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THE EFFECTS OF SUGAR AND FAT SUBSTITUTION ON THE TEXTURAL PROPERTIES OF THE PIE DOUGH

***Dana HUȚU[1], Sonia AMARIEI[1]**
[1]*Faculty of Food Engineering , Stefan cel Mare University of Suceava, Romania*
*Corresponding author
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Abstract: *Understanding the current technologies related to the food industry, which deal with the reduction of sugar in processed foods, research made on the subject and the consumers response to the reduction of sugar in food, has become a very important factor for food producers in the mission, to design and produce low sugar products. Due to the multiple functions that sugar has in food, reducing it is a difficult task in itself, but progress is still being made in order to make the products acceptable to future consumers. In this quest, the process of identifying ways to incorporate apple puree as a healthy food ingredient in a diet may be a solution because it could offer many advantages for a healthy diet, mainly due to the reduction of sugar and respectively the fat, beneficial for both categories: adults and especially children, whose health may be affected by added sugar from pastries, for instance. In addition, apple puree brings an increased nutritional value to bakery and pastry products, through its composition which has a rich content of nutrients. Apple puree could be considered an alternative source of dietary fiber needed for muscle strengthening and permanent burns in the body activity, which can be included in the daily diet as a special food ingredient used in pastries. Therefore, the potential exploitation of apple puree in the industry as a healthy food ingredient, due to its benefits, is higher ranked, with a high degree of interest, being more and more common in the bakery industry and selected functional foods, which allows it to have a promising future in this industry.*

Keywords: *apple puree,sugar, fat, substitution, texture, dough development*

1. Introduction

There is an alarming increase in obesity and diseases related to obesity such as diabetes heart diseases and hypertension in developing children.Although the risks of obesity can be increased due to genetics and environmental factors, the most frequent cause of obesity is energy imbalance [1].
Sugar is high in calories and is found in a wide variety of foods and beverages. Reducing or removing sugar from confectionery is an important research objective for the food industry,considering information as an important factor in consumer awareness of the diseases of civilization and the gouvernment's strategies for reducing sugar in high-sugar products [2].
In Europe, some gouvernments have implemented taxes and recommendations for producers and consumers of sucrose-rich foods. For example, the Irish gouvernment introduced a sugar tax in 2018, which increased the price of

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beverages with a sugar content of > 5 g / 100 ml of beverage.In the UK, Public Health England has launched an action plan to combat childhood obesity. This strategy aims to encourage the food industry to reduce the sucrose content of a variety of products by 20% by 2020. These initiatives put pressure on the food industry to produce low-sucrose products, while consumers continue to require high quality products [2].

“Added sugar” refers to sugar added to food before consumption, during preparation or during processing to enhance the flavour or texture of food, as opposed to the sugar inherent in a product [3]. Added sugar and sugar naturally present in food do not differ chemically, but there is a great health concern about added sugar due to the addition of unnecessary calories [4]. In the last two decades, consumer focus on health has increased, leading to significant pressure for healthier food choices [5-7].

Consumers generally have basic knowledge of nutrition when it comes to sugar, but what differentiates a healthy consumer from an unhealthy consumer is how they use their nutritional knowledge to make food choices [8]. Many parents want low-sugar products for their children, and current studies emphasize the importance of developing healthy eating habits at an early age [9,10]. Sigman-Grant and Hsieh (2005) found that consumers who selected low-sugar versions or a combination of low-sugar and whole-sugar products generally had more favorable diets [11].

Apple puree contains a high concentration of dietary fiber, manufactured as a by-product in the apple juice and cider industry. It has been used to increase the fiber content of pastries [12, 13]. It has been reported that the addition of apple puree can increase the perceived sweetness of some pastries [13]. Apples are one of the most frequently consumed fruits, reaching an intake of about 20-30 kg a year for each citizen. Apples come in over 7,500 varieties worldwide and are generally a good source of a variety of nutrients and non-nutrients [19].

