemical properties to be stored by long periods. (Anandharamakrishnan *et al.*, 2017).

Unpeeled green banana flour may be used in bakery and confectionery, but specifically in cold developed alternative process of filling preparation, which does not require the addition of any significant heat in the manufacturing process (Rock *et al.*, 1999). Fillings obtained by this application should be stable at high temperatures without losing their quality during or before the baking process.

Developing bake stable fruit filling with unpeeled green banana flour can be an alternative to add nutritional value and make them more attractive for consumers. Thus, the present work had the objective to develop, by central-composite design and feature, a bake stable fruit filling applying the unpeeled green banana flour dehydrated in a drum dryer.

2 MATERIALS AND METHODS

The green bananas variety "known as Nannica" comes from the state of Santa Catarina in the region of Corupá, and was acquired in CEASA/PR (Paraná S/A Supply Center), before entering the maturation chamber. The values of total soluble solids and total acidity (in malic acid) were used to standardize the green bananas samples, reaped on the same date. The Brix/total acidity (malic acid) degree ratio provided maturity parameters (Zenebon and Pascuet, 2005).

The green bananas were baked at an atmospheric pressure under temperature of 80°C for 20 minutes. Next, they were transformed into pulp using a chipper/emulsifier at a blade rotation speed of 3,000 rpm and a hopper rotation speed of 20rpm for 3 minutes.

A thin layer of pulp was applied continuously on the top of the main drum in rotational motion and with heated outside surface. The applicator rolls and main drum were parameterized to 148°C, distance of 0.4mm, 600kPa and 3.5rpm. These variables optimized the formation of the dry product layer that reached the knife for scraping and product removal from the main drum. The dry product in flour form, with maximum humidity at 6%, was milled and standardized with a 9 mesh sieve and wrapped in a metallic packaging at room temperature, with 0.266 g/cm^3 density.

Unpeeled green banana flour was characterized using the following methods: moisture nº 934.06, protein nº 920.152 and dietary fiber nº 991.43 from Horwitz (2005); ash nº 945.18 (AOAC, 1990); resistant starch (Mcclearly and Monaghan, 2002); particle size (AACC, 2000); lipids 032/IV from Adolfo Lutz (Zenebon and Pascuet, 2005); amylose Yun and Matheson (Morrison and Laignelet, 1983); water absorption capacity (Sosulski, 1962); and pasting properties RVA – 4 by Newport Scientific Warriewood.

The bake stable fruit filling, with 2.5% of unpeeled green banana flour, was optimized by central composite design by combining the levels -1 and +1, two axial points (± α) and two central points of interactions between variables: pregelatinized phosphorylated starch (RD 712/ULTRATEX), pregelatinized acetylated starch (RD 692) and microcrystalline cellulose with sodium carboxymethylcellulose (TABULOSE). The variables on three levels and actual values were presented in Table 1. The levels of the variables were established according to technical limits of application, in preliminary trials, and recommendations from the literature.

TABLE 1 - LEVELS OF THE VARIABLES STUDIED IN EXPERIMENTAL PLANNING

Independents variables	Levels of variation			
	- α	**- 1**	**+ 1**	**+ α**
Microcrystalline cellulose	0.124	0.5	2.88	3.256
Acetylated starch	2.253	2.5	4	4.237
Phosphorylated starch	5.683	6	8	8.316

α= ±1.3161 for K=3 (three independent variables).

Cold development of bake stable fruit filling was performed using a central composite design and the (Rock and Hansen 1999)and adapted formulation from the unaltered quantities listed on Table 2.

TABLE 2 - FRUIT FILLING FORMULATION WITH UNALTERED QUANTITY OF INGREDIENTS

Ingredients	Quantity - (% w/w)
Water 25 ºC	8.00 %
Corn syrup 42 DE	26.00 %
Glycerin	21.00 %
Dextrose powder	6.00 %
Unpeeled green banana flour	2.50 %
Fruit juice concentrates 65 ºBrix	20.00 %
Flavoring	0.60 %
Acidifier	0.38 %
Antioxidant	0.20 %
Natural dyes	0.44 %

First of all, water (under 25°C), Tabulose® and half of the corn syrup (under 70°C) were mixed for 5 minutes. The other half of the corn syrup and the pregelatinized acetylated and phosphorylated starches were then added and mixed for 3 minutes, respectively. A premixed solution of glycerin, fruit juice acidified concentrate, antioxidant, flavoring and dextrose powder were added during the last 3 minutes.

Second, the unpeeled green banana flour was added and mixed for 6 minutes and packed in plastic containers, for storage at temperature range from 20°C to 28°C.

The samples with 10g were molded with an 8mm height and set within a 30mm diameter circle on an aluminum tray with a metric scale from zero to 100mm. The samples were placed in a conventional oven with forced air and preheated at 180°C/10min with the maximum limit of 1% of flow.

After 72 hours in storage, the sample's texture was measured using a TAX-T2 texture analyzer with a 50kg load cell, cylindrical aluminum probe – diameter of 25.4mm. Speed and penetration depth were of 2.0mm/s and 20mm, respectively. After five repetitions, 16 samples with 346g under 20°C were analyzed for gel strength, rupture strength, springiness and adhesiveness.

