applied sciences

Article

Investigation of the Effects of Wafer-Baking Plates on Thermal Distribution, Wafer Thickness, and Wafer Color Distribution

Uğur Köklü [1,2,*], Abdullah Sadık Tazegül [3], Fatih Serin [3] and Gültekin Basmacı [4]

1 Department of Mechanical Engineering, Faculty of Engineering, Karamanoğlu Mehmetbey University, 70100 Karaman, Türkiye
2 Department of Mechanical Engineering, Recep Tayyip Erdogan University, 53100 Rize, Türkiye
3 Tüfekçioğulları Machinery Food Manufacturing Industry Limited Company R&D Center, Organized Industrial Zone, 70200 Karaman, Türkiye; sadik.tazegul@bitaenergy.com (A.S.T.); serin_303@hotmail.com (F.S.)
4 Department of Mechanical Engineering, Faculty of Engineering and Architecture, Mehmet Akif Ersoy University, 15200 Burdur, Turkey; gbasmaci@mehmetakif.edu.tr
* Correspondence: ugurkoklu@kmu.edu.tr; Tel.: +90-506-234-4820

Featured Application: The thermal distribution of two baking plates with different materials (GG-25 gray cast iron and GJV-350 vermicular cast iron), their effects on the thickness of the wafer sheet, and their effects on the color distribution of the wafer sheet were investigated at different baking rates. The GJV-350 vermicular casting plate provides a more homogeneous heat distribution, more stable wafer sheet thickness, and more homogeneous color distribution of the wafer sheet at a maximum production rate.

Abstract: Wafer-baking ovens are machines that bake liquid batter by heating the interconnected cast plates in a gas oven. The plates in contact with the wafer batter are generally made of the cast material. Although there are many studies on the contents in the recipes of wafer products and the effects of the additives included in the recipes on the quality of the wafer sheet, there are few studies on the effects of the material type of the wafer-baking plate on the baking process. In this study, the thermal distribution of two baking plates made of different materials (GG-25 gray cast iron and GJV-350 vermicular cast iron), their effects on the thickness of the wafer sheet, and their effects on the color distribution of the wafer sheet were investigated at different baking rates. The experiments were conducted in an industrial wafer-baking oven at two different production rates. As a result, it was observed that the GJV-350 vermicular casting plate provides a more homogeneous heat distribution, more stable wafer sheet thickness, and more homogeneous color distribution of the wafer sheet at a maximum production rate.

Keywords: wafer-baking oven; wafer production; wafer-baking plate; cast irons; wafer sheets

Academic Editor: Alexandre Carvalho

Received: 8 October 2024
Revised: 2 January 2025
Accepted: 3 January 2025
Published: 6 January 2025

Citation: Köklü, U.; Tazegül, A.S.; Serin, F.; Basmacı, G. Investigation of the Effects of Wafer-Baking Plates on Thermal Distribution, Wafer Thickness, and Wafer Color Distribution. *Appl. Sci.* **2025**, *15*, 466. https://doi.org/10.3390/app15010466

1. Introduction

The wafer is defined as a snack product made of thin sheets of flour stacked on top of each other and containing sweet fillings such as chocolate/cream/honey and jam between them [1]. Wafer sheets are produced by baking liquid batter between heated metal plates until it becomes thin and crispy. The cooked wafer sheets are folded by applying sweet filling materials such as hot liquid chocolate/cream, etc., on them and then are turned into blocks in different machines. In order for the hot wafer blocks to be cut smoothly, the liquid chocolate/cream between the blocks is transferred to the solid phase in the block-cooling machine. The wafer block is cut, and thereafter, it can be coated with chocolate or not according to customer demand. The wafer block cut can have some defects, such as color differences, cracks, etc., which are hidden after the process of chocolate coating. It is also known that consumers prefer light-colored wafers more in uncoated wafers [2]. The baking plates in the wafer ovens are connected to each other with cast parts holding them, moving on rails via a motor drive, and heated with the help of furnaces during this movement. Figure 1 shows a visual of wafer-baking plates chained to each other. Baking plates are heated using natural gas or LPG fuel on the stoves.

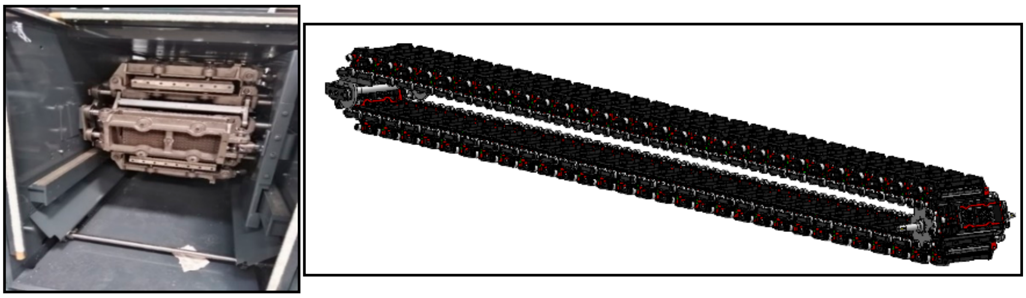


Figure 1. Wafer-baking plates chained by a connecting part.

There are upper and lower ovens in wafer ovens. On these stoves, parallel to the ground, the plate first moves on the upper rails, then turns and moves on the lower rails. Thereafter, the baking plates are heated with the help of the stoves, and the wafer batter is baked. It takes 2–3 min for the baking plate to return to the point where it receives the batter, that is, to make one full turn [3,4]. According to the 24/7 working principle of the plate, which is opened every 2 min, a plate is opened and closed at least 255,000 times a year. It is known that the internal surface temperature of baking plates is 150–180 °C, and they usually are baked above this temperature [2–6]. Figure 2 shows the time-dependent temperature relationship between the baking plate and wafer sheet [4].

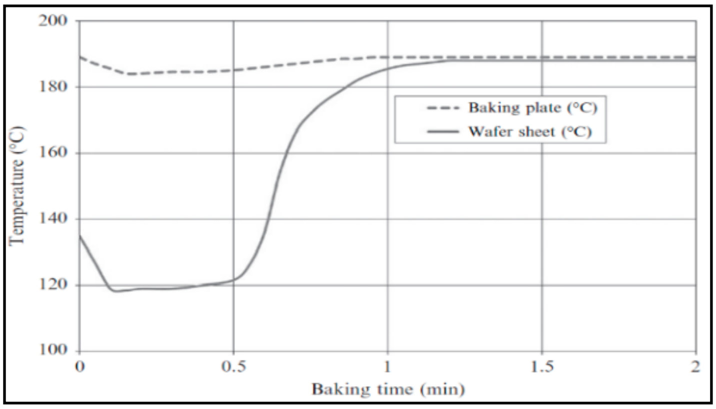


Figure 2. Temperature change of the wafer baking plate and wafer sheet as a function of time.

