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Original article

Study on the opportunity to improve the quality of flour for pastry by adding chemical leavening agents

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Abstract

Food products that do not require practices for processing, and are easy to prepare have attracted the attention of consumers. An example of this type of product is the premixes formulations for cake mix which allows the cake to be made easily and quickly. The consumer of this type of product has the expectation, when following the instructions, to obtain a uniform and quality product. There are many different chemical leavening agents available to the baker. These include baking soda (sodium bicarbonate), ammonium bicarbonate, potassium bicarbonate, baking powder (baking soda, calcium phosphate and sodium aluminum sulfate) and leavening acids. Generating CO₂ and neutralizing sodium bicarbonate is the primary role of leavening acids, but, it is important not to forget their secondary role and their effects. Taking into consideration these facts, the objective of experiments was to establish the connection between quantity and quality of leavening agents and the quality of bakery products. As these chemical leavening agents get into flour, it is also important to comprehend how they influence the rheological parameters of flour with direct implication in the quality of the products made. For experiments, backing powder was used, which was added in specific quantities to wheat flour. The flour samples were analyzed both as initial rheological properties and technological behavior. Baking samples were made, and the samples obtained were sensory evaluated in the panel. Correlating Mixolab Profiler indices with the baking samples, and also with the legislation regarding, the best results were obtained for flour with 2% baking powder

Keywords

cake, leavening agents, baking powder, rheological parameters

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Introduction

Being faced with high market demand, segments of the industry should be focused on the production of quality food, which is a determining factor in terms of competitiveness on the international market. Therefore, the quality of raw materials and finished products is essential and it can be influenced by a number of factors. The rheological properties have effects on product quality and nutrition has been thoroughly investigated as they relate to the chemical composition and physical characteristics of foods. [T. M. Souza, 2019] The survival of food industry depends on timing and actions to respond to consumers' desires and needs as well as on monitoring the changes in consumers' behavior. An average modern consumer is interested in the issue of quality, herein several aspects are being considered, such as: ease of preparation, adequate shelf life foods, products containing the least possible amount of additives, food security, products marketed in different servings sizes, and sensory and texture attributes. [VETTER, J. L, 2009] This fact does not apply any longer when a cake is prepared using a homemade recipe, when problems can occur during various stages of its processing. Generally it is about lack of experience and practice of the modern consumer in making cakes, in addition to lack of uniformity of the raw materials used. One of the advantages of using cake mixes is the guarantee of product standardization, since the responsibility for the quality control of the product is being transferred from consumer to industry. During baking, the combined effect of starch swelling and protein denaturation in the presence of other ingredients transforms the liquid batter into solid foam. These events tremendously increase the viscosity of the batter and finally provide structure of the matrix [Hesso et al., 2015]. Cakes are defined as being aerated, chemically leavened bakery products, which are made from many ingredients, such as wheat flour, sugar, egg, fat, leavening agents, salt, nonfat dry milk solids and water. The main parameters of cake quality are the following: volume, firmness, color, and weight loss. Cake quality is influenced by several factors such as quality and level of ingredients [Kahraman et al., 2008] Food quality is defined by a complex set of stimuli beginning with the visual assessment. Once the decision is made to consume food, quality is based not only on the magnitude of flavor, taste and texture, but it also takes into account the temporal coordination of these stimuli. From a historical point of view, food ingredients have been approached from three perspectives regarding their function in foods: formation of structures, stabilization of structures and contribution to sensory quality [Foegeding et al., 2010] Chemical leavens are used to provide cookies, cakes, and other baked goods with characteristic textures. They produce gas resulted from the reaction that takes place when a carbon dioxide source and an acid are mixed together and