3 RESULTS AND DISCUSSION

According to Chitarra & Chitarra (2005), soluble solids contents (SS), titratable acidity (TA), SS/TA ratio are attributes that best define banana quality. For the samples, the titratable acidity (TA) (in malic acid) were 0.11 ± 0.01, soluble solids contents (SS) were 4.56° ± 0.74 and the SS/TA was 41.45, similar to the maturation stage data of green bananas found by Izidoro (Izidoro *et al.*, 2011).

This correlation (SS/TA) tends to increase during the maturation period of the fruit, due to the decrease of acids and increase of sugars, considering that the absolute values depend, among other factors, of genotype. This relation also serves as an important indication of their expected shelf life and appearance. (Silva, 2016).

The average results for nutritional and physicochemical characterization of unpeeled green banana flour, in triplicate, and its standard deviation were listed on Table 3.

TABLE 3 - PHYSICOCHEMICAL CHARACTERIZATION OF UNPEELED GREEN BANANA FLOUR

Variables	Quantity	Standard deviations
Moisture	5.95 g / 100 g	± 0.038
Ash	4.07 g / 100 g	± 0.030
Carbohydrates	70.20 g / 100 g	± 0.241
Protein	4.56 g / 100 g	± 0.176
Total fat	0.60 g / 100 g	± 0.080
Total dietary fiber	11.11 g / 100 g	± 0.014
Soluble fiber	3.31 g / 100 g	± 0.050
Insoluble fiber	7.80 g / 100 g	± 0.050
Sodium	100.00 mg / 100 g	± 4.230

The unpeeled green banana flour showed 5.95 g/100 g of moisture – this result is in accordance with to RDC 263 (Brazil, 2005), compatible with the findings by Pacheco-Delahaye *et al*. (2008) of 5.46g /100g. Concerning the high ash contents (4.07g/100g), higher concentration of minerals in the banana, mainly potassium, calcium, phosphorus and magnesium can be indicated. The result of 11.11g/100g of dietary fiber is in accordance with the findings by Zuleta, of 10–19g /100g dietary fiber (Zuleta *et al*., 2012). Presence of dietary fiber in foods is of great interest in health areas, since studies relate their role to reduce the risk of diseases as diverticulitis, colon cancer, obesity, cardiovascular problems and diabetes. (Mudigil *et al*., 2013).

Nutritionally, unpeeled green banana flour showed 4.56g/100g of protein and this result was above that found by Santos *et al*. (2010) of 3.53g/100g. The difference was probably due to the presence of the banana peel. The content of total lipids was compatible with that found by Santos: 0.6g/100g. (Santos *et al*., 2010).

The Water activity was of 0.421 ± 0.008, below the 0.60 recommended by Troller to prevent the development of xerophilic yeast and osmophilic molds (Troller, 1980).

The result of 1.880 ± 0.586g/100g of resistant starch showed a significant loss due to the single rotating drum drying process, compatible with the findings by Germano. The results of resistant starch approximate to a banana in the mature stage (Germano, 2016).

The pregelatinized flour showed water absorption capacity of 500g/100g and the cold developed bake stable fruit filling did not undergo syneresis when stored.

The amylose content of 7.430 ± 2.407g/100g was below the data obtained by Kayiusi and Hood (1981), Lii *et al*. (1982) and Garcia and Lajolo (1988), which were respectively 16%, 19.5% and 17%, with *Musa cavendishii*. Low amylose content resulted in low final viscosity, which had little tendency to retro gradation.

The pasting property showed instantaneous viscosity, with immediate water absorption by the pregelatinized starch granules, facilitating the rehydration. In foodstuffs can be incorporate easily without heating to increase viscosity. In general, starch is used as a thickener in products such as fillings. (Ribeiro *et al*., 2004).The nutritional and physicochemical results of bake stable fruit filling, with 2.5% unpeeled green banana flour were listed on Table 4.

TABLE 4 - PHYSICOCHEMICAL CHARACTERIZATION OF BAKE STABLE FRUIT FILLING

Variables	Quantity	Standard deviations
Moisture	15.68 g / 100 g	± 0.20
Ash	0.37 g / 100 g	± 0.10
Carbohydrates	80.97 g / 100 g	± 0.20
Protein	0.68 g / 100 g	± 0.10
Total fat	< 0.30 g / 100 g	± 0.10
Total dietary fiber	2.30 g / 100 g	± 0.87

The bake stable fruit filling with unpeeled green banana flour showed in its chemical composition meaningful carbohydrates content and low lipids content, being important findings for the values of caloric intake.

It also showed, positively for the nutritional aspect, that the amounts of soluble and insoluble dietary fiber improve the intestinal function (Leon, 2010). As for the technological aspect, its application serves as fruit source and bulking agent, conferring a fruit-like pulpy texture to the fruit filling.

The high solids content (76%) in the bake stable fruit fillings decreased the tendency for water to migrate into the baked product, improving the quality of the final product. Furthermore, application of food acids, such as citric acid, malic acid and ascorbic acid, improved the flavor and the preservative effects.