Wafer batter contains between 52–60% water [1,4,5,7]. The liquid batter is poured onto the metal plate in the specified amount, and the plate closes, and the wafer batter cooked between the hot plates releases water vapor and creates nearly a pressure of 1–1.3 bar. Figure 3 shows the time-dependent change of the pressure that occurs inside the plate during wafer baking [4].

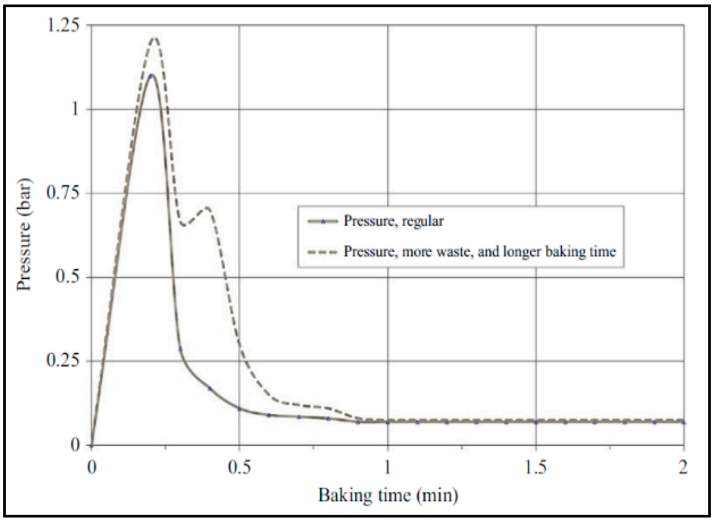


Figure 3. Time-dependent variation of the pressure inside the plate during wafer baking.

Water vapor that is not properly evacuated causes a heterogeneous color distribution of the wafer sheet; some parts of the wafer sheet become very brittle, and its mechanical properties deteriorate, while excess remaining moisture causes it to stick to the baking plate [2,3,8]. Factors determining the mechanical properties and color of the wafer sheet are the batter recipe, baking method, baking time, and material of the baking plate [2,3,5–18]. Metal baking plates are usually made of cast materials, but they are known to get dirty quickly in wafer production [19]. Materials for wafer-baking plates are usually made of the ductile cast iron (nodular cast iron) due to its volumetric heat capacity, thermal conductivity, high mechanical properties, and high-pressure resistance [20]. Spheroidal graphite cast iron shows properties similar to steel but has low thermal conductivity [21]. In gray cast iron, although the mechanical properties are not as good as ductile cast iron, it stands out with high heat storage [22].

Another study [22] investigated the effects of different materials on reducing the sticking behavior of wafers on the baking plates. In this study, it was emphasized that the main causes of wafer adhesion to the baking plate are the batter recipe, baking processes, baking time, baking temperature, cleanliness of the baking plate, material of the baking plate, surface roughness, and surface coating material. Also, it was observed that different materials had different effects on the color of wafer sheets under the same cooking conditions. In similar studies, it has been stated that the cooking time, surface roughness of the baking plate, and baking plate material have great effects on the adhesion and color of the wafer sheet [4,6,9,23].

Most of research in the literature has focused on the effects of the ratios of the additives used in the wafer batter, the fermentation time of the wafer batter, the pH value, the viscosity of the wafer batter, the additives in the flour used in the batter, the baking method, the baking time, and the cleanliness of the baking plate on the quality or sticking of wafer sheet. However, the effect of the material type of the baking plate on the quality of wafer is one of the critical research directions in this area [3,22]. Specifically, how the material type of the plate affects the distributions of temperature and color on the wafer sheet and the thickness of the wafer sheet is a vital gap in this area. To this end, in this work, the thermal distribution of two baking plates made of different materials (GG-25 gray cast iron and GJV-350 vermicular cast iron), their effects on the thickness of the wafer sheet, and their effects on the color distribution of the wafer sheet were investigated at different baking rates.

2. Materials and Methods

In this study, 62 wafer baking plates with dimensions of 350 × 500 mm, used in an industrial wafer-baking oven, were used. A detailed solid model of the wafer-baking plate is given in Figure 4. In the experiments, the casting plates in contact with the wafer batter were made of two different casting materials (gray cast iron/GG-25 and vermicular cast iron/GJV-350). The mechanical properties of GG-25 and GJV-350 casting plates are given in Table 1 [24–26].

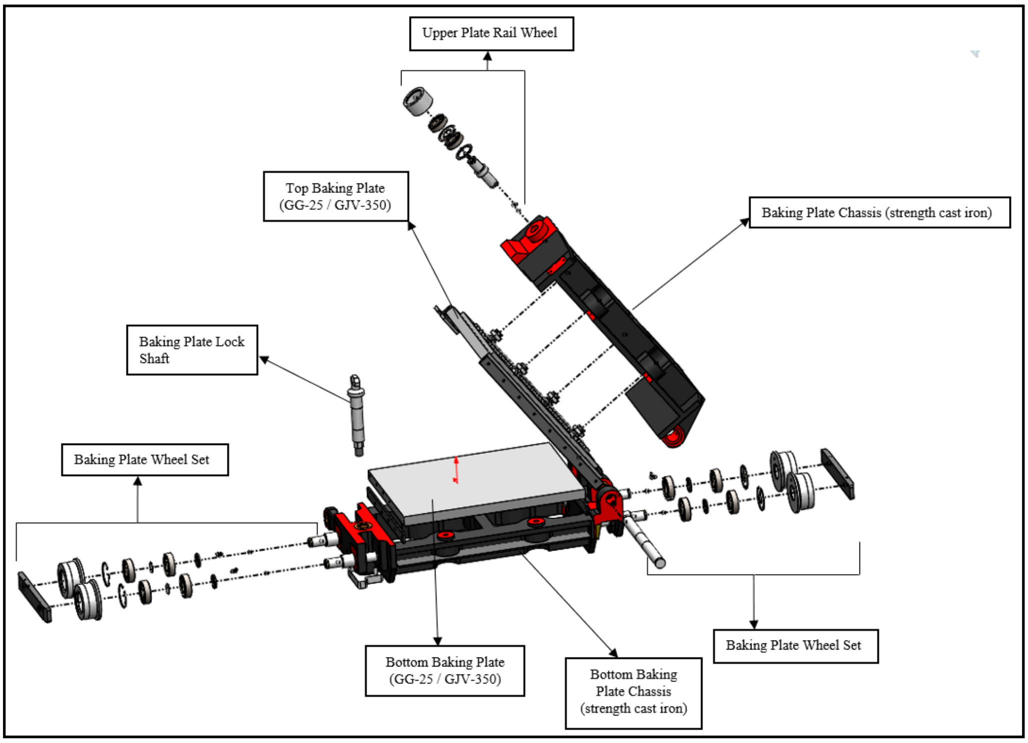


Figure 4. Wafer baking-plate component descriptions.