In addition to simple carbohydrates - mainly sugars - apples are rich in vitamin C, a number of minerals, especially potassium, and also non-essential constituents such as polyphenols, fiber and additional phytochemicals such as triterpenes and phytosterols. Many of these constituents have been associated through their mechanism of action and also in epidemiological studies with anti-inflammatory and antioxidant properties, lowering the risk of developing diseases such as diabetes and cardiovascular complications, many of which are increasing. It is believed that apples contribute to a healthy diet, and the old saying "an apple a day keeps the doctor away" is believed to still contain a lot of wisdom [14].

2. Matherials and methods

The determination of the texture profile of the pie dough using the Perten TVT-6700 texturometer (Perten Instruments, Sweden) was performed by applying a double compression of up to 50% of the initial sample height, using a cylindrical probe with a diameter of 45 mm., at a speed of 5.0 mm / s, a force of 20 g and a recovery period between compressions of 12 s [15].

In order to evaluate the texture of the pie dough, spheres of 50 g of dough were made which were then subjected to the double compression test, up to 50% of the initial height, using the Perten TVT-6700 texturometer (Perten Instruments, Sweden). and a cylindrical probe with a diameter of 35 mm, with the application of a speed of 5.0 mm / s, a force of 20 g and a recovery period between compressions of 12 s [16].

The fermentation behavior of the pie was analyzed using the Chopin reofermentometer (Chopin Rheo, type F4, Villeneuve-La-Garenne Cedex, France) [17] according to Chopin protocol by testing a pie dough sample under 2000 g cylindrical weight constraint at 30°C for 3 h. For this purpose, pie dough samples were mixed in a Consistograph device. To 250 g sample 5 g salt and 7 g yeast of *Saccharomyces cerevisiae* type were added. The dough development curve parameters such as maximum development reached by the dough, H_m (mm) and the curve height of the end of the test, h (mm) were determined. Also the gas production curve parameters were analyzed such as: total volume of gas production, (mL) total volume of carbon dioxide lost (mL), volume of carbon dioxide retention (mL), and retention coefficient (%).

3. Results and discussion

Texture profile analysis

Texture profile analysis (APT) allows objective measurements of food texture parameters and is a major influencing factor on food acceptability. APT was designed as a two-cycle compression performed to simulate successive chewing (Tuoc and Glasgow, 2018). In addition, this test allows the evaluation of the texture parameters of the product such as cohesiveness, adhesiveness, firmness, fracturability both in various stages of the technological process and in the finished product stage [18].

Sample preparation: M-sample obtained according to the manufacturing recipe without substitution of sugar and fat, P1 - sample obtained by substituting 10% of the amount of sugar and fat, P2 - sample obtained by substituting 20% of the amount of sugar and fat, P3 - sample obtained by substituting 30% of the sugar and fat content, P4 - sample obtained by substituting 40% of the amount of sugar and fat, P5 - sample obtained by substituting 50% of the amount of sugar and fat [19].

The samples obtained by substituting 10%, 20%, 30% of the amount of sugar and fat with apple puree showed significantly lower hardness values than the control sample, instead, the hardness values of the samples obtained by replacing 40%, respectively 50% were approximately similar to those of the control sample. At the same time, in the case of stickiness, the samples with a lower percentage of sugar and fat substitution with apple puree showed values close to those of the control sample, on the other hand, the samples with a higher percentage of substitution showed lower values than witness. The elasticity may vary depending on the quality of the flour, the components of the dough and their proportion.As such, the values obtained for the elasticity of the samples varied from 0.9981 to 1.0011, the minimum extreme value being also the closest to the value of the elasticity of the control sample.

The samples obtained by substituting 20%, respectively 50% of the amount of sugar and fat with apple puree showed a significantly higher elasticity than that of the control sample. In contrast, the samples with a substitution of 10% and 30% showed an elasticity closer to that of the control sample, while the sample obtained by substituting 40% of the amount of sugar and fat with apple puree had a higher elasticity, smallbut closest in value to the elasticitycontrol.

The fibers present in apple puree contain –OH groups in the structure that can favour higher interactions with water through hydrogen bonds. Due to the water solubility of sugars present in apple puree, the cohesiveness of the dough can be influenced.