The result of water activity of bake stable fruit filling was of 0.645 ± 0.002, prior to baking, resulting in a shelf life stable product. Furthermore, these results prevented the need of additives such as sodium benzoate, sorbic acids, usually applied to improve the microbial stability in fruit fillings.

The central composite design and surface response model were used to study the independent variables, colloidal microcrystalline cellulose with sodium carboxymethylcellulose (Tabulose®), phosphorylated (Ultra Tex) and acetylated (RD 692) pre-gels maize starches, and the interaction between them in the bake stable fruit filling.

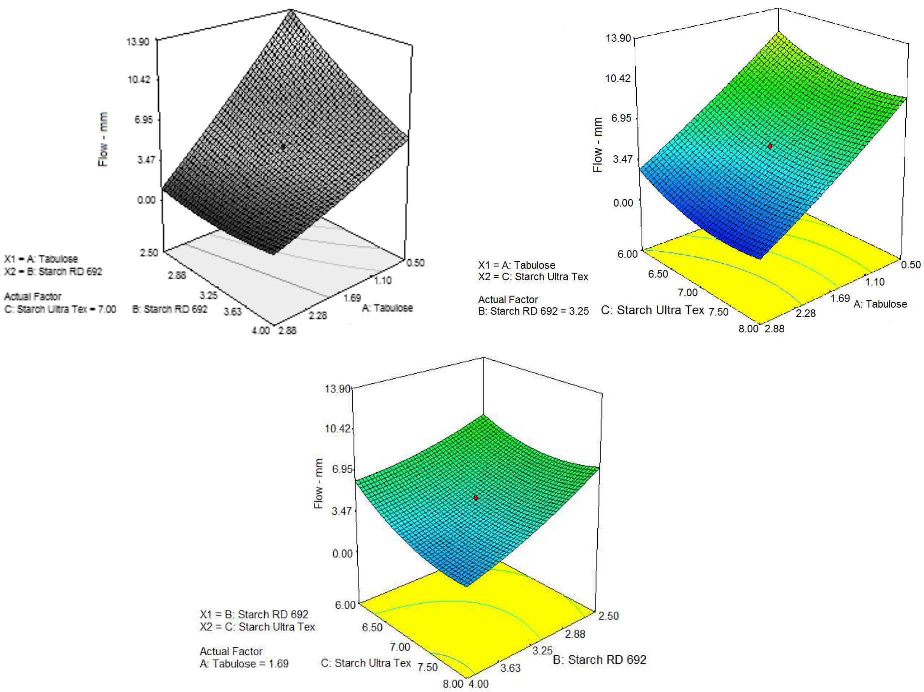
For experimental data analysis there were developed some mathematical models, for the responses variables, flow, gel strength, rupture strength and springiness. The mathematical expressions were as follows:

$$Flow=+4.82-4.45*A-1.94*B-1.09*C+1.94*A*B+0.0063*A*C-0.69*B*C+0.28*A^{2}+0.48*B^{2}+1.05*C^{2}$$

The regression equation model was explained in 91% by the flow “melting” variability of the bake stable fruit filling at 180°C.

The response surface diagram (Figure 1), corresponding to the model, indicated that the combination of Tabulose® with starches (RD 692) and (Ultra Tex), contributed to stabilize the bake stable fruit filling flow during the baking. However, without the Tabulose® combined with the starches, the behavior was different in the stabilization.

FIGURE 1 - QUADRATIC RESPONSE SURFACE MODEL OF FLOW (MM)