Table 1. Mechanical properties of GG-25 and GJV-350 for the casting baking plate.

Properties	Unit	GG-25	GJV-350
Coefficient of heat conduction	W/(mK)	47.5	42
Specific heat	J/(kgK)	460	475
Coefficient of thermal expansion	10^{-6} (1/°C)	11.7	11
Tensile strength	MPa	250–350	350–425
Modulus of elasticity	GPa	103–118	135–150

For the experiments, five sets of GG-25 gray cast iron (selected baking plate numbers: 1-10-17-30-37) and five sets of GJV-350 vermicular cast iron (selected baking plate numbers: 6-15-20-26-43) baking plates in the same wafer-baking oven were selected for measurements. The temperature measurements of the wafer-baking plates and the thickness measurements of the wafer sheets made with these baking plates were taken at the time of wafer production. Temperature measurements of the wafer baking plates and wafer sheets were carried out using both a thermal camera and an infrared laser thermometer.

In the temperature measurement with both the infrared laser thermometer and the thermal camera, the operator was in a fixed position and at a fixed distance. The repeatability of the infrared laser thermometer is ±0.5%; basic accuracy is ±1%. In addition to the temperature values measured with the infrared laser thermometer, the temperature values of the baking plate and wafer sheet were measured with the thermal camera during the period of production. A Flir TG165 model thermal camera was used in the experiments. Before starting the measurements, the thermal camera emissivity value (ε) was adjusted according to the 0.95 value of cast iron. An Insize 2365-055 model thickness comparator was used to measure the thickness from four corners of the produced wafer sheets (Figure 5). In addition, the color distribution of the produced wafer sheets was visually examined.

Figure 5. Temperature measurement of baking plates during period of wafer production and thickness measurement of the wafer sheet.

3. Results

3.1. Temperature Measurements of Wafer-Baking Plates with Infrared Laser Thermometer

The temperature values of the baking plates made of GG-25 material, numbered 1, 10, 17, 30, and 37, and the baking plates made of GJV-350 plate material, numbered 6, 15, 20, 26, and 43, were measured by infrared laser thermometer and thermal camera. Table 2 shows the temperature values obtained from infrared laser thermometer measurements of wafer-baking plates. Temperature measurements were taken three times each from the specified baking plates.

Table 2. Temperature measurement results of wafer-baking plates (infrared laser thermometer).

	Baking Plate Temperature Measurement			
GG-25	**1st Measurement (°C)**	**2nd Measurement (°C)**	**3rd Measurement (°C)**	**Arithmetic Mean (°C)**
Plate No. 1	144	145.4	142.8	144.1
Plate No. 10	154	146.9	151.5	150.8
Plate No. 17	146	146.4	138.6	143.7
Plate No. 30	138.7	142.8	143.6	141.7
Plate No. 37	164.2	161.1	164.4	163.2
	Baking Plate Temperature Measurement			
GJV-350	**1st Measurement (°C)**	**2nd Measurement (°C)**	**3rd Measurement (°C)**	**Arithmetic Mean (°C)**
Plate No. 6	145	147.2	142.7	145.0
Plate No. 15	146	143.7	140	143.2
Plate No. 20	149	145.7	145	146.6
Plate No. 26	139	144.1	142	141.7
Plate No. 43	148.7	146	142	145.6

From the data obtained from Table 2, it can be seen that the GG-25 casting baking plates have a temperature value between 141.7 and 163.2 °C. There is a temperature difference of 21.5 °C between the GG-25 casting baking plates. The GJV-350 casting baking plates have a temperature value between 141.7 and 146.6 °C. The GJV-350 casting baking plates have a temperature difference of 5 °C between them. It can be said that the temperatures of GJV-350 cast-iron baking plates are more stable. It is thought that the low temperature difference between the baking plates has a direct effect on wafer color and quality.

3.2. Thermal Camera Measurements of Wafer-Baking Plates and Wafer Sheets

Table 3 shows images of the GG-25 and GJV-350 baking plates and thermal camera measurements of the wafer sheets produces with these baking plates. When the average temperatures of the baking plates in Table 3 were researched, it was found that GG-25 cast-iron baking plates have temperature values between 139.7 and 152.5 °C. There is a temperature difference of approximately 13 °C between the GG-25 cast-iron baking plates. It was observed that GJV-350 casting baking plates had temperature values between 138.6 and 145.1 °C. There is a temperature difference of approximately 7 °C between the GJV-350 casting baking plates. Similar results were obtained from the infrared thermal camera. It was found that the temperatures of the GJV-350 casting plates were more stable in the values read from the thermal camera. When the temperatures of the wafer sheets obtained from the same baking plates were researched, it was found that the wafer sheets produced in GG-25 casting baking plates had temperature values between 120.6 and 126.7 °C. There is a temperature difference of 6 °C between the wafer sheets produced in the GG-25 casting material. It was observed that the wafer sheets produced in the GJV-350 casting baking plates had temperature values between 125.1 and 127.1 °C. There is a 2 °C temperature difference between the wafer sheets produced in the GJV-350 casting material. When both plate and wafer temperatures were evaluated together, it was found that the GJV-350 plate material gives more stable and repeatable results.

Table 3. Thermal camera measurements of baking plates and wafer sheets.

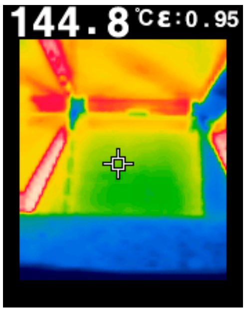
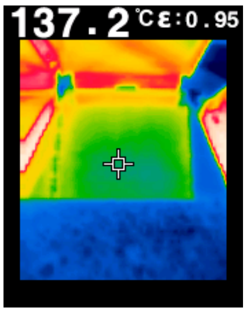
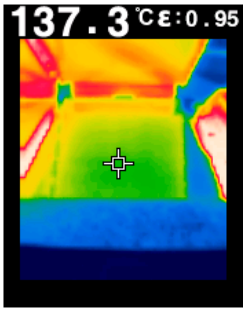
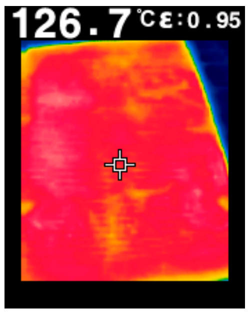
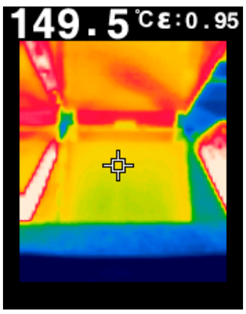
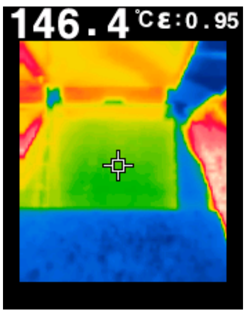
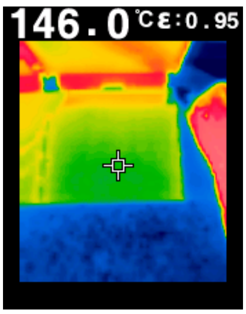
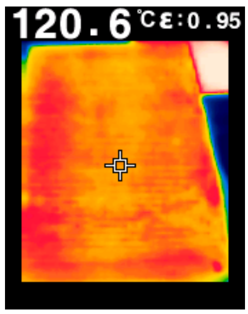
	Baking Plate Temperature Measurement			Wafer Sheet Measurement (°C)
GG-25	**1st Measurement (°C)**	**2nd Measurement (°C)**	**3rd Measurement (°C)**	
Plate No. 1				
Plate No. 10				