As a measure of the strength of the internal bonds that maintain the shape of the sample [20], the cohesiveness varied between 1.04 and 1.58, extreme values corresponding to the control sample, respectively the sample obtained by substituting 20% of the amount of sugar and fat. Substituting fat and sugar with apple puree has led to a higher cohesiveness of the dough, especially in the case of samples obtained by substituting 20% and 30% of the amount of sugar and fat in apple puree.

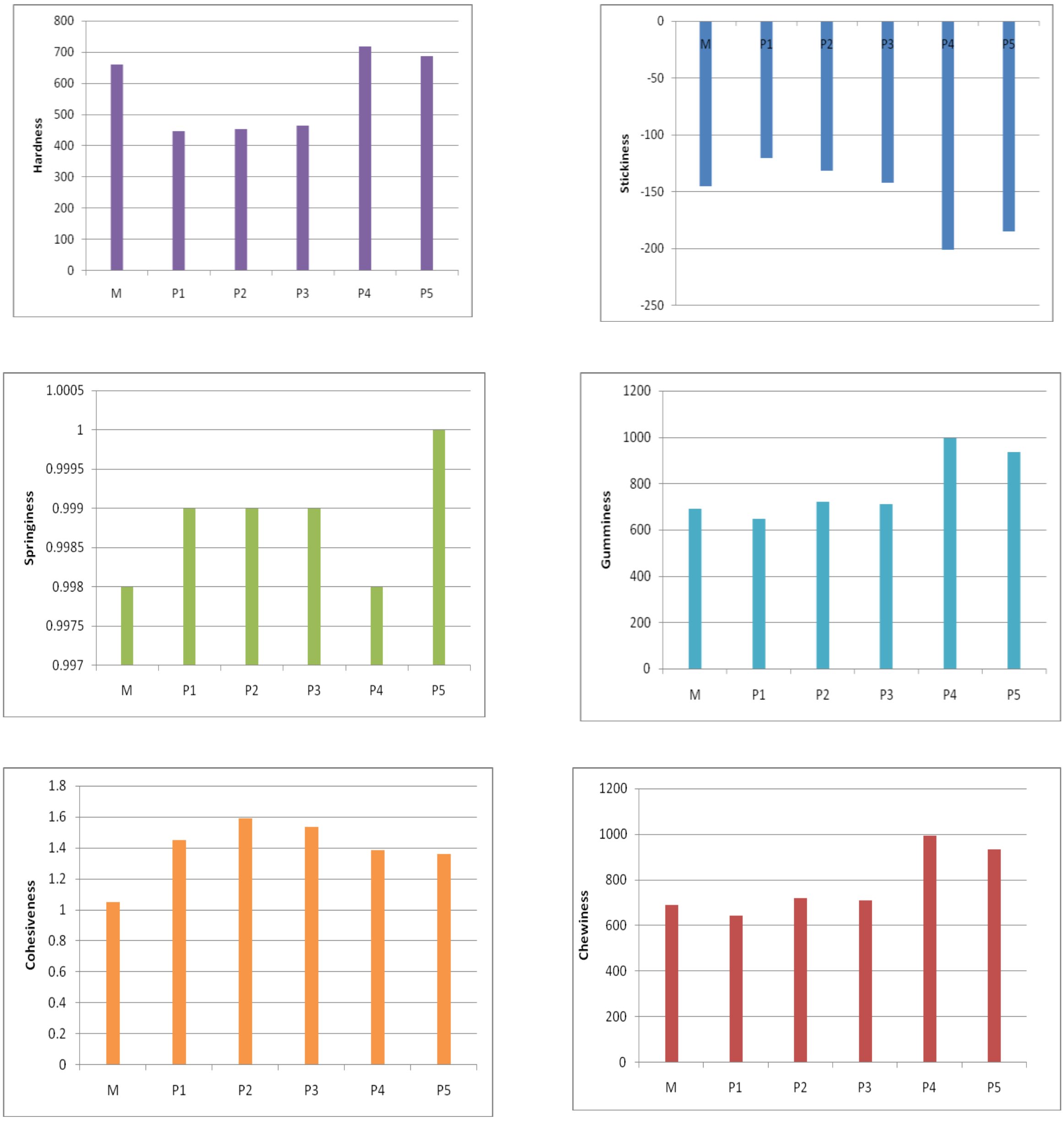

Fig.1. Graphical representation of pie dough texture parameters: M-sample obtained according to the manufacturing recipe without substitution of sugar and fat, P1 - sample obtained by substituting 10% of the amount of sugar and fat, P2 - sample obtained by substituting 20% of the amount of sugar and fat, P3 - sample obtained by substituting 30% of the sugar and fat content, P4 - sample obtained by substituting 40% of the amount of sugar and fat, P5 - sample obtained by substituting 50% of the amount of sugar and fat

Dough rheological properties during fermentation

