Luis Henrique Almeida Castro
(Organizador)

# ALIMENTAÇÃO, NUTRIÇÃO E CULTURA 2

Atena Editora
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# APRESENTAÇÃO

Segundo Almeida-Bittencourt no artigo “Estratégias de atuação do nutricionista em consultoria alimentar e nutricional da família” publicado em dezembro de 2009 no periódico Revista de Nutrição – citando a obra de Vasconcelos em “O nutricionista no Brasil: análise histórica” – a profissão do nutricionista no Brasil pode ser dividida em quatro fases: a de emergência da profissão que tem início com o primeiro curso de graduação desta área em nosso país; a fase de consolidação que foi caracterizada pelos avanços no campo da regulamentação deste ofício; a terceira que contempla a evolução da profissão no tocante a criação dos Conselhos Federal e Regionais; e, a quarta fase denominada de “reprodução ampliada” que, se por um lado, gerou uma demanda pela aquisição de novos conhecimentos e de novas ferramentas tecnológicas, por outro aumentou a expectativa da população em relação à nutrição.

Esta dinâmica, por sua vez, impulsionou a ampliação dos campos de atuação do profissional nutricionista no Brasil. Neste sentido, a obra “Alimentação, nutrição e cultura 2” da Atena Editora reflete esta expansão da categoria trazendo ao leitor 15 artigos técnicos e científicos que abordam as mais diversas áreas de atividade desta profissão.

A organização deste e-book, em volume único, levou em conta uma divisão entre estas áreas começando por uma análise acerca da atuação nutricional nas redes sociais; seguido de textos que abordam novas tecnologias na produção, conservação e distribuição de alimentos em território nacional; na sequência, a obra contempla produções textuais que discutem a saúde nutricional em nível individual e/ou coletivo; e, por fim, a obra finaliza convidando o leitor a refletir sobre a esfera social da nutrição estabelecendo o debate entre a agricultura familiar e a segurança nutricional.

Agradecemos aos autores por suas contribuições científicas nesta temática e desejamos a todos uma boa leitura!

Luis Henrique Almeida Castro

## SUMÁRIO

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# CAPÍTULO 7

# RHEOLOGY OF BAKERY PRODUCTS - FLOURS, DOUGHS AND BAKED GOODS, INCLUDING TEXTURE: A SHORT REVIEW

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**Suzana Caetano da Silva Lannes**

**ABSTRACT:** As consumers become more aware of what they eat. The demand for premium products with recognizable ingredients is in evidence. Functional ingredients have an important role. Clean label bakery products are gaining prominence with bread leading the way and setting the course for today's bakery ingredient trends. Nevertheless, traditional baking ingredients, such as flour, have their highlight. Rheology is the study of the deformation behavior that matter has when subjected to stress. The study of rheology is of great importance in the food field, since the knowledge of these rheological properties helps in industrial processes, such as equipment design, quality control and the determination of shelf-life of the product. Texture is the sensory and functional manifestation of the structural, mechanical and surface properties of food detected through the senses of sight, hearing, touch and kinesthesia. Along with color, taste and smell, texture makes up the attributes necessary for the sensory quality of food. The aim was to carry out a short review of the literature on rheology of baked goods: flours, pasta and baked goods, including the texture property, and some studies.

**KEYWORDS**: Structure, physical properties, bakery goods.

## 1 I FLOUR RHEOLOGY

### 1.1 Alveograph Parameters

Tenacity or Maximum resistance to extension (P): To obtain this parameter it is necessary to obtain the average of the maximum heights of the ordinates of the graph generated in the analysis and multiply by 1.1. Therefore, the unit of this parameter is mm (millimeter). This parameter is related to the resistance of the dough in relation to its deformation, since the dough tends to return to its initial shape, that is, it is the pressure necessary to change the shape of the dough, it is also a measure of the absorption capacity of water (PROPAN, 2019 and CAUVAIN, YOUNG, 2009).

Extensibility (L): To obtain this parameter, it is necessary to obtain the average of the abscissa of the graph generated in the analysis. Therefore, the unit of this parameter is mm (millimeter). This parameter is related to the dough's ability to extend without breaking its wall. It is also related to the volume of bread, along with protein. The value of this parameter depends on the product in which the flour will be used: for bread, the value of L should not be too high, but in the case of cookies, a higher value of L is acceptable, however, a high degree of extensibility said low flour yield (PROPAN, 2019 and CAUVAIN, YOUNG, 2009).