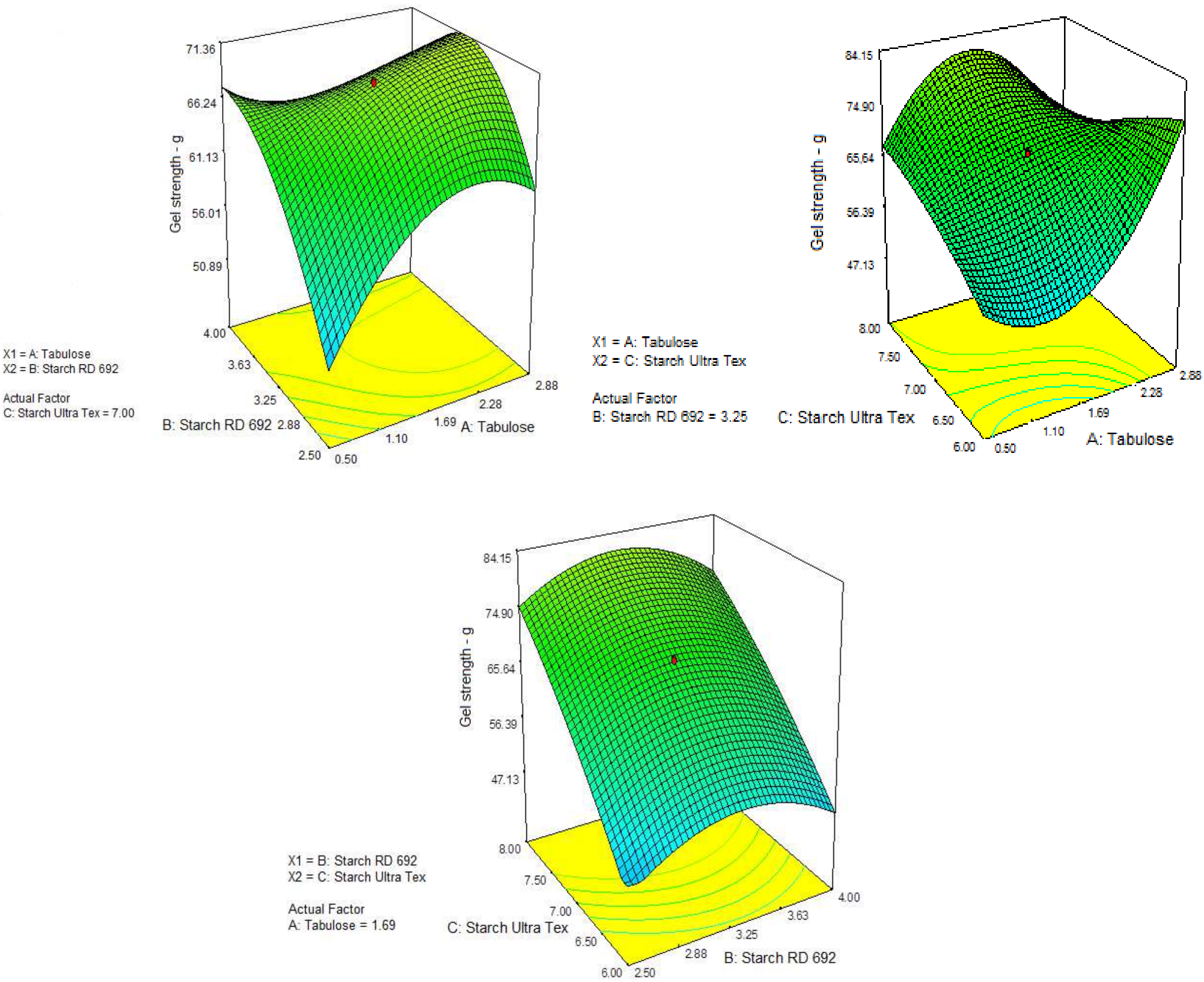


$$Gel\ strength = +68.86+4.05*A+0.37*B+14.06*C-3.42*A*B-7.06*A*C-0.75*B*C-1.70*A^2-6.49*B^2-1.84*C^2-11.06*A*B*C+4.42*A^2*B-15.03*A^2*C-2.38*A*B^2$$

The regression equation model was explained in 99.9% by the gel strength variability of the bake stable fruit filling at 20°C.

The response surface diagram (Figure 2), corresponding to the model, indicated that the concentration variation between the combinations of Tabulose®, starches RD 692 and Ultra Tex showed a positive correlation of the gel strength to the point of gel rupture. The associated starches (RD 692 and Ultra Tex) and Tabulose® showed a resistance to retro gradation, resulting in lower water loss and hardening of the final product.