come into contact with water. The gas forms bubbles that are trapped in the batter or dough and then, it expands during baking to form the holes that are retained in the finished product. The timing of CO₂ release is critical in establishing uniform cell structure. Upon heating, the CO₂ will release and expand, resulting in increased volume and desirable texture characteristic of good tasting, high quality baked goods. [D, Manthey, 2012] Baking soda is the most common carbon dioxide source. It is low in cost, high in purity, easy to handle, and leaves no after taste. Flour and other ingredients are slightly acidic, so baking soda will release some carbon dioxide if added by itself, but more will be produced when more acid is added.[H. I. WIDIASTUTI, 2019]. Baking involves baking soda, one or more leavening acids, and filler. The leavening acids are added under powdered form as salts which do not react until they get dissolved in water. The filler stabilizes the product by keeping the baking soda and leavening acid separate and standardizes it to the desired strength. Leavening acids are selected primarily on the basis of reactivity—how fast they react and at what temperatures. Reactivity depends mostly on solubility, which in turn depends on chemical composition, particle size, and special treatments such as coating. Single-acting baking powders contain a single leavening acid and can be slow acting or fast acting. Slow-acting types are the most common ones and they use a slow-acting acid like SALP (sodium aluminum phosphate) that reacts very little when heated in the oven. Fast-acting types are less common but they use a fast-acting acid such as monopotassium tartrate (cream of tartar) to provide gas production at low temperatures immediately after addition.[J. Brodie, 2006]. Double-acting baking powders contain a mixture of a fast-acting leavening acid like MCP (monocalcium phosphate monohydrate) and a slow-acting leavening acid like SAPP (sodium acid pyrophosphate). They react partially at low temperatures and partially at high temperatures to provide uniform leavening throughout processing. [J. Brodie 2016] In various experimental studies, the influence of different percentages of added leavens on the characteristics of the finished product was highlighted. [G.Pop, 2016]

This study aims to show the influence of the additions of chemical processors on the rheological parameters of flour and the correlation with the quality of the finished products. Taking all into consideration we could say that the key to superior chemical leavening is the selection of the correct type and grade of bicarbonate and acid for the baked goods and the baking process being used.

Materials and Methods

The aim of this experiment is to bring a better understanding of how the addition of baking powder influences the rheological parameters of flour and how the quality of

Table 1. Analytical parameters of Cake control flour

Moisture %	Ash %	Wet gluten %	Protein %	Hydration capacity %
13.9	0.65	27.4	12.2	56.5

the finished products obtained is influenced. It has in view a better understanding of leavening agents' role in batter and cakes' quality and also to apply the mixing techniques-multistage-method.

In order to obtain some available experimental data, witness flour, purchased from the market, from Băneasa - Moara was used. The quality characteristics of this flour are shown in table 1.

The analytical flour quality was determined according to the international standard methods (ash content – ICC104/1, protein content – ICC105/2, wet gluten – ICC106/2, hydration capacity with Farinograph - ICC115/1).

The most popular type of leavening agents based on their properties and level of usage were used: Baking Powder provided by Lallemand, Inc., Montreal, Canada, and based on sodium bicarbonate, MCP and corn starch like filler.

The witness flour was added 1% baking powder for sample P1, 2% baking powder for sample P2 and 3% baking powder for sample P3.

The flour was studied from a rheological point of view based on the Mixolab Chopin protocol.

Baking samples M, P1, P2, P3 were made from these flours following the protocol in Table 2

The sensory analysis was carried out following the work protocol in the panel, following the taste, texture, porosity and color of the peel (those that are also appreciated by potential consumers)

All the experiments are made in the research laboratory of Stefan cel Mare University of Suceava.

Results and discussion

Evaluation of flour samples

In order to be evaluated, the flour samples were marked as follows: M-control flour, P1 –control flour with 1% baking powder, P2 - P1 –control flour with 2% baking powder and P3- control flour with 3% baking powder

The samples were analyzed on Mixolab Chopin, according to the Profile protocol. The curves obtained are shown in figure 1, 2, 3 and 4.