Gluten Strength or Dough Strength (W):

Since gluten is a protein that acts as a “glue”, giving shape, flexibility and texture to food, the strength of gluten is given by the energy required for the deformation of the dough, from its expansion to breaking the wall. It is a property that is related to the carbon dioxide retention capacity of the dough and the performance of cooking a flour. However, the values themselves are more relevant to define the application of flour than if it is a good or bad product (CARCEA et al., 2020; PROPAN, 2019; CAUVAIN, YOUNG, 2009).

### *1.1.1 Ingredient Addition Studies*

The study of the influence of sodium chloride (NaCl) on bread doughs in the Italian industry, an alveograph was used to measure parameters W, P and L. It was observed that the addition of salt increases W, P and L, showing that salt strengthens the gluten network and improves the viscoelastic characteristics of the dough. (CARCEA et al, 2020).

The effect of adding water-soluble polysaccharides from date seeds (DSP) and hemicellulose (DSH) was studied as a fiber source in wheat flour breads. To study the properties P, L and W an alveograph was used, which showed that the addition of DSH improved the alveograph profile, that is, it increased the value of W and the P / L ratio reached the value of 1.28, so more efficient than that of the DSP (BOUAZIZ et al, 2020).

The addition of Apulian black chickpea flour and durum wheat breads: focaccia and pizza crust was evaluated. Tests to determine alveograph properties using an alveograph and showed that the strength of gluten (W) is inversely proportional to the addition of chickpea flour and the values of the P / L ratio remained constant with the addition of chickpea flour (PASQUALONE, ANGELIS et al, 2019).

### *1.1.2 Studies to understand influences*

To study the effects of the addition during kneading of an alternative refrigerant, namely $CO_2$ snow on dough rheological properties in breads produced with two types of flour: “Bologna”, a modern cultivar, or “Verna”, an ancient cultivar, the alveograph tests was used. The results showed that there were no significant differences in alveographic parameters when comparing breads produced with Bologna flour with different percentages of addition of $CO_2$ snow and the same applies to breads produced with Verna flour. (CAPPELLI, et al, 2020)

To understand the influence of environment and genotype in the quality in wheat were used three treatments, among them: “High/High”, one non-limiting nitrogen treatment and “Low/Low”, one nitrogen treatment that was limiting for the crop over the entire cropping season. As a conclusion, it was observed that, for the measured parameters, W, P and L, the High/High samples compared to the Low/Low ones presented higher values of W and L. (VAZQUEZ et al, 2019)

To investigate the effects of heat and moisture treatments on the rheological

properties of bread wheats, an alveograph was used to determine the parameter W. It was noted that the samples treated at 55, 65 and 75 °C generally had similar or better W values as compared to that of the untreated sample. Generally, W values significantly decreased at the treatment temperatures of 85 and 95 °C (CETINER, et al, 2017)

## 1.2 Farinograph Parameters

Water absorption (WA): It is the amount of water that is needed for the center of the curve in the farinogram to reach 500 Farinographic Units, this value is given in percentage (YAMANI, 2015)

Dough Development Time (DDT): It is the time necessary for the curve in the farinogram to reach its maximum value, that is, the time for the dough to reach its maximum viscosity, this value is given in minutes (min), if two points appear, the second must be considered. This value is related to the protein quality of the flour and the ideal time needed to develop the gluten network (CARCEA et al., 2020; NOGUEIRA et al, 2020; YAMANI, 2015)

Stability (S): It is the time interval between when the curve reaches 500 farinographic units and when it starts to decline, it is the period of time that the curve remains a straight line worth 500 farinographic units, so this value is given in minutes (min). This property is linked to the time that the flour maintains consistency during mixing and the tolerance of the flour to the mixing process (YAMANI, 2015; SAHI, 2012; BRANDÃO, LIRA, 2011).

Mixing Tolerance Index (MTI): It is the vertical difference between the peak value up to 5 minutes after the peak, a value given in farinographic units. The flour tolerance to the mixture is inversely proportional: the higher the ITM, the lower the tolerance (YAMANI, 2015)

### *1.2.1 Ingredient Addition Studies*

A study was made of the effect of adding CMC (Carboxymethylcellulose) and Alhydwan flour, which has the function of inhibiting moisture during storage, in the rheology of the dough. To study the farinographic properties a farinogram was used, with the results it can be seen that the addition of CMC and Alhydwan flour provided an increase in water absorption (AMMAR et al, 2020).