The rheological properties of the dough during fermentation were determined using the Rheofermentometer device. For the maximum height of gaseous production and the curve height of the end of the test parameters have been analyzed its behaviour during the 180 minutes fermentation period for every 30 minutes.

Table 2.

Rheofermentometer parameters of pie dough samples

Sample	Hm (mm)	h (mm)	H'm (mm)	The total volume of gas production (ml)	The volume of carbon dioxide lost (ml)	Volume of carbon of dioxide retention (ml)	Retention coefficient (%)
Control	43.2	37.6	52.8	1137	101	1036	91.1
Sample 1	55.1	55.0	60.3	1084	3	1081	99.7
Sample 2	57.2	57.1	57.7	1093	2	1091	99.8
Sample 3	49.0	47.7	71.2	1431	24	1407	98.3
Sample 4	41.1	39.9	47.1	905	3	902	99.7
Sample 5	45.6	45.5	59.0	1087	4	1083	99.6

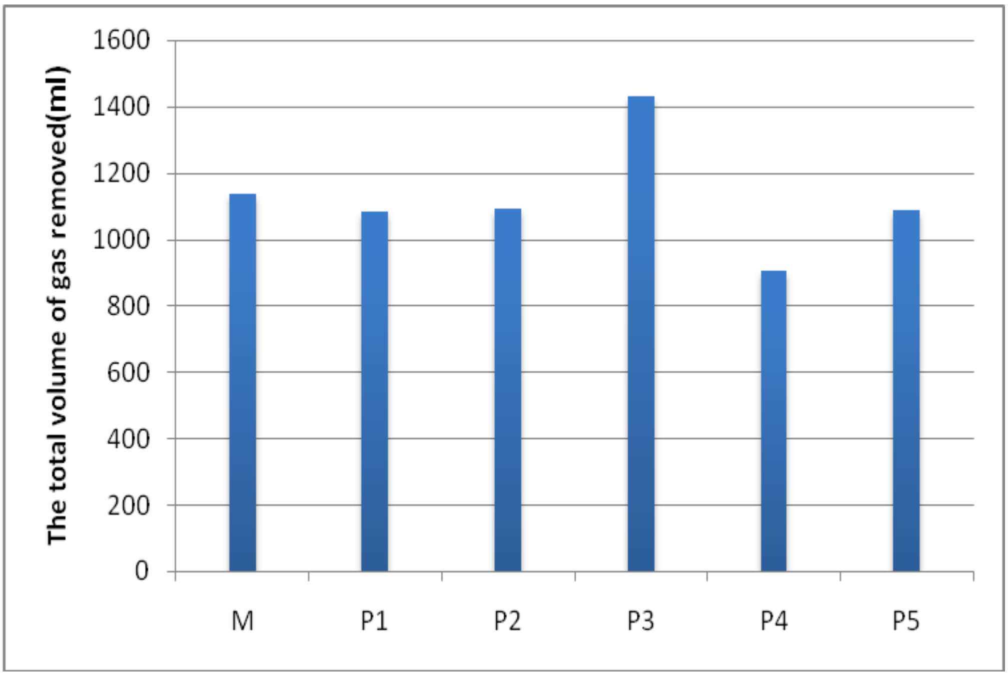

Fig. 2. Graphical representation of the total volume of gas removed

The fermentation activity of yeast expressed by carbon dioxide emission is more intense in the dough in which 30% of the sugar and oil have been replaced. This being 20.55%, 24.25%, 23.62%, 36.76% and 24.04% higher than the control sample, sample 1, sample 2, sample 4 and sample 5 respectively.