Table 3. *Cont.*

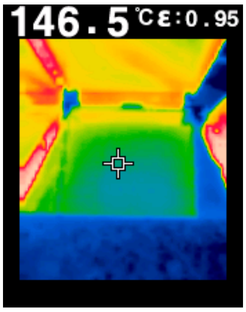
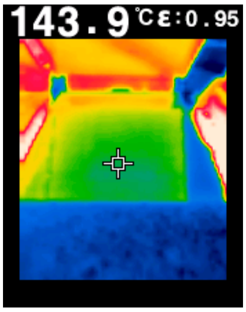
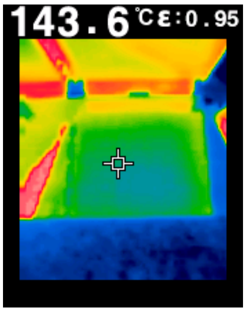
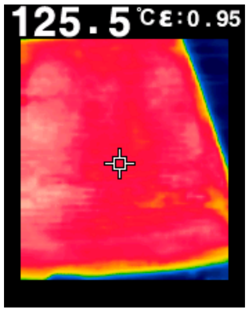
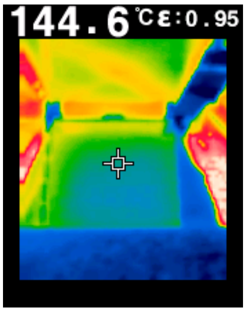
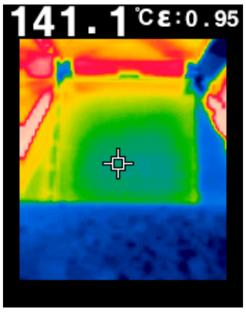
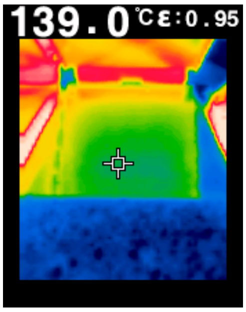
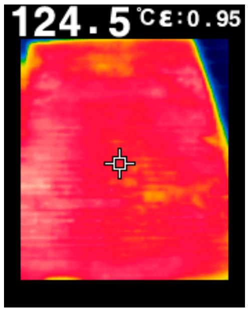
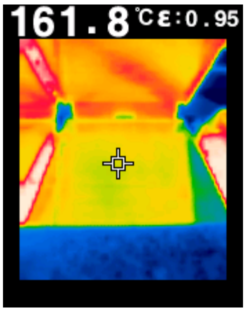
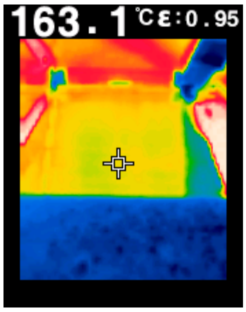
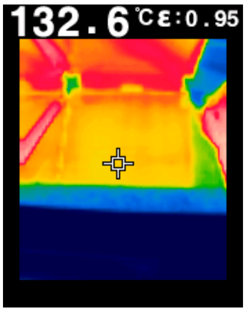
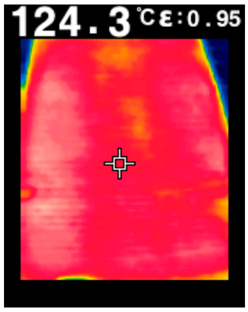
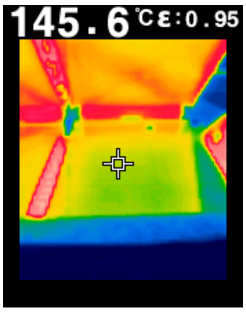
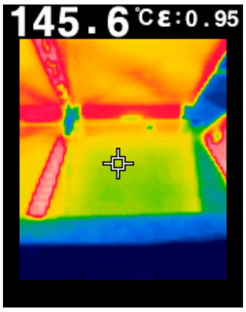
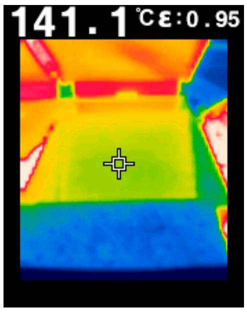
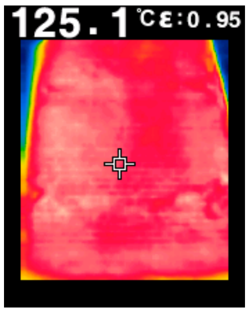
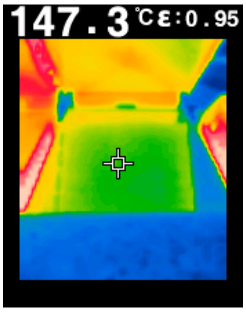
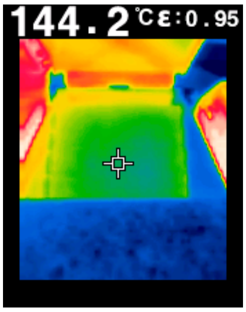
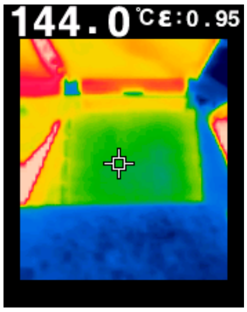
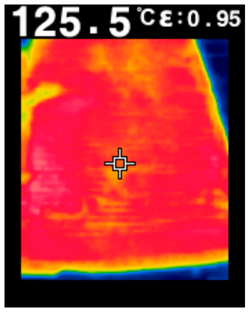
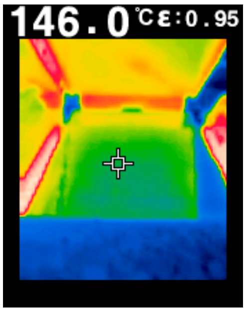
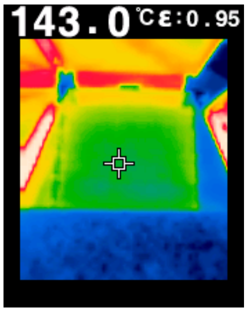
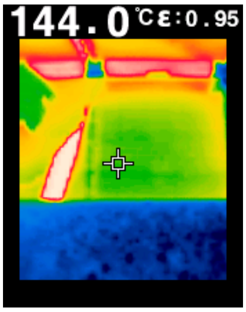
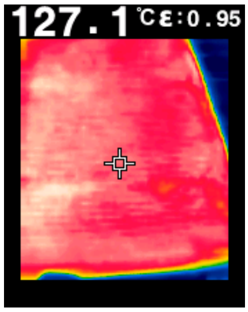
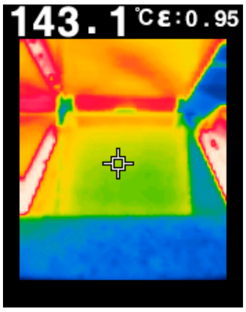
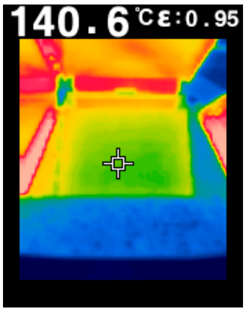
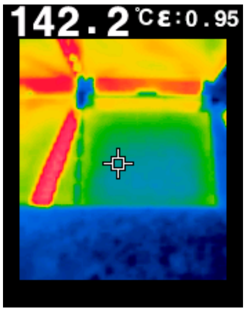
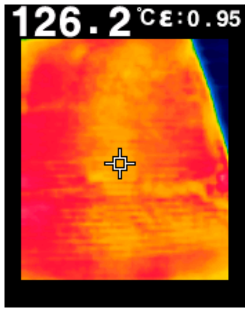
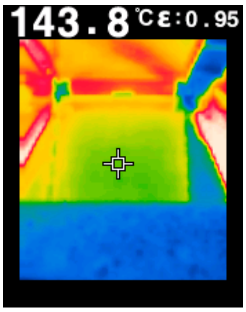
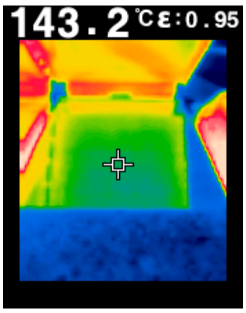
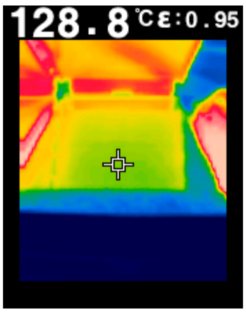
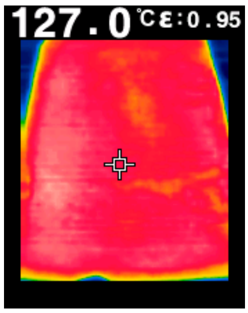
	Baking Plate Temperature Measurement			Wafer Sheet Measurement (°C)
GG-25	1st Measurement (°C)	2nd Measurement (°C)	3rd Measurement (°C)	
Plate No. 17				
Plate No. 30				
Plate No. 37				
	Baking Plate Temperature Measurement			Wafer Sheet Measurement (°C)
GJV-350	1st Measurement (°C)	2nd Measurement (°C)	3rd Measurement (°C)	
Plate No. 6				