FIGURE 2 - CUBIC RESPONSE SURFACE MODEL OF GEL STRENGTH (G), AT 20°C

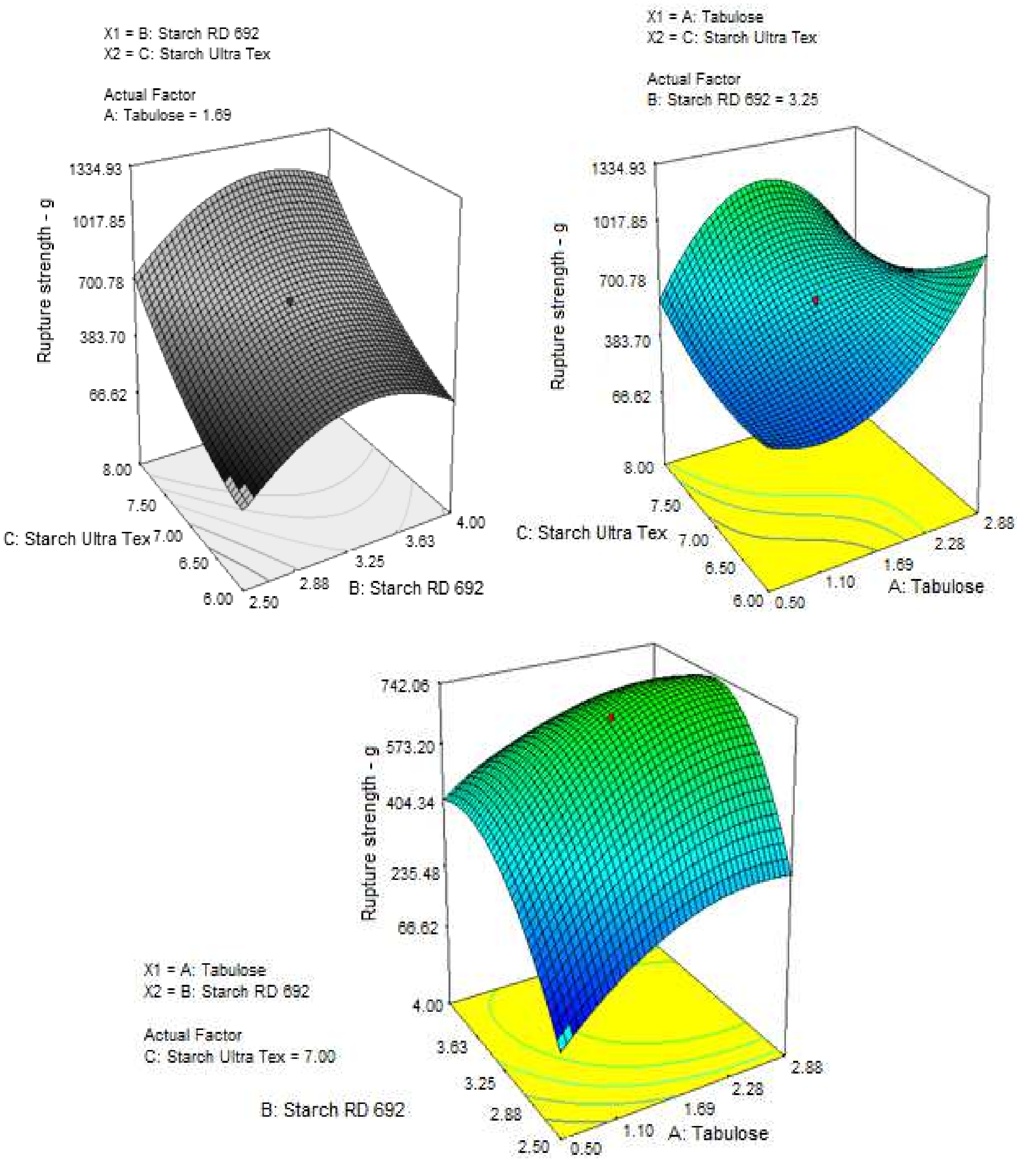


$$Rupture\ strength = +671.59+170.91*A+133.01*B+364.02*C-65.95*A*B-156.53*A*C+25.32*B*C-109.90*A2-245.16*B2+97.91*C2-99.13*A*B*C-18.45*A2*B-414.10*A2*C-101.50*A*B2$$

The regression equation model was explained in 99.60% by the gel strength of the bake stable fruit filling at 20°C.

The response surface diagram (Figure 3), corresponding to the model, demonstrated that the concentration variation between a combination of Tabulose®, starches RD 692 and Ultra Tex showed a positive correlation up to the maximum value of the force, indicating the point of rupture of the gel.

FIGURE 3 - CUBIC RESPONSE SURFACE MODEL OF RUPTURE STRENGTH (G), AT 20ºC



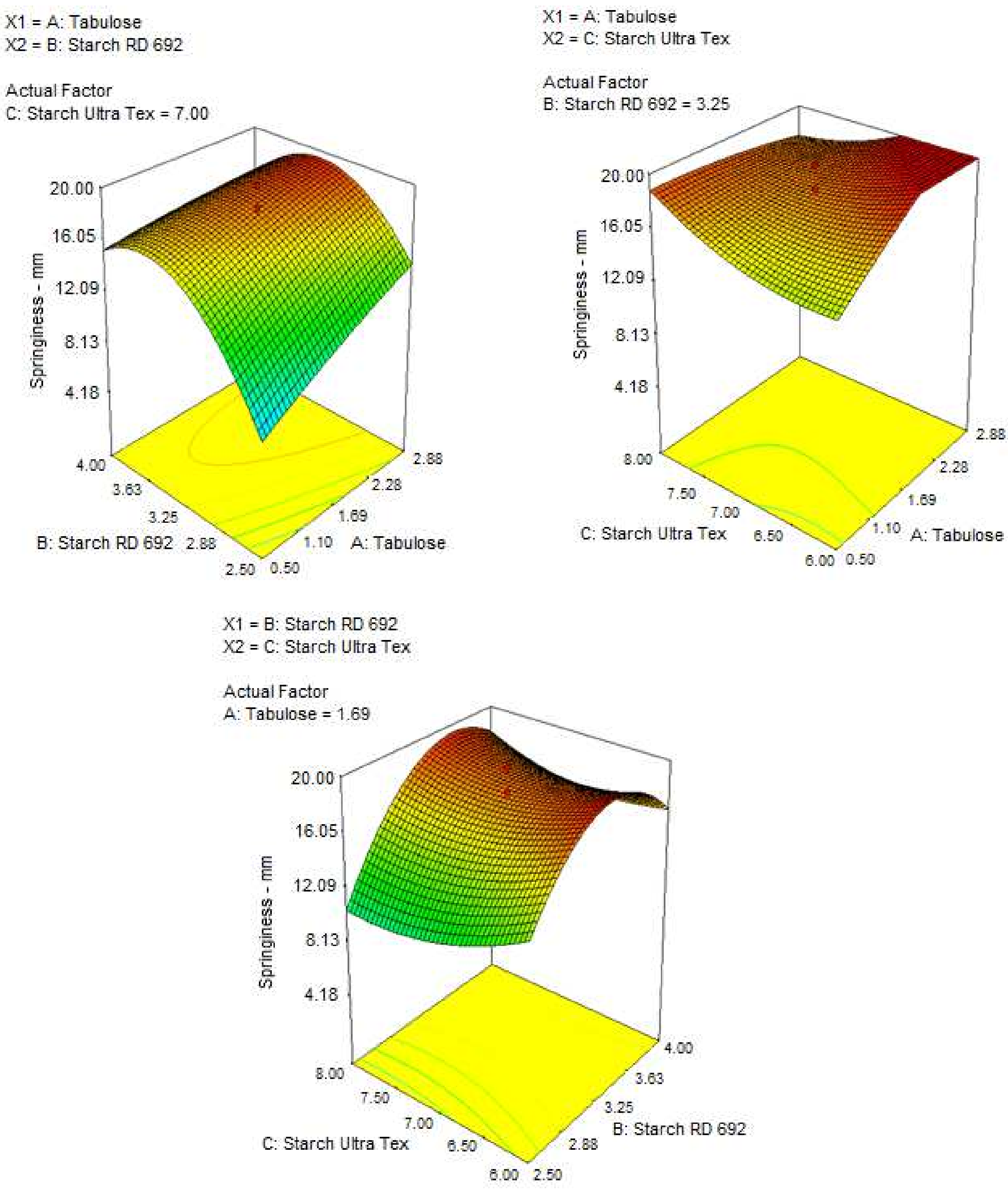
*Springiness = +17.88+1.82*A+2.49*B-0.51*C-1.35*A*B-2.42*A*C+1.27*B*C-0.32*A2-4.25*B2+1.20*C2*