It was studied, with a farinogram, how the addition of table salt to bread doughs influences the water absorption properties, development time, stability. It was observed that the addition of salt decreased the absorption of water, but increased the time of development and stability, so the presence of salt requires a longer time to form a strong gluten network, but when formed, it is fully developed (CARCEA et al, 2020).

The possibility of protein enrichment of bakery products was studied, for this purpose wheat flour, hydrolyzed whey protein and hydrolyzed collagen protein were used. For the study of farinographic properties, a Brabender farinograph was used. As a

result, the replacement of wheat flour with hydrolyzed whey protein (HW) and hydrolyzed collagen protein (HC) reduced water absorption, with the greatest effect being HC and both hydrolysates caused an increase in the time of dough development and a weakening of the dough (NOGUEIRA et al, 2020)

Farinograph was used to evaluate the influence of the addition of chickpea flour in the dough of durum breads, with this analysis it can be concluded that the water absorption and time of dough development increased, while the dough stability decreased with the addition of chickpea flour (PASQUALONE, ANGELIS et al, 2019).

### *1.2.2 Ingredient Substitution Studies*

The effect of replacing sodium chloride with sea salt (SS), dry yeast (SD) and fermented sugar (FS) on the farinographic properties was studied, for this purpose a farinograph was used to determine the water absorption (AA), dough development time (TDM), stability (E). As a result, it was noticed that the substitution by SS and FS resulted in a negative effect on AA and the degree of softening, whereas substitution by SD resulted in a positive effect on both. For stability, the effect was the opposite: the substitution by SS and FS resulted in a positive effect, while for the substitution by SD it had a negative effect: SS and FS strengthened the wheat flour dough (VOINEA et al, 2020).

### *1.2.3 Studies to understand influences*

The study of the impact of heat treatments on the rheological properties of pasta and semolina bread used a farinograph. With the results it can be concluded that the water absorption values increased with the duration of the heat treatment and the time of development of the dough, as well as the stability, increased with the temperature and the duration of the heat treatment (RAIOLA et al, 2020)

In the same study that evaluated the effects of the addition during kneading of an alternative refrigerant, namely $CO_2$ snow on dough rheological properties, a farinograph was used to determine the amount of water to be added to the Bologna and Verna flours. With the aid of a farinograph, it was observed that the water absorption was higher to Bologna flour than Verna, in addition, Bologna flour showed a longer time of dough development and stability. (CAPPELLI et al, 2020)

## 1.3 Extensograph Parameters

Resistance to extension or elasticity (R): This value is obtained at the highest point of the generated curve of the 50 mm extensogram and is given in extensographic units. This parameter is related to the dough's capacity to retain carbon dioxide that is generated during fermentation (YAMANI, 2015, ICTA).

Extensibility (E): This value is a measure of the length of the extensogram from the

beginning to the end of the curve and is given in mm (millimeters). This value is related to how many times the dough was extended until it broke (YAMANI, 2015, ICTA).

Maximum resistance (Rm): This value is obtained at the highest point of the curve and is also given in extensographic units (YAMANI, 2015).

Proportional number (D): This value is the ratio between elasticity (R) and extensibility (E) and represents the behavior of the dough: the higher this ratio, the more elastic the dough is, therefore, it tends to return to its original state ("Shrink") and the smaller, the more extensible the dough is, therefore, it tends to flow, that is, it stretches and does not break (YAMANI, 2015)

#### *1.3.1 Ingredient Addition Studies*

In the same study where CMC (Carboxymethylcellulose) and Alhydwan flour were added, an extensographer was used, with which it was noticed that the extensibility of the dough was not influenced, but the resistance to extension and the proportional number decreased, ie, the dough is more extensible but less elastic. (AMMAR et al, 2020).

#### *1.3.2 Ingredient Substitution Studies*

In the same study where the effect of replacing sodium chloride with sea salt (SS), dry yeast (SD) and fermented sugar (FS) was studied, an extensometer was used to measure the resistance to extension, maximum resistance to tension, extensibility, energy - which is the area on the curve generated in the extensogram. As a result, a positive effect was observed in the substitution by SS and FS on these properties, indicating a strengthening of the dough, already a negative effect with the substitution by the SD, indicating a weakening of the dough (VOINEA et al, 2020).