Table 3. *Cont.*

	Baking Plate Temperature Measurement			Wafer Sheet Measurement (°C)
GJV-350	1st Measurement (°C)	2nd Measurement (°C)	3rd Measurement (°C)	
Plate No. 15				
Plate No. 20				
Plate No. 26				
Plate No. 43				

In the study by Carzino et al. [27], a temperature of 179.6 °C was measured in the top baking plate by thermographic measurement. Karl Tiefenbacher stated that the wafer-baking plates work continuously at a temperature between 170 °C and 200 °C. In the study by Steinbach et al. [28], the upper baking plate and lower baking plate temperatures were measured separately. Temperatures around 120 C were measured. It was emphasized by the author [5] that cooking time is very important in the cooking of wafer sheets. It was found that a baking temperature of 170 °C and a baking time of 2 min was sufficient for high-quality wafer sheets with a water level of 155–165% [5]. Wafer sheets cooked at lower temperatures stuck to the plates and broke into several pieces. At a lower water level

(<145%) and a baking temperature of 150 °C, tough and flint-like sheets were obtained, while at a water level higher than 160% and a higher temperature (190 °C), brittle sheets were obtained.

3.3. Wafer Sheet Thickness Measurements

The thickness of the wafer is affected by the amount of dough poured into the wafer-baking plates and the pressure the plates exert on the dough [2]. Wafer sheet thickness measurements were performed by taking into account the wafer sheets baked in the same numbered baking plates determined in the temperature measurements. The wafer sheet thicknesses were measured with a thickness gauge from four corners of the hot wafer sheet coming out of the wafer baking oven after waiting for a certain period of time (after 300 s). The graph in Figure 6 was obtained by using the average numerical values of the wafer sheet thickness measurements. The thickness values of the wafer sheets produced in the standard were between 2.8 and 3.2 mm, which is within acceptable limits. When the average wafer sheet thicknesses in Figure 6 were researched, it was seen that the wafer sheets produced in GG-25 casting baking plates had thickness values between 2.78 and 3.16 mm. There is a thickness difference of 0.38 mm between the wafer sheets produced in GG-25 casting baking plates. In addition, it was determined that the number 37 baking plate of the GG-25 material produced wafer sheets with a thickness less than the desired thickness. It was observed that the wafer sheets produced in GJV-350 casting baking plates had thickness values between 3.03 and 3.19 mm. There is a thickness difference of 0.16 mm between the wafer sheets produced in GJV-350 casting baking plates. It was seen that the stability in the temperature distribution of GJV-350 casting baking plates reflects positively on the thickness of the wafer sheet.

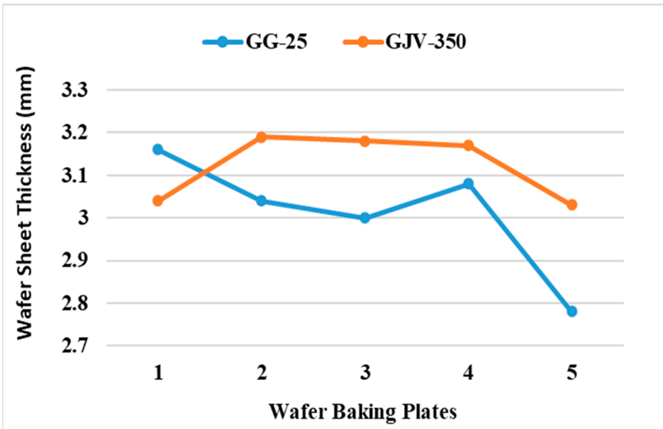


Figure 6. Thickness distributions of wafer sheets from two different baking plates.