The regression equation model was explained in 88.1% by the springiness variability of the bake stable fruit filling at 20°C.

The response surface diagram (Figure 4), corresponding to the model, showed that the concentration variation between the combination of Tabulose®, starches RD 692 and Ultra

Tex showed a positive correlation with a significant distance (mm) before rupturing of the filling's gel, indicating a filling with elastic characteristics.

FIGURE 4 - QUADRATIC RESPONSE SURFACE MODEL OF SPRINGINESS (MM), AT 20°C



The p value was significant for all parameters and showed that the models adjusted well to the experimental data. The determination coefficient (R^2) was above 0.8 on all instances, regardless the parameters.

TABLE 5 - MODEL VARIANCE ANALYSIS FOR FLOW (MM) AT 190°C, GEL STRENGTH (G) AT 20°C, RUPTURE STRENGTH (G) AT 20°C, AND SPRINGINESS (MM) AT 20°C

Parameters	**Model**	**SS**	**FD**	**MS**	**F**	**p**
Flow	Squared	325.470	9	36.160	6.77	0.00152
Gel strength	Cubic	2699.240	13	207.630	1793.98	0.00060
Rupture strength	Cubic	1.576E+006	13	1.212E+005	42.37	0.02330
Springiness	Squared	301.100	9	33.460	4.94	0.00326

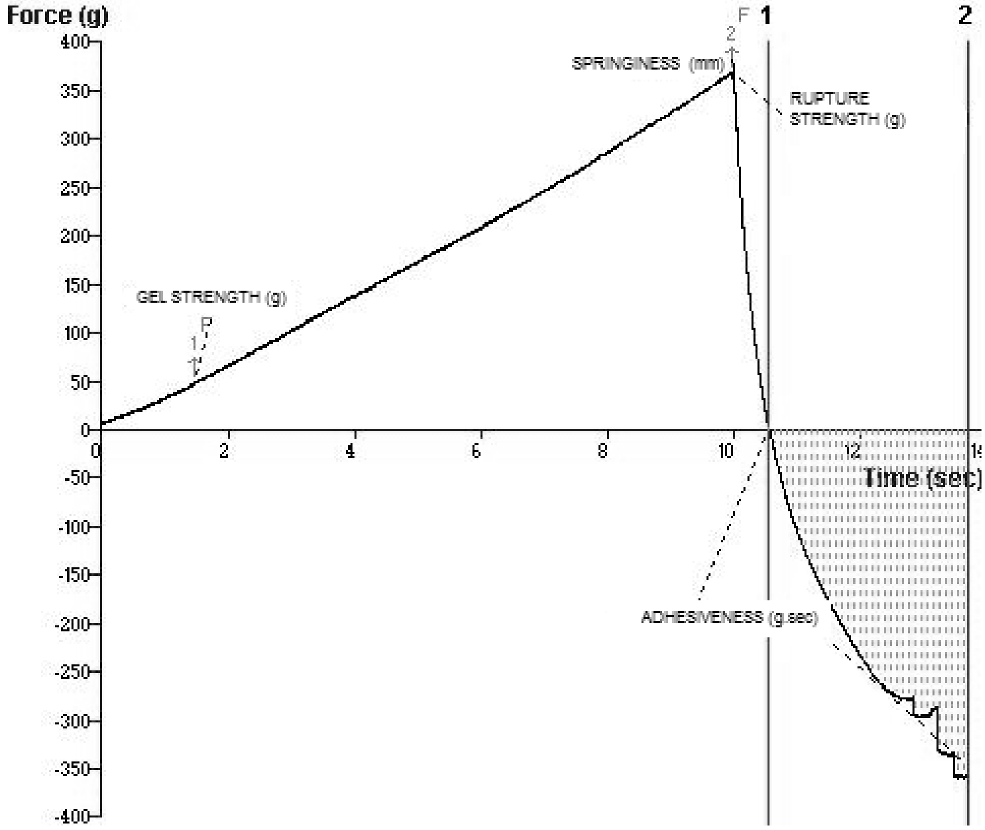
Evaluations of response variables found that treatment 14, on Table 6, resulted in a bake stable fruit filling with a 0.00 mm flow, and other variables with absolute values falling within an expected range.