#### *1.3.3 Studies to understand influences*

To evaluate the rheological properties of dough produced with or without sodium chloride from two types of vital gluten, extensographic measurements were used, which showed that the dough prepared with salt solution had greater resistance, maximum resistance and area under curve than when prepared with water (ORTOLAN et al, 2017)

### 1.4 Amylograph properties

#### *1.4.1 Starch gelatinization*

The gelatinization of starch in water is a process of breaking the bonds between amylose and amylopectin with heating, thus, it can be said that the gelatinized is the hydrated starch. (TAKO et al, 2014; CAMARGO, CAMARGO, 1987).

### *1.4.2 Starch retrogradation*

Starch retrogradation is a process that occurs after the dissolution of starch molecules (which occurred after heating), the solution becomes highly viscous, and when cooled for a long time, turns into a gel and rearranges itself back into a crystalline structure, that is, an ordered structure, but different from that which was originally in the granules (WANG et al, 2015; TAKO et al, 2014).

### *1.4.3 Ingredient Addition Studies*

To produce gluten-free breads, breads were produced with a ternary mixture of fermented cassava, sweet potato and sorghum flours and using xanthan gum as a gluten substitute. In the paste properties it was noted that the fermented cassava flour has higher paste values than the other two flours, that is, higher viscosity values, characteristic of the fact of having high starch content and low amylose content, while sweet potato flour decreases the paste parameters (MONTHE et al, 2019).

The effects of the addition of *Phaseolus mungo* L. on the amylographic characteristics of bread doughs were studied. It was noticed that this addition provided an increase in pasting temperature and a decrease in peak viscosity (INDRANI et al, 2015). The paste temperature is the temperature at which the viscosity begins to increase during the heating process, the higher this temperature, the greater the granule's resistance to swelling and rupture (KUMAR, KHATKAR, 2017). In KUMAR, KHATKAR, 2017, the pulp properties of the wheat granule varieties (WH-147 and C-306) were studied, it was noticed that the starch of the WH-147 strain has a higher paste temperature than that of the variety C-306.

### *1.4.4 Ingredient Substitution Studies*

The influence on rheological properties during kneading in the dough was studied with the replacement of sodium chloride by sea salt (SS), dry yeast (SD) and fermented sugar (FS). These properties were measured with an amylograph, properties such as gelatinization temperature (Tg), temperature at the peak of viscosity (Tmax) and peak of viscosity (Vmax). In this study, it was noticed that the Vmax decreased with the interaction between SS, SD and FS, since these contribute to a decrease in pH that affects amylase activity. A positive effect of Tmax for SS and SD was also observed, since Tmax depends on the amount of water in the dough: sea salt decreases water activity and SD weakens protein and the availability of water in the dough (VOINEA et al, 2020).

There was a study to evaluate the substitution of wheat flour for corn flour - in order to obtain gluten-free breads - in the rheology of the pasta. It was noticed that the corn flour reduces the viscosity of the mixtures at the time of starch gelatinization and has a very high viscosity, when compared to pure flour, at the time of starch retrogradation (MARTINS et al, 2020).

## 1.5 Rheological Properties during Fermentation

In the analysis of rheological properties during fermentation, a reofermentometer is used. This equipment makes it possible to assess the flour's fermentation capacity, yeast activity and indirectly indicates the quality of the gluten complex proteins. In real time, approximately 3 hours, two curves are generated simultaneously: one that describes the development of the dough and another that describes the volume of $CO_2$ retained in the dough, the volume and time of $CO_2$ release, also allows to obtain the parameter Tx that represents the time of appearance of the porosity of the dough (HADNADEV et al, 2011).

### *1.5.1 Ingredient Addition Studies*

It was studied the effect of reduced glutathione on the rheological properties of bread doughs. For the study of rheology during fermentation, a reofermentometer was used, which measured properties such as: maximum dough height (Hm), time to reach maximum height (T1), loss of dough volume at the end of 3 h, formation time maximum gas (T′1), time of initiation of the dough gas escape (Tx), and the percentage of the retention volume in relation to the total volume. It was noticed that the reduced glutathione decreased Hm and the gas retention capacity during fermentation; as the viscoelastic network, formed by the protein of gluten and starch, is largely responsible for the retention of $CO_2$, it is clear that glutathione causes instability in the development of dough (GUO et al, 2020)

The influence of the fermentation time and the addition of potato pulp on the properties of wheat breads was studied. To study the properties during fermentation, a reofermentometer was used to measure: the maximum height of the dough during 3 h of fermentation (Hm); total production of $CO_2$ volume for 3 hours (VT) and retention coefficient (CR). This analysis allowed us to conclude that the gas holding capacity of the pasta decreases with the increase in the amount of potato pulp (CAO et al, 2020).