The maximum height of gaseous production during fermentation period are shown in the table 3.

Table 3.
Maximum height of gaseous production values during fermentation period for the pie dough sample

Sample	**Maximum height of gaseous production, H'm (mm)**					
Time	30´	60´	90´	120´	150´	180´
M	26.6	40.4	46.8	50.5	52.8	52.2
P1	12.6	32.7	44.7	50.7	56.4	60.3
P2	15.2	35.4	44.8	50	55	57.7
P3	29.6	49.9	58	63.3	66.1	71.2
P4	17.5	28	34.8	40.2	44.1	47.1
P5	13.6	32.9	44.8	51.5	56.4	59.0

Gas production is constantly increasing for all. This is due to the use of the old fermentable ingredients present in the dough.

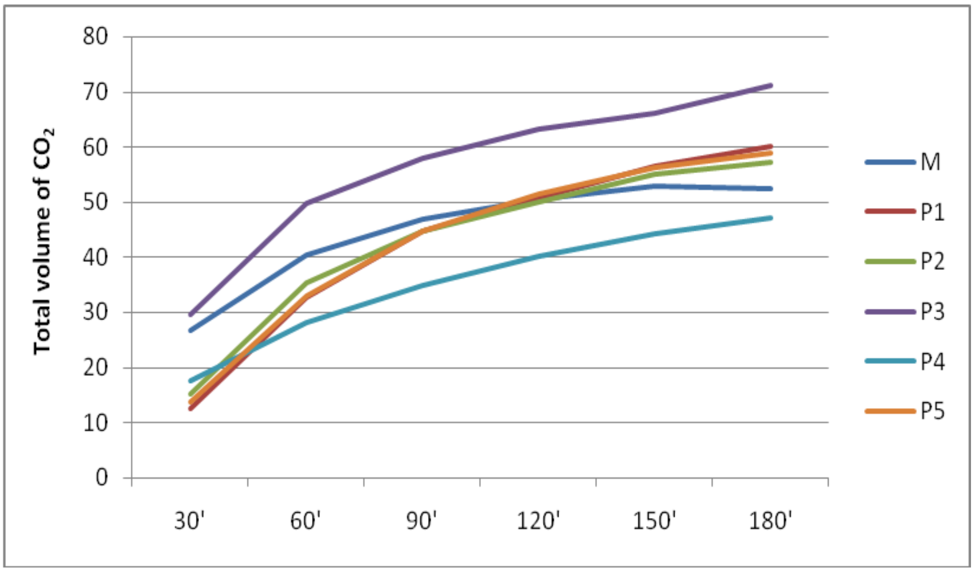

Fig. 3. Graphical representation of the maximum height of gaseous production during fermentation period for the pie dough sample

The maximum height of gas production reaches maximum values in any of the moments of determination for the period of 3 hours in the case of the sample obtained by substituting 30% of the amount of sugar and fat, reaching the maximum value at the end of the fermentation period.

The minimum values were recorded for the sample obtained by substituting 40% of the amount of sugar and fat.

The samples obtained by substituting 10% and 20% of the amount of sugar and fat are those which show a fermentation activity similar to the control sample.

Table 4.
The curve height of the end of the test values during fermentation period for the pie dough samples

Sample	The curve height of the end of the test, h (mm)					
Time	30´	60´	90´	120´	150´	180´
M	6.3	17.9	30.6	40.4	43.2	37.6
P1	1.7	10	24	39.7	51	55
P2	2.5	11.9	26.2	41.7	54.4	57.1
P3	6.5	21.7	39.4	48.5	48.9	47.7
P4	4.2	12.7	24.1	35.8	40.6	39.9
P5	0.7	9	23.2	38.2	44.5	45.5

At first the entire amount of gas produced is retained by the dough and the height increases rapidly. During fermentation. the Hm value increases more slowly to a maximum value after which it stops. Even if the production of gas continues during the fermentation only part of them are retained by the dough. the rest is lost. Also. the value of the maximum growth height of the dough is correlated with the volume of gas dioxide lost. Therefore. the dough made with 16.66g of sugar. 4.16g of puree and 33.32g of oil had a value of 57.2 mm.