TABLE 6 - RESULTS OF THE EXPERIMENTS OBTAINED BY THE CENTRAL COMPOSITE DESIGN FOR THE VARIABLES FLOW, AW, PH, SOLUBLE SOLIDS, GEL STRENGTH, SPRINGINESS AND ADHESIVENESS OF BAKE STABLE FRUIT FILLING

	Level of variables			Response				
Treat.	A: Tabulose	B: RD 692 starch	C: Ultra Tex starch	Flow mm	Gel strength g	Rupture strength g	Springiness mm	Adhesiveness g.sec
1	0.50	4.00	6.00	9.00	49.14	288.31	13.41	-551.04
2	1.69	3.25	7.00	5.00	69.04	611.66	19.98	-1093.07
3	1.69	3.25	8.32	5.00	84.15	1334.93	19.99	-1291.66
4	2.88	2.50	6.00	4.00	55.51	561.69	19.99	-801.42
5	3.26	3.25	7.00	0.00	71.21	720.84	20.00	-809.77
6	0.50	4.00	8.00	4.00	81.94	750.10	19.99	-1119.71
7	1.69	2.26	7.00	5.00	57.09	86.59	4.18	-855.14
8	1.69	3.25	5.68	8.00	47.13	376.78	17.98	-546.65
9	1.69	3.25	7.00	5.00	69.24	694.31	18.29	-928.46
10	0.12	3.25	7.00	10.30	60.55	270.99	12.68	-887.84
11	1.69	4.24	7.00	6.00	58.07	436.70	14.91	-727.24
12	0.50	2.50	6.00	16.00	53.34	176.18	10.99	-631.66
13	0.50	2.50	8.00	16.50	44.89	140.18	9.81	-553.59
14	2.88	4.00	8.00	0.00	42.22	245.69	13.92	-506.35
15	2.88	4.00	6.00	2.00	81.87	806.52	19.67	-1016.26
16	2.88	2.50	8.00	2.00	63.07	296.09	11.81	-821.64

The bake stable fruit filling stored for 3 days and with null flow in treatment 14, was studied using a texture analyzer in order to determine instrumental texture profile of the product. The results were represented by the mean average curve on Figure 5.

FIGURE 5 - CURVE TEXTURE PROFILE BAKE STABLE FRUIT FILLING AT 20°C



The resulting 0.051kg ± 0.01 of gel strength from the initial penetration phase shows good gel strength, to the point when breaking occurs. Further penetration until the required depth showed a maximum rupture strength value of 0.202kg ± 0.09, in other words, gel firmness. The distance of 0.011m ± 0.005 that the probe penetrated before rupture indicated a more elastic gel. When the probe was removed from the sample, the total force (area under the negative region of the curve) recorded -0.630kg ± 0.103 of filling adhesiveness.

4 CONCLUSION

According to the results, the unpeeled green banana flour developed in drum drying technology, presented as a quality ingredient, mainly by its water absorption capacity and increasing the content of fruit solids in formulation of fillings. However, the greyish green coloration of the flour limits its application in formulation of light tone fillings.

The results showed that the central composite design was an efficient statistical tool to optimize the formulation of the analyzed matrix. Thus, the best condition for the proposed process was the formula with Tabulose® 2.88%, 4.00% RD 692 acetylated corn starch, 8.00% Ultra Tex phosphorylated corn starch, and 2.5% unpeeled green banana flour.

The formula optimization allowed the achievement of a heat-resistant fruit filling with water activity 0.645 ± 0.002, a value compatible with fruit fillings marketed in the industrial market for application in coextruded products. The results of the instrumental texture of the thermosetting fruit filling prototype with green banana flour with peel provides dosage and formatting in stuffed products, ensuring that it remains drained during the delivery, maintaining its sensorial appeals. The obtained texture profile enables its application in transfer process by means of dosing pumps in the industrial processes of products supplied of confectionery and bakery.

REFERENCES

1 AMERICAN ASSOCIATION OF CEREAL CHEMISTS – AACC: **Approved Methods of the American Association of Cereal Chemists.** v.66, 22 ed. Saint Paul, 2000.

2 ANANDHARAMAKRISHNAN, C.; KARTHIK, P.; CHHANWAL, N. **Handbook of Drying for Dairy Products.** John Wiley & Sons Ltd, 2017. p. 43-44.

3 ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC.: **Official methods of analysis of AOAC**. 15 ed. Washington, DC, 1990.

4 BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Resolução n. 263 de 22 de setembro de 2005. Regulamento técnico para produtos de cereais, amidos, farinhas e farelos. **Diário Oficial da República Federativa do Brasil**. Brasília, 2005.

5 CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutas e hortaliças**: Fisiologia e manuseio. 2. ed. Universidade Federal de Lavras, 2005. p.785.

