ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 06,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

THE INFLUENCE OF FLOUR GLUTEN ON THE STRUCTURE AND LAMINATION OF CROISSANTS

Gulboeva Zakhro Azamat kizi,

Masharipova Zulkhumar Atabekovna, Jabborov Alisher Oltiboyevich

PhD student, e-mail: zahrogulboeva1995@gmail.com

Tashkent Chemical-Technological Institute

Abstract: This article provides a comprehensive analysis of the quality indicators of flour used in croissant production, the research methodology employed, and the laboratory test results of two different flour samples. Among the samples analyzed, one was found to be suitable for croissant preparation, while the other negatively affected the dough structure, leading to issues such as loss of shape, poor lamination, and reduced baking quality.

The study focuses on key quality parameters of flour—including moisture content, gluten percentage, gluten quality (measured by the IDK index), and enzymatic activity—and examines how these factors influence the elasticity, stability, and lamination properties of the dough. The analysis also includes visual comparisons of the baked croissants made from both samples, highlighting structural differences such as porosity, crumb texture, and layer definition.

The results demonstrate that optimal flour characteristics are crucial for achieving light, airy, and well-laminated croissants. The article concludes that not only the quantity of gluten but also its quality plays a vital role in forming a dough that can withstand the stress of lamination and proofing while maintaining structural integrity during baking..

Keywords: Flour, gluten, whiteness, falling number, ash content, moisture, proofing, croissants

Introduction

The secret to perfect croissants: Choosing the right flour. Making croissants is a true art, where every detail matters. From butter temperature to the technique of rolling the dough — all these nuances affect the taste and texture of the final product. But perhaps one of the most important factors is the choice of flour. Below, we will explore why flour characteristics are so important and how laboratory test results can help determine which flour is suitable for laminated dough and which is not [8,3].

Croissants are a laminated yeast dough, where repeated layering of dough and butter gives a tender, airy structure. To ensure the layers “work” well and don’t stick together, the flour must possess certain properties [4].

The following flour quality indicators are essential in the production of flour-based products:

1. **Flour gluten:** A complex of protein substances in flour that can form a cohesive elastic mass when swollen in water.

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1.1 Gluten quantity (raw gluten content): The ratio of the mass of washed raw gluten to the flour sample mass, expressed as a percentage.
1.2 Gluten quality: A characteristic defined by the combination of rheological properties (stretchability, elasticity, and springiness), determining the degree of compression deformation of gluten formed into a 4g ball, expressed in arbitrary units of devices like IDK — IDK units — and classified by groups.

Gluten quality (strength and stretchability indicator). Laboratory analysis often evaluates not only the total amount of gluten but also its "strength" or "stretchability." For example, in CIS countries, the IDK (Gluten Deformation Index) is widely used:

- ☑ Too low an IDK indicates very "tough" gluten, which is hard to roll out.
- ☑ Too high indicates excessively "loose" and weak gluten, which doesn't give the dough elasticity and volume.
- ☑ The optimal range for laminated products is a medium IDK level, where the dough remains elastic but doesn't tear or spread out [2,9].

Sufficient protein (gluten) content.

Gluten forms an elastic, springy structure, allowing the dough to retain air and water during fermentation and baking. Too low a gluten content results in dough that doesn't rise well and loses shape. Too high a content may lead to a firmer texture and difficulty in rolling [5].

Croissants are made from relatively "clean" fine-milled wheat flour without bran particles. This ensures a smooth texture and bright, appetizing layers in the final product.

Croissants are one of the most technically challenging baked goods, requiring not only proper preparation technique but also the right flour. The main requirements for croissant flour include:

- ⇨ Medium gluten content — 28–30% (for dough elasticity);
- ⇨ Optimal gluten quality as measured by IDK — 60–70% (to maintain lamination during proofing);
- ⇨ High falling number (at least 350) for good dough rise;
  Low ash content (0.3–0.4%) for a clean taste and bright color.
- ⇨ As part of the study, laboratory tests were conducted on two flour samples with differing quality characteristics, and their impact on croissant structure was analyzed.