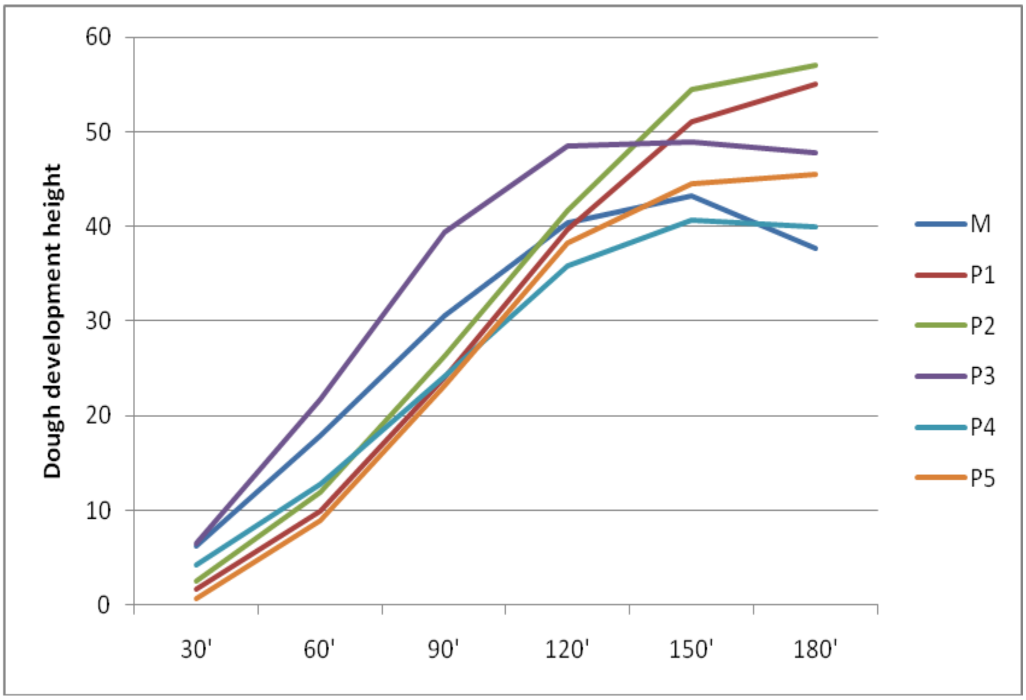

Fig. 4. Graphical representation of the curve height of the end of the test