3.4. Wafer Sheet Color Distribution Research

The color of the wafer sheet is influenced by the dough formula (moisture content, amount of reducing carbohydrates and free amino acids, etc.) and the baking condition (time and temperature). The color of the wafer sheet should be uniform, very regular, and not too dark [2,16,29].

The color distribution of wafer sheets is one of the key indicators of aesthetic and quality standards in food production and is a critical element that directly affects consumer perception and satisfaction. Color uniformity provides important clues as to the consistency of the production processes, and any defects in production can be indicated by color variations on the surface. Temperature differences during baking, variations in the composition of the dough, and the equipment used are among the factors that significantly affect the distribution of the surface color of the wafer. In particular, a homogeneous color distribution strongly conveys the perception of quality and professionalism to the consumer, indicating that even baking has taken place throughout the product and that evaporation is balanced. The strong relationship between color distribution and moisture distribution is one of the most important parameters to consider in this process. The color change on the surface of the wafer sheet is directly related to the moisture evaporation process. A homogeneous coloration on the surface is an indication that the moisture evaporates evenly and that each part of the product is evenly cooked [4,5,9].

In addition, the baking plate material used in production is another critical variable that directly affects the color distribution on the wafer sheet. Different baking plate materials affect the color differences that occur during baking by changing the temperature distribution on the surface according to their thermal conductivity properties. For example, while cast molds conduct heat more homogeneously and provide a balanced color distribution on the surface, materials such as steel may tend to cool faster and disrupt the temperature balance on the surface, which may adversely affect the color uniformity of the product. In addition, factors such as the smoothness of the baking plate surface and the coating material also play a critical role in color uniformity by affecting the heat distribution on the surface. In order to achieve a homogeneous color distribution, physical properties such as thermal conductivity and surface structure should be taken into account when selecting the baking plate material [3,9,29].

Wafer sheet samples were taken from the same wafer-baking plates whose temperatures and thicknesses were measured for color distribution research. The experiments were carried out at two different production rates (23 pcs/min and 31 pcs/min) on wafer sheets taken from the same baking plate numbers. Figure 7 shows the wafer sheets produced at a production rate of 31 pcs/min in baking plates made of GG-25 casting material.

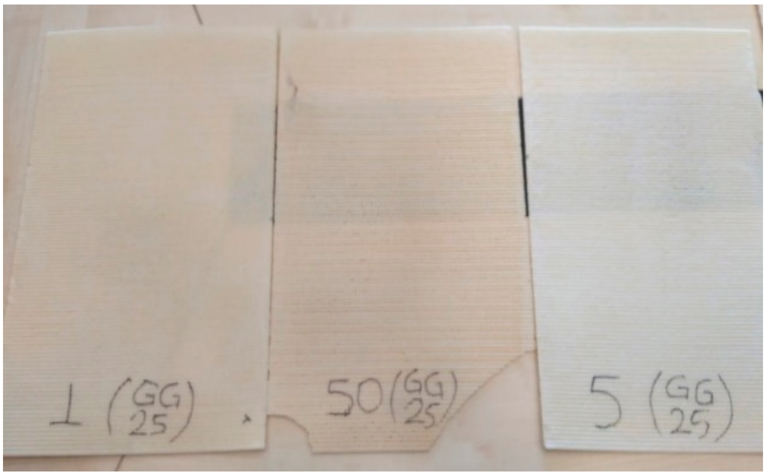


Figure 7. Wafer sheets produced on GG-25 cast-iron baking plates at a production rate of 31 pcs/min.

From Figure 7, it is clearly seen that there are large color differences between the colors of the wafer sheets produced in baking plates made of the same casting material (GG-25) at a production rate of 31 pcs/min. Figure 8 shows the wafer sheets produced in baking plates made of GG-25 and GJV-350 casting materials at a production speed of 31 pcs/min.

From Figure 8, it is clearly seen that the wafer sheets obtained from the baking plates made of GJV-350 casting material have a more homogeneous color distribution than the color of the wafer sheets obtained from the baking plates made of GG-25 casting material. Figures 9 and 10 show the wafer sheets produced from baking plates numbered 1, 10, 17, 30, and 37 (GG-25) and 6, 15, 20, 26, and 43 (GJV-350) at a production rate of 23 pcs/min. From Figures 9 and 10, no significant color difference is observed between the wafer sheets.

It was observed that there was no significant color difference between the wafer sheets obtained at a low production speed.

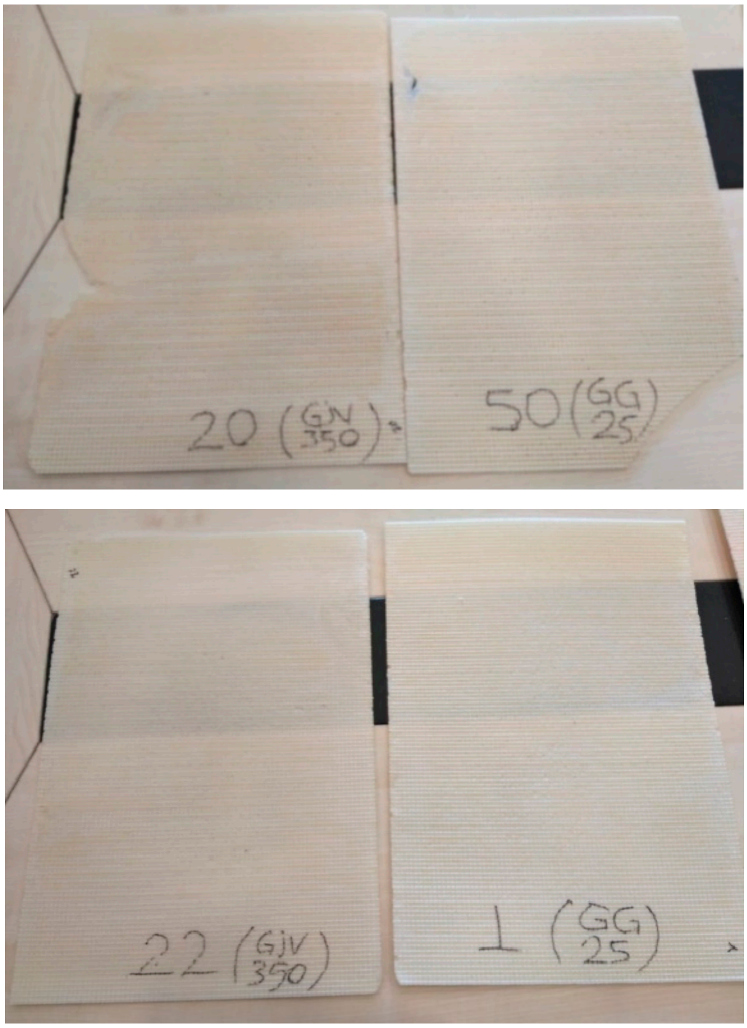


Figure 8. Wafer sheets produced in two different baking plates (GG-25 and GJV-350) at 31 pcs/min production speed.