2. Research Methodology

Determination of Gluten Content [9]

Dough Mixing

Water dosing and dough mixing are carried out using a dough mixer with a built-in doser. The doser measures the required amount of water into the dough mixer's bowl according to Table 1, then the flour sample is added, and mixing continues until the dough mixer completely stops.

Table 1 – Amount of Water for Dough Mixing from Wheat Flour

Mass of Analyzed Flour Sample, g	Volume of Water, cm^3
25	14

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30	17
35	20

After mixing, the dough formed into a cylinder is removed from the bowl; any remaining dough on the pins and in the bowl is cleaned off and added to the total mass. If a well-formed dough is not achieved in the first mix, a second mix is conducted without removing the dough from the bowl. Dough mixing is permitted no more than twice. When working with flour that forms a crumbly dough, mixing is carried out until a dough forms—three times or more if necessary.

Gluten Washing by Mechanized Method

1. **Dough Preparation.** Immediately after mixing, the dough is rolled out using a special water-moistened tool (rolling pin) into a sheet 1.5 to 2.0 mm thick and placed in a container with water (at least 1 dm^3) for 10 minutes.
   If the dough forms an incoherent, crumbly mass during mixing, it is placed into a closed container (without water) for 10 minutes, then rolled out into a sheet and immersed in water for 2.0 to 2.5 minutes.
2. **Washing.** After the resting period, the dough sheet is removed from the water, squeezed, and divided into five or six arbitrary pieces, which are placed in the central part of the lower tray of the working chamber of the MOK device.
   The inner surface of the working chamber is pre-moistened with water. The working chamber is closed, and gluten washing is performed depending on the type of flour. For baking and general-purpose flour, the regime parameters are given in Table 1.

If, during washing, a large amount of gluten particles are observed on the trap sieve of the device, and upon opening the chamber at the end of the wash the gluten is not cohesive (i.e., not formed into strands), the analysis is repeated using the regime for crumbly dough, presented in Table 3 or 4 (depending on the type of flour).

The allowable error in the duration of any operation (stage) must not exceed ±15 seconds. If the analyzed flour sample weighs more than 35.0 g, the duration of stage I of the washing process is increased by 1 minute.

Removal of Excess Moisture. The washed gluten is pressed once between dry palms to remove surface water, as unbound water is only present on the surface after mechanized washing.

Table 2 – Regimes for Washing Gluten from Baking Wheat Flour*.

Stage	Stage-wise Parameters for Washing Gluten	Flour Grade or Type		
		Extra, Semolina, Highest, First, M55-23, MK55-23, MK75-23, M75-23	second, M100-25, M125-20	wholemeal flour, M145-23
I	Gap, mm	7,0	7,0	
	time, min	3	3	

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	Drain valve position	1	1	
	Water flow rate, dm³/min	0,30	0,30	0,35
II	Gap, mm	1,5	1,5	
	time, min	7	2	
	Drain valve position	1	1	
	Water flow rate, dm³/min	0,30	0,50	
III	Gap, mm	7,0	1,5	
	time, min	2	4	1
	Drain valve position	1	1	
	Water flow rate, dm³/min	0,30	0,30	0,35
IV	Gap, mm	-	1,5	
	time, min	-	2	
	Drain valve position	-	2	
	Water flow rate, dm³/min	-	0,30	0,35
V	Gap, mm	-	7,0	
	time, min	-	2	
	Drain valve position	-	1	
	Water flow rate, dm³/min	-	0,30	0,35

* Flour characteristics – according to the regulatory documents of the country that adopted the standard.

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Pieces of gluten, washed free from bran particles, are extracted from the working chamber and pressed once between dry palms to remove excess moisture.

Determination of Pressed Gluten Mass

The total amount of raw gluten is calculated as the sum of the mass of the main washed gluten and the additional gluten — washed from bran particles. The pressed raw gluten is weighed with an accuracy of 0.01 g.

Number of Determinations

Two determinations are carried out under repeatability conditions, i.e., using the same method on identical test objects, in the same laboratory, by the same operator, using the same equipment, within a short time period.

Determination of Raw Gluten Quality Using the IDK Device [2]

To determine the quality, a 4.0 g test sample is taken from the fully washed, pressed, and weighed gluten. If a large amount of raw gluten is obtained, it is permissible to take two 4.0 g samples for analysis.