### *1.5.2 Ingredient Substitution Studies*

In the study of the influence of replacing sodium chloride with sea salt (SS), dry yeast (SD) and fermented sugar (FS) on the rheological properties during fermentation, a reofermentometer was used to measure properties such as height maximum gas production (H'm), total $CO_2$ volume production (VT), gas volume retained in the dough at the end of the test (VR) and retention coefficient (CR) (which is the ratio between VR and VT) . There was a positive effect on the values of H'm, VT and VR with the addition of SS and SD, a phenomenon that can be explained by the possible increase in the yeast fermentation speed with this addition, and a negative effect on these same values with the addition of FS, which can be explained by a reduction in enzymatic activity caused by the decrease in the pH value caused by the organic acids present in the FS (VOINEA et al, 2020)

### *1.5.3 Studies to understand influences*

The effect of reducing the sodium chloride (NaCl) content on the quality of durum wheat breads was studied. The reofermentometer was used to measure: maximum dough height (Hm); time needed to reach the maximum dough height (T1); dough height after 3; volume of gas produced (VT), lost (VL), and retained (VR), at the end of the test (3 h) and gas retention coefficient (VR / VT). As a result, he obtained that the lowest development of the dough was observed in the highest level of salt, since the salt inhibits the activity of the yeasts, thus there is a lower value of VT, and the less salt, the greater the development of the dough; however, with the inhibition of fermentation, salt helps in the strengthening of gluten, which helps to retain the gas produced with a low VL (PASQUALONE, CAPONIO et al, 2019).

## 2 | DOUGH RHEOLOGY

These measurements are performed by a rheometer, in which a voltage is applied and the response is measured. The viscoelastic characteristic is characterized by G 'and G". The elastic modulus (G ') is a measure of the energy stored in the sample at the moment of shear, which energy is restored when the external force ceases, for this reason G' is also called a storage module. The viscous modulus (G") is a measure of the energy that is dissipated during the shear process, which is lost to the sample, so G" can also be called a loss modulus (ZHANG et al, 2018).

### 2.1 Ingredient Addition Studies

The influence of the use of taro flour on the rheological properties of bread was studied. For this, a controlled tension rheometer was used, which allowed us to conclude that the addition of taro flour increased the values of G 'and G", with a greater increase in G', thus strengthening the structure of the dough (ARICI et al, 2020).

To produce gluten-free breads, breads were produced with a ternary mixture of fermented cassava, sweet potato and sorghum flours and using xanthan gum as a gluten substitute. The rheological behavior of the fermented doughs was evaluated by a Rheometer, in the measurement of the storage (G ') and loss (G") modules, a constant frequency of 1 Hz was used and the voltage amplitude varied between 0.001 and 1000%. With the data obtained it was possible to construct a quadratic model equation, with an appropriate adjustment of an $R^2$ of 0.9, to describe the characteristics of the dough. As a conclusion he obtained that the critical proportion of sorghum is 5%, since if this proportion is increased, the proportion of cassava decreases and the dough is more solid and when below the proportion of 5%, the proportion of cassava is increased and the dough is more fluid (MONTHE et al, 2019).

## 2.2 Ingredient Substitution Studies

There was a study to evaluate the substitution of wheat flour for corn flour - in order to obtain gluten-free breads - in the rheology of the pasta. For the study of rheological properties, a Rheometer with controlled tension was used, with the results it was concluded that breads with the addition of corn flour obtained higher values of the storage module (G ') than the loss module (G"), this increase in the elastic modulus shows that the structure was strengthened (MARTINS et al, 2020).

## 2.3 Studies to understand influences

There was a study to verify the effects of defrosting methods on the properties of the pasta: defrosting in the refrigerator, at room temperature, proofer and in the microwave. To measure the rheological characteristics, a Rheometer with a frequency of 0.1 to 10 Hz was used, with the data it was noticed that the highest values of G 'and G" were for the samples thawed in the microwave while those that were by the proofer showed lower values (YANG et al, 2020).

## 2.4 Studies with Back Extrusion

Extrusion is a process in which a force is applied under a material until it flows through an outlet under pressure. In the back extrusion the sample is confined to an open upper cylinder and a piston (smaller in diameter than the cylinder) is forced downwards, so the sample flows into the space between the piston and the cylinder, a space called an annulus (AQUINO, 2012).