Table2 Formulating sheet

1st STAGE				
Ingredients, grams	Control cake	P1 1% baking powder	P2 2% baking powder	P3 3% baking powder
Sugar	250	250	250	250
Eggs	280	280	280	280
Mixing procedures: Start mixing 1minute in 1st speed adding the eggs quickly. Scrape down bowl with a plastic scraper. Continue mixing for 4 minutes in 1st speed				
2nd STAGE				
Ingredients, grams	Control cake	P1 1% baking powder	P2 1% baking powder	P3 3% baking powder
Milk	150	150	150	150
Oil	100	100	100	100
Salt	10	10	10	10
Mixing procedures: Mix 1 minute in1st speed gradually by adding milk in 3 parts,by avoiding splashing and lumps. Scrape down bowl and continue mixing for approximately 4 minutes in 1st speed, and add oil				
3rd STAGE				
Ingredients, grams	Control cake	P1 1% baking powder	P2 1% baking powder	P3 3% baking powder
Baking powder	-	5	10	15
Flour 650	500	500	500	500
Flavor	12,5	12,5	12,5	12,5
Cacao	10	10	10	10

Add the powdered ingredients and mix them for about 5 minutes at 1st spee

The composition was transferred into 2 regular check forms and cocoa can be added to create a marbled look.

Baking was done at 180 ° C for about 20 minutes, then another 15 minutes at a temperature lower than about 160 ° C. After baking, slice them.

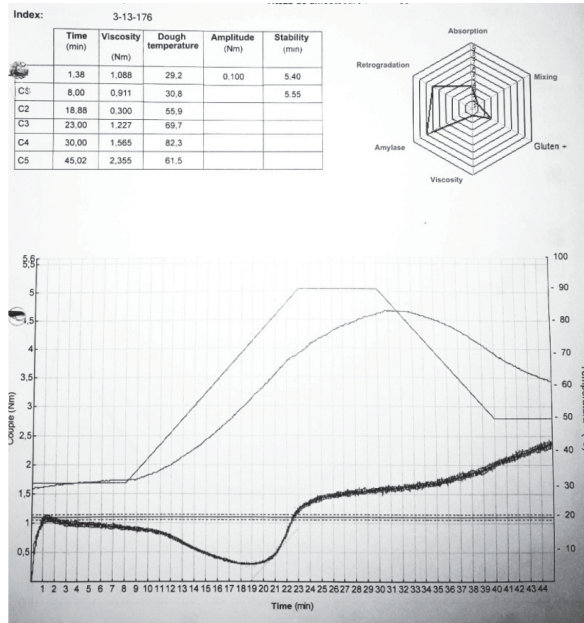


Figure 1 Evaluation curves of control flour M

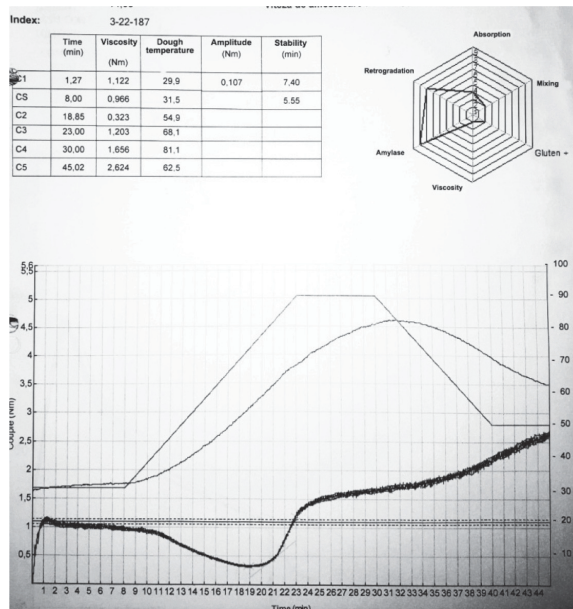


Figure 2. Evaluation curves of P1 (control flour with 1% baking powder)

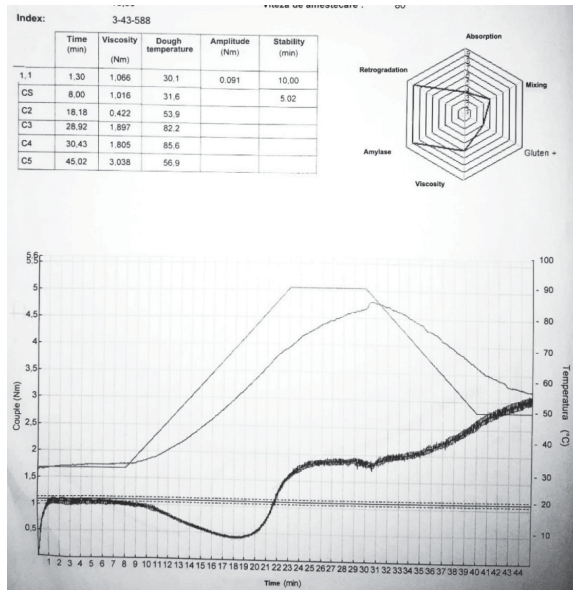


Figure 3 Evaluation curves of P2 (control flour with 2% baking powder)