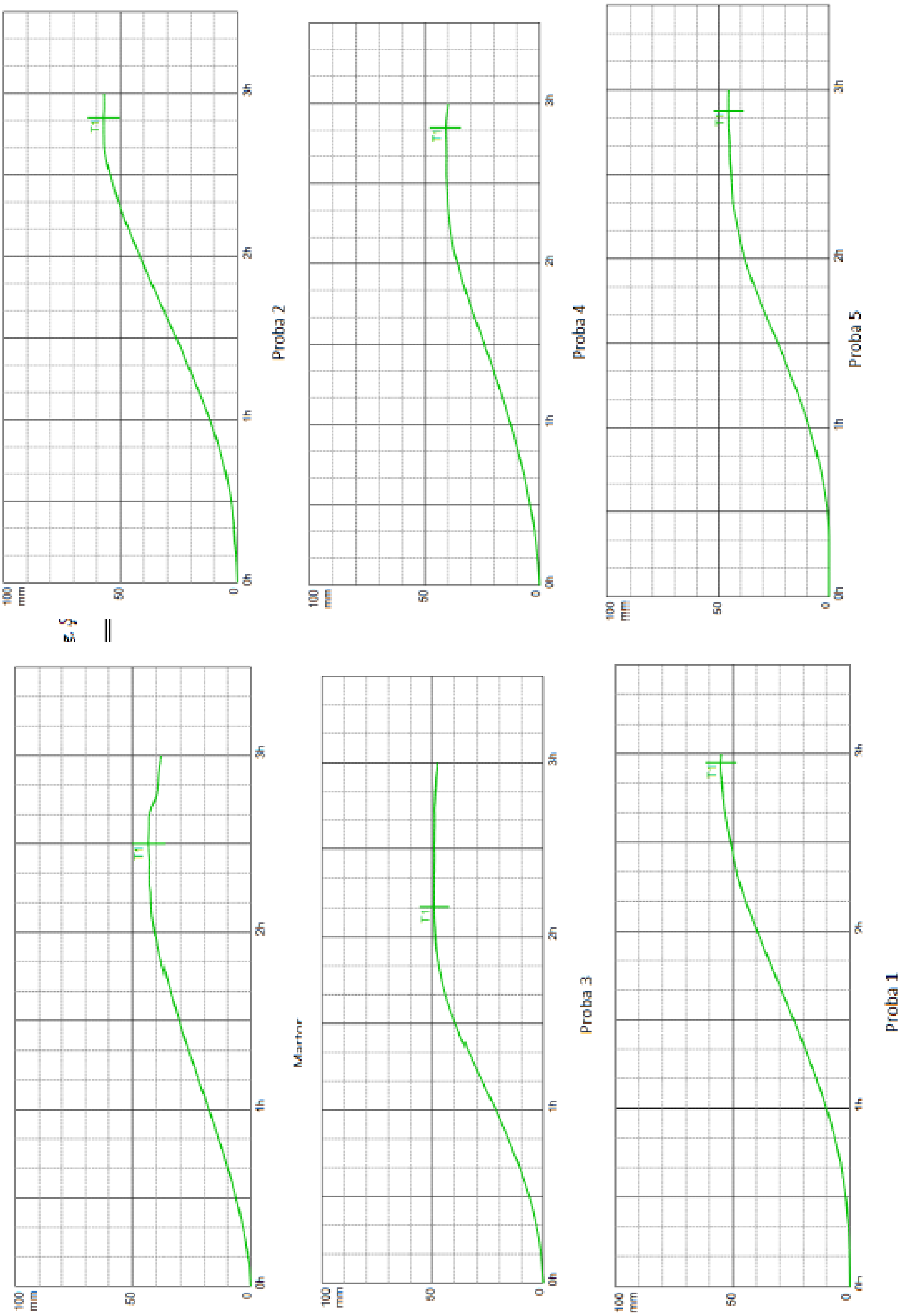

Figure 5. Graphical representation of the development of the height of the dough during fermentation [19]