6 CARVALHO, C.; SANTOS, C. E.; KIST, B. B. **Anuário Brasileiro da Fruticultura 2017.** Editora Gazeta Santa Cruz, p. 36, Santa Cruz do Sul, 2017.

7 GARCIA, E.; LAJOLO, F.M. Starch transformation during banana ripening: The amylase and glucosidase behavior. **Journal of Food Science**, v.53, p.1181–1186, 1988.

8 GERMANO, L.M.L.P. **Métodos alternativos de secagem de banana verde.** Departamento de Engenharia Química,Universidade Federal do Rio Grande do Norte, Natal, 2016.

9 HORWITZ, W. (Ed.). **Official methods of analysis of AOAC International**. 18 ed. Gaithersburg, Maryland, 2005.IZIDORO, R.D.; SIERAKOWSKI, R.M.; HAMINIUK, I.W.C.; SOUZA, F.C.; SCHEER, P.A. Physical and chemical properties of ultrasonically, spray-dried green banana (*Musa cavendish*) starch. **Journal of Food Engineering**. v. 104, p. 639-648, 2011.

10 KAYISU, K.; HOOD, L.F. Molecular structure of banana starch. **Journal of Food Science**. v.46, p.1894 – 1897, 1981.

11 LEON, T.M. **Elaboração e aceitabilidade de receitas com biomassa de banana verde**. 2010. 55 f. TCC (Graduação) - Curso de Nutrição, Universidade do Extremo Sul Catarinense*,* Unesc*,* Criciúma, 2010.

12 LII, C.; CHANG, S.; YOUNG, Y. Investigation of the physical properties of banana starches. **Journal of Agricultural and Food Chemistry**. Easton, v.47, p. 1493-1497, 1982.

13 MCCLEARLY, B.V.; MONAGHAN, D.A. Measurement of resistant starch. **Journal of AOAC International.** v.85, p. 665-675, 2002.

14 MORRISON, W. R.; LAIIGNET, B. **Journal of Cereal Sci**. v.1, p. 9-20, 1983.

15 MUDIGIL, D.; BARAK, S. Composition, properties and health benefits of indigestible carbohydrate polymers as dietary fiber: A review. **International Journal of Biological Macromolecules**. v.61, n.1-6, 2013.

16 PACHECO-DELAHAYE, A.N.; MALDONADO, R.; PEREZ, E.; SCHROEDER, M. Production and characterization of unripe plantain (*Musa paradisiacal L.*) flours*.* **Interciencia.** v. 33, n.4, p. 290 – 296, 2008.

17 RAMOS, D. P.; LEONEL, M.; LEONEL, S. Resistant starch in green banana flour. **Alimentos e Nutrição**. Araraquara, v. 20, n. 3, p. 479-483, jul.- set. 2009.

18 RIBEIRO, E. P.; SERAVALLI, E. A. G. **Química de alimentos**. Edgard Blücher: Instituto Mauá de Tecnologia, São Paulo v. 1, p. 67, 2004.

19 ROCK, J.D.; HANSEN, J.P. (invertors). The J.M. Smucker Company, assignee. **Cold process, oven stable fruit paste and method of making such paste.** United States patente US 5932270. 1999.

20 SANTOS, J. C.; SILVA, GABRIEL F.; SANTOS, JOÃO A. B.; JÚNIOR, ANTONIO M. O. **Processamento e avaliação da estabilidade da farinha de banana verde**. Exacta, São Paulo, v. 8, n. 2, p. 219-224, 2010.

21 SILVA, M.J.R. et al. Caracterização agronômica e pós-colheita das bananeiras 'Maravilha' e 'Preciosa' no Submédio do Vale São Francisco. **Revista Ceres.** Viçosa, v. 63, n. 1, p. 46-53, Feb. 2016.SOSULSKI, F.W. The centrifuge method for determining flour absorption in hard red spring wheats. **Cereal Chemistry.** St. Paul. n.4, v.39, p.344-350, 1962.

22 TRAVAGLINI, D. A.; AGUIRRE, J. M.; SIQUEIRA, .E. T. F. **Desidratação de frutas.** Campinas: CETEA/ITAL, p.40, 2001. TROLLER, J.A. Influence of water activity on microorganisms in foods. **Food Technology.** v.34, n.5, p.76 – 82, 1980.

23 YUN, S. H.; MATHESON, N. K. **Starch/Starke.** v. 42, p.302- 305, 1990.

24 ZENEBON, O.; PASCUET, N.S. **Métodos físico-químicos para análise de alimentos.** Instituto Adolfo Lutz. 4 ed. Método 0312/IV. Brasília, v.1, p. 582, 2005.

25 ZENEBON, O.; PASCUET, N.S. **Métodos físico-químicos para análise de alimentos.** Instituto Adolfo Lutz. 4 ed. Método 0316/IV. Brasília, v.1, p. 577, 2005.

26 ZULETA, A.; BINAGHI, M.J.; GRECO, C.B.; AGUIRRE, C.; DE LA CASA, L.; TADINI, C.; FERRER, Par. Diseño de panes funcionales a base de harinas no tradicionales. **Revista Chilena de Nutrición**, v.39, n.3, p.58-64, 2012.