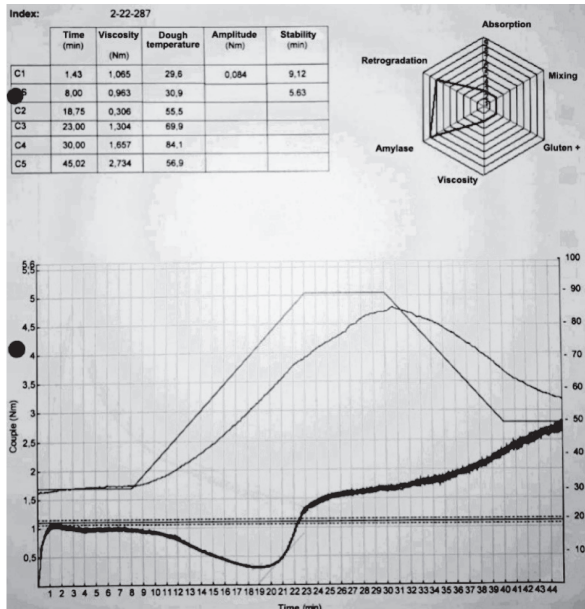


Figure 4 Evaluation curves of P3 (control flour with 3% baking powder)

Based on the results obtained, it is observed that the dough stability increases from 5.4 min to 7.4 (P1) respectively 10.0 (P2) and 9.12 min to P3. The hydration capacity given by the absorption index is constant in all samples, but it decreases from 3 to 2 in P3. Regarding the kneading index, it is observed that it is small regardless of the percentage of baking powder added. A slight increase is observed in P2, which indicates dough stability during kneading. The gluten index is at a minimum in all samples, which indicates that the strength of gluten is low. The addition of baking powder does not improve the strength of gluten. The index expressing the viscosity index is minimal in all the samples 1 and 2, except in sample P2 where it is 5. This means that the enzymatic activity is low and the viscosity increases.

For the other quality indices, the values are close in all the samples and close to the maximum value 8.

Baking test

It was very important to check specific gravity of cake (optimum 0.8-0.85) after 2nd and 3rd stage, to determine the proper mixing time required and record the specific gravity with the final batter temperature and also with viscosity

It could be observed that the viscosities of the samples are almost the same with an exception (sample 4) which is a little grainier. The specific gravity (S.G.) has a direct relationship to volume, grain and texture of cakes and it could be also a measure of incorporated air cells.

In order to observe the influence of different amounts and of leavening agents on batters and cakes quality, 4 samples using the following formulas were made (table 2).

After mixing was completed, 4 cakes pan from each of samples were prepared. Each cake had 370 grams. All the cakes were loaded at one time to better control congestion in the oven. Oven temperature was set at 182 °C and the time of baking was approximately 24 minutes.

After baking, the cakes were placed on the rack to cool, and after 15-20 minutes they were removed from the cake pans. Also, they were cut for a complete sensory exam.

By visual analysis of the 4 baking samples it is observed that the control has a crumb with uneven pores and it is not

well developed. The samples that have added baking powder have a more aerated crumb, and in the sample P2, it is observed that the slice section is more uniform, with no appearance “in the corners”. In sample 4 it is observed that although the slice is beautiful in the section, without the appearance of corners, the crumb is colored to reddish, showing an overdose of the tiller. The crust is quite thick and the crumb dense.

As can be seen, in the case of control flour M, the pores are very dense, while at P1 (1% baking powder) and P2 (2% baking powder) the crumb is loose. In the case of P3 (3% baking powder) the pores are large and uneven and the crumb over fermented. A plus to the shape, is at P2 (2% baking powder, where the section is nicely rounded uniform, without corners.