Figure 9. Wafer sheets produced on GG-25 cast-iron baking plates at a production rate of 23 pcs/min.

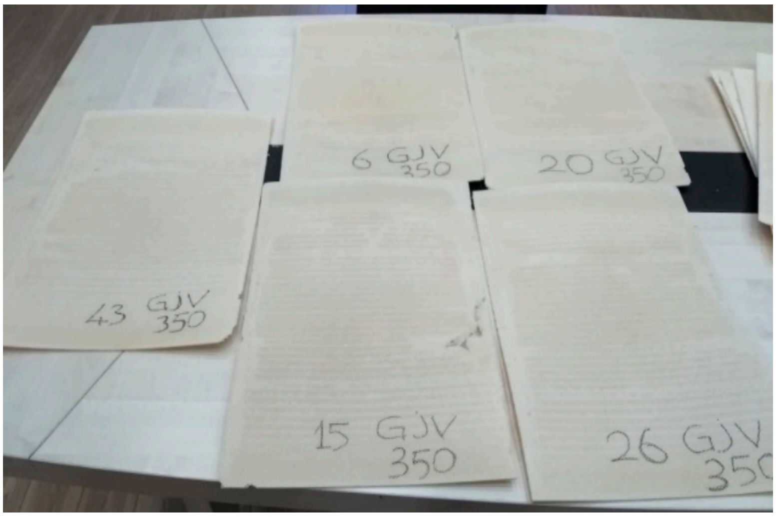


Figure 10. Wafer sheets produced on GJV-350 cast-iron baking plates at a production rate of 23 pcs/min.

Figure 11 shows the wafer sheets produced at two different production rates (23 pcs/min and 31 pcs/min) in baking plates made of GG-25 casting material. From Figure 11, it is seen that the color of the wafer sheets changed significantly at different production speeds, although they were produced in the same plate material (GG-25) and from the same batter recipe. This shows that the production speed is extremely important for the color of the wafer sheets.

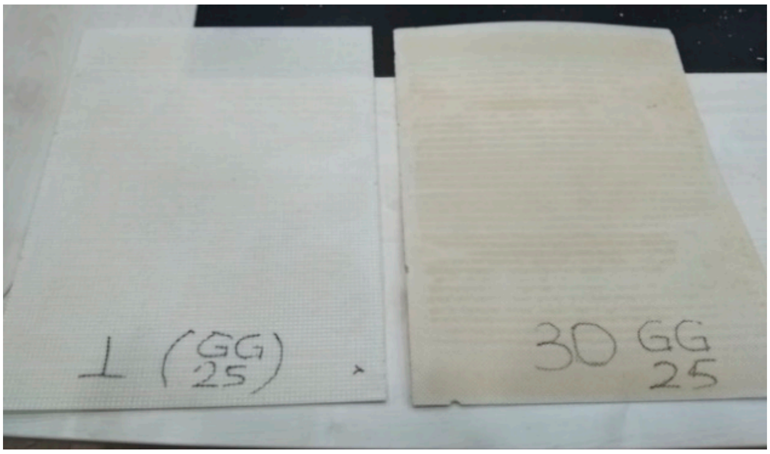


Figure 11. Wafer sheets produced at two different production rates (31 pcs/min and 23 pcs/min) in GG-25 cast-iron baking plates.

At low production rates (23 pcs/min), it was found that different casting materials had almost no effect on the color formation on the wafer sheets. However, as the production speed increased (31 pcs/min), the effects of different casting plate materials on the color of the wafer sheets became apparent. In other words, while there was no color difference between the wafer sheets coming out of the baking plates made of two different casting materials at a production rate of 23 pieces per minute, as the production rate per minute increased (31 pieces per minute), the color difference between the wafer sheets emerged clearly. It was observed that the baking plate made of GJV-350 casting material exhibited more stable wafer sheet color.

4. Conclusions

In this study, the thermal distribution of two baking plates made from two different casting materials (GG-25 and GJV-350), their effects on the thickness of the wafer sheet, and their effects on the color distribution of the wafer sheet were investigated. The findings are given below.

- The baking plates made of GJV-350 casting material can be said to have more homogenous temperature distribution compared to that of the baking plate made of GG-25 casting material. The homogenous temperature distribution of the baking plate made of GJV-350 casting material can be said to positively affect the thickness of the wafer sheet;
- Great differences were found between the wafer sheet colors produced in baking plates made of GG-25 casting material at a low production rate and a high production rate. However, no difference was found between the colors of wafer sheets produced in baking plates made of GJV-350 casting material at a low production rate and a high production rate, with wafers produced with close to homogeneous color;
- The material type of the plate and the baking time considerably affect the temperature distribution, the general color distribution, and the thickness of the wafer sheet because of the differences in the thermal characteristics of these materials. It is known in the literature that these dark lines can be reduced by certain factors, including the ratios of the additives used in the wafer batter, the fermentation time of the wafer batter, the pH value, the viscosity of the wafer batter, the additives in the flour used in the batter, the baking method, the baking time, and the cleanliness of the baking plate. It is concluded in this study that the material type of the plate does not significantly affect the shape of distinct dark lines on the wafer sheet.

Author Contributions: Conceptualization, U.K. and A.S.T.; methodology, F.S.; validation, A.S.T., U.K., and F.S.; investigation, U.K. and A.S.T.; writing—original draft preparation, U.K. and G.B.; writing—review and editing, G.B. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by Karaman city-KOSGEB Institution (Project No: 205719). We would like to thank Tüfekçioğulları (NEFAMAK) Machinery Food Manufacturing Industry Limited Company and KOSGEB Institution for initiating the project.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available in a publicly accessible repository.