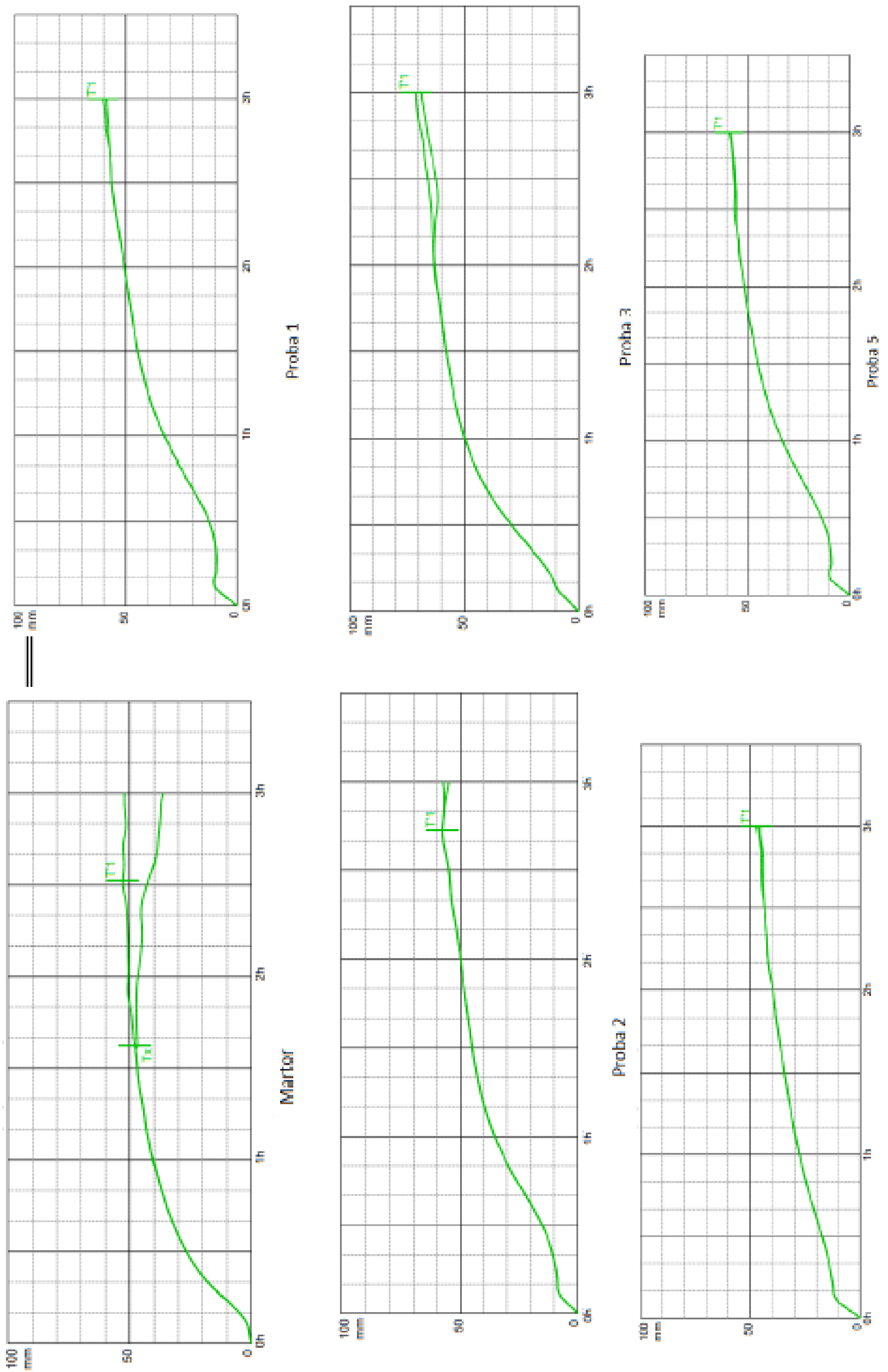

Figure 6. Representation of gas production determined with Chopin rheofermentometer [19]

4. Conclusion

Replacing some quantity of sugar and fat with apple puree has led to an increase in the nutritional. functional and technological value of pie. The nutritional value has increased due to the content of nutrients. especially fiber.

A reduction of sugar between 10 and 50% was achieved in 5 samples of pie dough. The use of apple puree as an ingredient in substituting a percentage of the amount of sugar and fat produced a dough with physicochemical. textural. rheological properties and with fermentative behaviour approximately as the control sample depending on the percentage of sugar and fat substituted. Therefore. for textural characteristics such as hardness. stickiness. elasticity. gumminess. chewability. adhesiveness and stiffness. the sample obtained by substituting 30% of the amount of sugar and fat is closest to the control sample.

Dough hardness. elasticity and cohesiveness were improved compared to the control sample. For the samples whose substitution was 10-30% of the amount of sugar and lipycositis fat. the gumminess and chewability kept their values around the control sample. Therefore. the textural characteristics were improved for the sample obtained by substituting 30% of the amount of sugar and fat.

Both the total volume of CO_2 production and the maximum development reached by the dough, increased with the increase of the amount of sugar substituted. The maximum value for the total volume of CO_2 were recorded for the sample with a substitution of 30% of the amount of sugar and fat.

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