Influence on cakes volume. From the analysis of these four cakes one can observe the fact that each of the four samples with chemical leavening agents had a good final volume. On the other side, the sample without baking powder had a poor volume, almost the same like batter before baking. We can also make the right connection between final cake's volume and specific gravity of this sample (~1) which was more than optimal (0.8).

Influence on cakes texture and mouth feel. Regarding these aspects we can observe (that the sample with high baking powder has got more open porosity and a more grainy aspect.

In the case of sample with 3% baking powder (P3) it is obvious the brown color and the very open porosity. Also this sample had a taste like a soap film on the tongue and as a dry product is unsuitable for chewing. The explanation could be the pH.

Taking into consideration these facts, it has become obvious the important role of cake's pH on color crust and flavor. And, of course, the level of pH is controlled by leavening acids. In these conditions we could say that it is very important to select the proper leavening acid based on type of products and characteristic and when carbon dioxide is aimed at to get released. If too little leavening acid is added, less gas is produced and the residual baking soda raises the



M
Control flour



P1
(1% baking powder)



P2
(2% baking powder)



P3
(3% baking powder)

Photo 1 Cake sections for sensory analysis

pH of the finished product. If too much leavening acid is added, gas production remains the same, but it will leave a bitter aftertaste in the finished product.

Conclusion

For the analysis of the samples according to the Mixolab Profiler protocol, there was no target profile based on which the flour with the addition of leavening agents to be considered accepted or refused. This is why baking tests have been carried out in parallel, in order to establish an optimal addition of leavening agents and a target profile for the flour that would be added and used in various applications.

The 6 indexes of the Mixolab Profiler for each flour sample were analyzed, in parallel with the baking samples.

By comparing the data, we can analyze:

- regardless of the percentage of added baking powder, the absorption was not significantly inhibited
- Mixing correlated with stability increases when baking powder was used, having a great value when a percentage of 2% baking powder was added.
- Gluten index, the power of gluten worsens when baking powder was added. This translates into the fact that when the baking powder was added, the gluten behavior on heating becomes worse.
- The viscosity index, increases as the percentage of baking powder was increased. This means that the enzymatic activity decreases and the viscosity increases. The highest value is observed at the addition of 2% baking powder, P2.
- in the indices the amylase activity and relegation do not have significant influences.

Correlating Mixolab Profiler indices with the baking samples the best results were obtained with P2, followed by P1.

From the analysis of the results obtained by backing tests on the possible effects of chemical leavening agents on cakes' quality, the following conclusions can be drawn:

- *Taste and texture* are influenced by the choice of leavening acid and ratio of leavening acid to baking soda;
- *Crumb color* is influenced by the pH of the finished product. A low pH in low baking soda levels gives whiter crumb color. A high pH in high baking soda levels gives a darker crumb color that is desirable in chocolate products.

Based on the two types of analysis, practical and laboratory, a target profile for flour with the addition of baking powder was established. The profile can be translated into minimum and maximum values for Mixolab indices: min 322-188 and max 343-588.

Complying with the legislation regarding the maximum percentage of sodium pyrophosphate allowed, the maximum baking powder used can be 2%.