The selected mass of raw gluten is shaped into a ball using a gluten forming device. For this, the gluten is placed on the rolling table, pressed with the forming bar (the surface opposite the limiting ring), and flattened into a sheet no thicker than 3 mm.

If the gluten is weak, to prevent it from spreading out, flattening is done using a forming bar with a limiting ring. After flattening the gluten, the bar is placed so that the center of the die aligns with the center of the gluten sheet. With a light press, the gluten is pushed into the die, and with trimming movements, it is formed into a ball. The remaining gluten inside the die is pushed out using the ejection pin. To do this, the bar with gluten is placed over the pin die, and while continuing to press the bar with the left hand against the pin, the right hand takes the clamp, opens it, and clasps it around the base of the gluten ball on the outer conical surface. The closed clamp with the gluten ball is then placed into water.

The formed gluten ball must be spherical, smooth, free from tears, cracks, and air bubbles, and with a uniformly clamped base using the clamp. Otherwise, the formation must be repeated, but no more than three times. The time for forming one gluten ball should be from 20 to 25 seconds.

For manual gluten washing, forming the raw gluten ball by hand is allowed. For this, the gluten is kneaded three to four times with fingers to form a ball with a smooth surface — free of tears, cracks, and air bubbles — and a well-shaped base.

The gluten ball is placed to rest in a container filled with water with a volume of 0.25 dm^3. If maintaining the water temperature between 18 °C and 20 °C is not possible, the 0.25 dm^3 container is placed inside another container with a volume of 4.0 dm^3 filled with water to maintain the temperature between 18 °C and 20 °C. The resting period before determining the quality is 15 minutes for the manual washing method and 10 minutes for the mechanized method.

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After resting, the gluten ball is removed from the container, the clamp is removed, and the base is placed precisely in the center of the table of the IDK-type device for measurement.

The results of the measurement of the elastic-plastic properties of the gluten are expressed in arbitrary units of the IDK device — IDK units. Readings from the indicator panel of the device are taken with an accuracy of 0.1 IDK units.

Based on the measurement results, the gluten is assigned to a quality group in accordance with Table 2.

Table 3. Classification of Gluten Quality Obtained from Wheat Flour

<table>
<tr><td rowspan="4">Quality group</td><td rowspan="4">Gluten characteristic</td><td colspan="4">Gluten quality, IDK units</td></tr>
<tr><td colspan="2">Baking and general-purpose flour.</td><td colspan="2">Pasta flour</td></tr>
<tr><td rowspan="2">grades: extra, semolina, highest, first, wholemeal;</td><td rowspan="2">Grade: second</td><td>from soft wheat**</td><td>from hard wheat ***</td></tr>
<tr><td>Grades: extra, highest (semolina), first (coarse semolina)</td><td>Grades: highest (semolina), first (coarse semolina), second</td></tr>
<tr><td colspan="2">Crumbly</td><td colspan="4">Not determined</td></tr>
<tr><td>III</td><td>Unsatisfactory strong</td><td>not more than 32</td><td>not more than 37</td><td>-</td><td>-</td></tr>
<tr><td>II</td><td>Satisfactory strong</td><td>33-52</td><td>38-52</td><td>-</td><td>-</td></tr>
<tr><td>I</td><td>Medium (good)</td><td colspan="2">53-77</td><td>48-77</td><td>48-82</td></tr>
<tr><td>II</td><td>Satisfactory weak</td><td colspan="2">78-102</td><td>78-102</td><td>83-107</td></tr>
<tr><td>III</td><td>Unsatisfactory weak</td><td colspan="2">103 and more</td><td>103 and more</td><td>108 and more</td></tr>
<tr><td colspan="2">Not-washable</td><td colspan="4">Not determined</td></tr>
</table>

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* Flour characteristic- according to the regulatory documents of the country that adopted the standard.

. ** Flour characteristic – according to GOST 31491. *** Flour characteristic – according to GOST 31463.

If the gluten, after washing, represents a strongly crumbling, sponge-like, incoherent, fragmented mass that cannot be formed into a ball, it is classified as "crumbly", and its quality is not determined on the IDK-type device.