Conflicts of Interest: Authors Abdullah Sadık Tazegül and Fatih Serin were employed by the company Tüfekçioğulları Machinery Food Manufacturing Industry Limited Company R&D Center. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Tazegül, A.S.; Duman, N.; Bal, A.; Bitkin, M. Wafer Production Technology. In *Cereal Science and Technology*; Sidas Media: İzmir, Türkiye, 2021.
2. Meral, R.; Doğan, İ.S. Determination of the Quality and Composition of Wafers. *Yüzüncü Yıl Univ. J. Agric. Sci.* **2004**, *14*, 65–71.
3. Huber, R.; Kalss, G.; Schoenlechner, R. Waffle Production: Influence of Baking Plate Material on Sticking of Waffles. *J. Food Sci.* **2017**, *82*, 61–68. [CrossRef] [PubMed]
4. Tiefenbacher, K. *The Technology of Wafers and Waffles I: Operational Aspects*; Academic Press: London, UK, 2017.
5. Doğan, İ.S. Factors Affecting Wafer Sheet Quality. *Int. J. Food Sci. Technol.* **2006**, *41*, 569–576. [CrossRef]

6. Doğan, İ.S.; Yıldız, O.; Meral, R. Optimization of Corn, Rice and Buckwheat Formulations for Gluren-Free Wafer Production. *Food Sci. Technol. Int.* **2016**, *22*, 410–419. [CrossRef] [PubMed]
7. Tiefenbacher, K.F. *The Technology of Wafers and Waffles II: Recipes, Product Development and Know-How*; Academic Press: London, UK, 2018.
8. Martínez-Navarrete, N.; Moraga, G.; Talens, P.; Chiralt, A. Water sorption and the plasticization effect in wafers. *Int. J. Food Sci. Technol.* **2004**, *39*, 555–562. [CrossRef]
9. Doğan, İ.S.; Meral, R.; Söylemez, G. A Study on the Determination of the Biscuit Consumption Habits. *World Food* **2004**, *10*, 62–65.
10. Mert, S.; Sahin, S.; Sumnu, G. Development of Gluten-Free Wafer Sheet Formulations. *LWT Food Sci. Technol.* **2015**, *63*, 1121–1127. [CrossRef]
11. Çarşanba, E.; Duerrschmid, K.; Schleining, G. Assessment of Acoustic-Mechanical Measurements for Cripness of Wafer Products. *J. Food Eng.* **2018**, *229*, 93–101. [CrossRef]
12. Dorohocych, V.; Hrytsevich, M.; Isakova, N. Effect of Gluten-Free Flour on Sensory, Physico-Chemical, Structural and Mechanical Properties of Wafer Batter and Waffles. *Ukr. Food J.* **2018**, *7*, 253–263. [CrossRef]
13. Rozylo, R.; Wójcik, M.; Dziki, D.; Biernacka, B.; Cacak-Pietrzak, G.; Gawlowski, S.; Zdybel, A. Freeze-dried elderberry and chokeberry as natural colorants for gluten-free wafer sheets. *Int. Agrophys.* **2019**, *33*, 217–225. [CrossRef] [PubMed]
14. Tufan, B.; Sahin, S.; Sumnu, G. Utilization of Legume Flours in Wafer Sheets. *Legume Sci.* **2020**, *2*, e12. [CrossRef]
15. Nasabi, M.; Naderi, B.; Akbari, M.; Aktar, T.; Kieliszek, M.; Amini, M. Physical, structural and sensory properties of wafer batter and wafer sheets influenced by various sources of grains. *LWT* **2021**, *149*, 111826. [CrossRef]
16. Naderi, B.; Nasabi, M.; Akbari, M.; Zargaraan, A.; Amini, M. Effect of enzymatic treatment on rheological properties of wafer batter and textural properties of wafer sheet. *J. Food Meas. Charact.* **2023**, *17*, 2213–2223. [CrossRef]
17. Cevoli, C.; Evangelisti, A.; Gradari, P.; Fabbri, A. Storage of wafer cookies: Assessment by destructive techniques, and non-destructive spectral detection methods. *J. Food Eng.* **2023**, *336*, 111209. [CrossRef]
18. Bitkin, M.; Tazegül, A.S.; Mayda, M. Quality Assessment of Wafer Oven Products by Image Processing. In Proceedings of the UMTS 2021—20th National Symposium on Theory of Machines, Diyarbakır, Türkiye, 15–17 September 2021; pp. 338–345.
19. Reinhart, A.; Haas, J.; Haas, J.; Jirascheck, S.; Lichtscheidl, M.; Obermaier, F. Baking Plate for Baking Ovens. Patent WO2013024152A1, 21 February 2013.
20. Köklü, U.; Tazegül, A.S. Determination of Mechanical Properties and Investigation of Surface Quality of GG-25, GGG-45 and GJV-350 Wafer Baking Plates. In Proceedings of the 6th International Congress on Engineering, Architecture and Design, Istanbul, Türkiye, 17–18 December 2020; pp. 136–144. Available online: https://www.guvenplus.com.tr/imagesbuyuk/412a054.pdf (accessed on 2 January 2025).
21. Weißbach, W. *Werkstoffkunde und Werkstoffprüfung*; Viewegs FachbiJcher der Technik; Girardet: Wiesbaden, Germany, 1994.
22. Huber, R. Sticking of Waffles on Baking Plates—Influence of Ingredients, Baking Plate Material, Baking Parameters and Release Agents. Ph.D. Thesis, University of Natural Resources and Life Sciences, Wienna, Austria, 2016.
23. Ashokkumar, S.; Adler-Nissen, J. Evaluating Non-Stick Properties of Different Surface Materials for Contact Frying. *J. Food Eng.* **2011**, *105*, 537–544. [CrossRef]
24. Norman, V.; Skoglund, P.; Leidermark, D.; Moverare, J. The effect of superimposed high-cycle fatigue on thermo-mechanical fatigue in cast iron. *Int. J. Fatigue* **2016**, *88*, 121–131. [CrossRef]
25. López, A.R.; Tsiampousi, A.; Standing, J.R.; Potts, D.M. Numerical investigation of a segmental grey cast iron tunnel ring: Validation with laboratory data and application to field conditions. *Comput. Geotech.* **2022**, *141*, 104427.
26. Wang, G.Q.; Liu, Z.L.; Li, Y.X.; Chen, X. Different thermal fatigue behaviors between gray cast iron and vermicular graphite cast iron. *China Foundry* **2022**, *19*, 245–252.
27. Carzino, M.; Stanescu, G.; Errera, M. Finned wafer baking plates for heat transfer and distribution. *Seatific J.* **2022**, *2*, 80–89. [CrossRef]
28. Steinbach, J.; Jadachowski, L.; Steinboeck, A.; Kugi, A. Modeling and observer design of an inductive oven with continuous product flow. *Mechatronics* **2023**, *95*, 103041. [CrossRef]
29. Huber, R.; Schoenlechner, R. Waffle production: Influence of batter ingredients on sticking of fresh egg waffles at baking plates—Part I: Effect of starch and sugar components. *Food Sci. Nutr.* **2017**, *5*, 504–512. [CrossRef] [PubMed]