References

1. AOAC Association of Official Analytical Chemists, Method 16192. Official Methods of Analysis of the Association of the Official Analytical Chemists, Washington D, (2000)
2. BELZ, M. C., RYAN, L. A., & ARENDT, E. K, The impact of salt reduction in bread: a review. *Critical reviews in food science and nutrition*, 52(6), 514-524. (2015)
3. J.BRODIE, *Chemical Leavening for Baking*, Formulating Bakery products, International seminar, AIB, International, Manhattan, KS, USA, (2016)
4. E. BEIZADEA, Fortification of Wheat Flour, *Romanian Biotechnological Letters* Vol. 14, No. 2, 2009, pp. 4300-4306, (2008)
5. BOOK, S., & BRILL, R, Effects of chemical leavening on yellow cake properties. *Cereal Food World*, 60, 71-75, (2015)
6. S.BUTT^AIDRIS,K.MOHAMMED^AVIVEK^RAGHAVAN^AJAMES^SOSBORNE^BHUGH^POWELL^BMARIA N.CHARALAMBIDES^A, Dough rheological, Mixolab mixing, and nutritional characteristics of almond cookies with and without xylanase, *Journal of Food Engineering*, Volume 105, Issue 2, Pages 227-232 (2011)
7. G.CANALI, F.BALESTRA, V.GLICERINA, F.PASINI, M.F.CABONI, S.ROMANI, Influence of different baking powders on physico-chemical, sensory and volatile compounds in biscuits and their impact on textural modifications during soaking, *Journal of Food Science and Technology* (2020)
8. CAUVAIN, S. P. Raw materials. In S. P. Cauvain (Ed.), *Baking problems solved* (pp. 33-144). Cambridge United Kingdom: Elsevier Science & Technology. (2017)
9. HT. GODEFROIDT, N. OOMS, B. PAREYT, K. BRIJS, J.A.DELCOUR, *Ingredient Functionality During Foam-Type Cake Making: A Review*, *Comprehensive Reviews in Food Science and Food Safety*, Institute of Food Technologists® doi:10.1111/1541-4337.12488, (2019)
10. E. IORGA, N. BELC, A. STANCOV, GH. CAMPEANU, Improvement of Falling Number on Romanian Wheat Flours, *Roum. Biotechnol. Lett.*, Vol. 7, pp 635-646 (2002)
11. HESSO, N., LOISEL, C., CHEVALLIER, S., LE-BAIL, A., QUEVEAU, D., PONTOIRE, B., & LE-BAIL, P., Monitoring cake baking by studying different ingredi-

- ent interactions: From a model system to a real system. *Food Hydrocolloids*, 51, 7-15, (2003)
12. KAHRAMAN, K., SAKIYAN, O., OZTURK, S., KOKSEL, H., SUMNU, G., & DUBAT, A. Utilization of Mixolab® to predict the suitability of flours in terms of cake quality. *European Food Research and Technology*, 227(2), 565-570.(2008)
 13. T. KHANAM, S. MALIK, P. GURURANI, V. CHAUDHARY, Nutritionally enriched cake using vegetable and fruit waste: A review, *Journal of Pharmacognosy and Phytochemistry*, 8(3): 722-725, (2019)
 14. LYNCH, E. J., DAL BELLO, F., SHEEHAN, E. M., CASHMAN, K. D., & ARENDT, E. K Fundamental studies on the reduction of salt on dough and bread characteristics. *Food Research International*42(7), 885-891(2009)
 15. D, MANTHEY, *A Comparison of Leavening Agents*, Cereal Chemistry, St.Pauli, Minneapolis, U.S.A, (2012)
 16. G.POP, Researches regarding the chemical leavening agents' role in quality of bakery products, *Journal of Agroalimentary Processes and Technologies*, Volume XIII, No.1, 105-112, (2007)
 17. R.TAMBA-BEREHOIU, N.C. POPA, D.BALAN, S. POPESCU, A. IANCU, Testing of some enzymatic mixtures used for the improvement of wheat flours Roumanian Biotechnological Letters Vol. 9, pp 1871-1878 (2004)
 18. T. M. SOUZA, Rheological properties for quality control of wheat and dry cake mixes, Ph.D Thesis, Oklahoma State University,(2019)
 19. A.M.TEMEA (MOROI), N. P.(VARTOLOMEI), A. I. SIMION, C.G. GRIGORAŞ, R.E.UNGUREANU (CĂRBUNE) , P.ALEXE, Improvement of Flour and Dough Rheological Properties by Maturation , *Romanian Biotechnological Letters* Vol. 21, No. 2, (2016)
 20. VETTER, J. L., *Leavening Agents*. *Encyclopedia of Food Sciences and Nutrition*, 2, 3485–3490,(2009)
 21. H. I. WIDIASTUTI, C.A. S. WULANDARI, Efektivitas natrium bikarbonat (NaHCO₃) terhadap karakteristik fisikokimia dan sensori keripik tulang ikan putak (*Notopterus notopterus*), *Masyarakat Pengolahan Hasil Perikanan Indonesia*, JPHPI 2019, Volume 22 Nomor 2