If the gluten, after washing, represents an incoherent, spreading mass that cannot be collected and formed into a ball, it is classified as "non-washable", and its quality is not determined on the IDK-type device.

Processing of test results

The amount of raw or dry gluten in the flour, X, %, is calculated for raw gluten to the first decimal place, for dry gluten – to the second decimal place, using the formula:

$$X = \frac{M_k}{M} \cdot 100$$

Where: M_k – mass of raw or dry gluten, in grams (g); M – mass of the flour sample, in grams (g); 100 – conversion factor to percent (%).

The quality of raw gluten in flour after its measurement, conducted to the first decimal place, is rounded to whole units.

If the decimal is less than 5, the whole number is not changed.

If the decimal is 5 or greater, the whole number is increased by one.

Tests were carried out in the laboratory of LLC "FOOD-TECH-PRO" according to GOST 26574-2017.

Samples were provided by two manufacturers from Kazakhstan:

1. → Sample 1 (suitable for croissants)
2. → Sample 2 (not suitable for croissants)

Test parameters and their influence on the dough

Parameter	Standard	Sample 1	Sample 2	Effect on croissants
Moisture, % (not more than)	15,0	14,3	15,0	Excess moisture in Sample 2 makes the dough sticky.

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Ash content, %	≤ 0,55	0,3	0,4	Cleaner flour (Sample 1) gives a lighter crumb.
Gluten, %	≥ 28	28,0	28,4	Both samples are within the standard, but quality is important.
Gluten quality (IDK)	60–70	62	57	Sample 1 gives stable dough, Sample 2 – weak dough.
Falling number	≥ 200	369	359	Sample 1 ensures better dough rise.

3. Analysis of Results

Gluten and Its Quality

Both samples contain a sufficient amount of gluten (~28%), but its quality (IDK) differs.

Sample 1 (IDK 62) demonstrates balanced elasticity, allowing the dough to retain its layers. Sample 2 (IDK 57) has overly soft gluten, causing the dough to spread out or show poor elasticity [8,1] (Fig. 1 and Fig. 2).

Fig. 1. Good stretchability and elasticity of dough made from Sample 1 flour

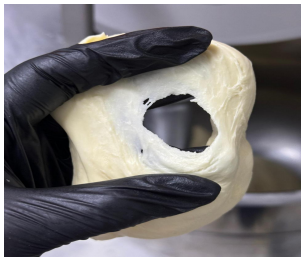

Fig. 2. Poor stretchability and elasticity of dough made from Sample 2 flour

Sample 1 shows better enzymatic activity [5], which contributes to proper dough fermentation. Sample 2 is slightly lower in this parameter, which may lead to insufficient rising (Fig. 3 and Fig. 4).

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Fig. 3. Rise and bubbles in dough made from Sample 1 flour

Fig. 4. Rise and bubbles in dough made from Sample 2 flour

4. Visual Comparison of Croissant Structure

Baking result – Sample 1:

- The dough holds its shape well during proofing;
- Croissants turn out fluffy, light, with distinct layers;
- Good porosity, uniform distribution of air cells;
- Pleasant taste and light texture.

Baking result – Sample 2:

- The dough holds its shape worse, slightly spreads during proofing;
- Croissants are less porous, denser;
- Lamination is less pronounced, the structure is less airy;
- On the cut, the cells are less uniform, the dough is heavier.

6. Conclusions

Sample 1 (IDK 62, moisture 14.3%) produces fluffy and laminated croissants thanks to balanced gluten parameters and good enzymatic activity.

Sample 2 (IDK 57, moisture 15.0%) results in less structured croissants; the dough loses its shape, and the layers stick together.

Laboratory analysis results show that flour with optimal moisture and a medium IDK value produces light, airy croissants with ideal lamination [3,8].

If the flour has overly soft or weak gluten, the dough loses its shape, holds layers poorly, and fails to deliver the delicate texture needed for croissants.

Thus, when choosing flour for croissants, it is important to consider not only the gluten content but also its quality (IDK).

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To achieve the ideal result, flour with an IDK of **60–70** should be used for stable dough.

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