The influence of the addition of dietary fiber on the rheological properties of French bread dough was studied. A texturometer with probe back extrusion was used for extrusion analysis. It was noticed that the addition influenced the characteristics of the dough leaving it less viscous, less firm and less cohesive (PESSANHA, 2016).

The effect of partially replacing wheat flour with amaranth, quinoa and maca flour was studied in the preparation of panettone. For texture evaluation, a texturometer was used, both for the analysis of back extrusion and uniaxial extensibility. It was noticed that the addition of maca flour provided an increase in firmness, consistency, cohesiveness and viscosity index, in addition to an increase in strength, while the addition of amaranth and quinoa flour provided a decrease in strength and extensibility (YAMANI, 2015).

Texture analyzes (extensibility and back extrusion) were made of different bread dough structures obtained by 9 different formulations. Both for the back-extrusion test and for the extensibility test, the samples were taken to a texturometer, but with different parameters. It is noted that the texture analysis using these techniques is effective, since the results obtained are consistent with the researched literature, among these results we have that: the triticale flour decreased the extensibility parameter due to the smaller amount

of gluten; the addition of yogurt increased parameters of firmness and consistency, and formulations with a sponge method (an indirect method, in which a fermented dough is prepared with part of the ingredients, allowed to ferment for an hour and then mixed with the rest of the ingredients). lower values of firmness in the back-extrusion test and decreased tension in the extensibility test, which indicates a more extensible dough (AQUINO, 2012).

## 3 | BAKED GOODS RHEOLOGY

Adhesiveness: the work required to separate food from contact with a surface and serves to indicate the sticky character of the crumb (MONTHE et al, 2019; YOUNG, 2012).

Chewability: related to the time to chew ready foods (YOUNG, 2012).

Cohesiveness: the strength of the internal connections of bread crumbs, that is, the strength with which the particles are joined, it is the limit for deformation without breaking (MONTHE et al, 2019; HLEAP, VELASCO, 2010).

Firmness or softness: used to describe the loss of softness in bread crumbs, this parameter is linked, for consumers, to the freshness of bread (MONTHE et al, 2019; YOUNG, 2012);

Fracturability: the necessary force to break the product (YOUNG, 2012).

Gumminess: the energy needed to disintegrate food ready to swallow (YOUNG, 2012);

Hardness: is sought after in products with low moisture content, and serves to describe the bread crust, and the strength required to chew the food; the value of this parameter should be as small as possible, in order to check malleability (MONTHE et al, 2019; YOUNG, 2012; HLEAP, VELASCO, 2010)

Springiness or resilience: serve to describe the crumb's ability to return to its original state after the cessation of a compressive force (YOUNG, 2012).

To measure these properties there are different test types: penetration, compression, cutting, extrusion, fracture etc.

### 3.1 Ingredient Addition Studies

In the study of the addition of water-soluble polysaccharides from date seeds (DSP) and hemicellulose (DSH) and as it affects the texture of wheat flour breads, a texturometer was used and showed that the addition of DSH decreased the hardness of the bread when compared with the bread without any addition (BOUAZIZ et al, 2020).

To perform the analysis of the texture profile, a texturometer was used, with the data obtained model equations were built for the hardness, elasticity, adhesiveness and cohesiveness of the bread crumbs. It was concluded that the best proportion, in order to have convenient textural properties, is 70% fermented cassava and a maximum of 20% sweet potato and 5% sorghum (MONTHE et al, 2019).

A texturometer was used to assess the influence of chickpea flour on durum bread doughs. It was noticed that the addition of this flour increased the bread's hardness and chewability, the elasticity remained indifferent to the addition and the cohesiveness was lower when compared with bread without addition (PASQUALONE et al, 2019).

### 3.2 Ingredient Substitution Studies

For the analysis of the texture profile, a texturometer was used, the results of which concluded that the addition of corn flour to breads improves the firmness and cohesiveness of the dough and bread (MARTINS et al, 2020).

### 3.3 Studies to understand influences

To analyze the thawed samples a texturometer was used and a texture profile was made, from which it can be seen that the samples thawed in the microwave showed higher values of hardness and chewability, while those of the proofer generated samples with softer texture and lower values in chewability (YANG et al, 2020).

## 4 I FINAL CONSIDERATION

The study of the rheology of baked goods is of great importance, both to improve the manufacturing process and the quality and nutritional value of products for consumers and materials; as well as texture, flavor and appearance, and increase shelf life. There are several studies on the subject that show the interest of researchers in improving bakery products, both in terms of production and quality.

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