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## Section: Food Technologies

# ANTIOXIDANT CAPACITY OF MATCHA IN SYRNYKY TECHNOLOGY: IMPROVING THE QUALITY OF FERMENTED MILK DISHES

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**Abstract.** The article presents the results of comparative studies on the antioxidant capacity and sensory profile of green tea and matcha, followed by their adaptation to syrnyky (cottage cheese pancakes) technology. It was found that water-alcohol infusion of matcha exhibits the highest antioxidant activity and the most favorable sensory characteristics: intense green color, pronounced herbal aroma, and a well-balanced astringent-sweet taste with a creamy aftertaste. Based on the obtained data, an improved syrnyky formulation was developed with the addition of 1-3% matcha powder, which enhanced their quality by increasing nutritional and biological value and improving organoleptic properties. The study confirms the potential of matcha as a functional ingredient that enhances the appeal of modern Ukrainian cuisine.

**Keywords:** matcha, green tea, antioxidant capacity, sensory evaluation, water-alcohol infusions, fermented milk dishes, syrnyky, cottage cheese pancakes, quality, technology, modern Ukrainian cuisine, foodservice establishments

**Introduction.** The modern interest in functional food products that combine nutritional value, safety, and appealing sensory properties is rapidly growing both globally and in Ukraine. This trend is driven by changing consumer priorities toward a healthy lifestyle, disease prevention, and maintaining a high quality of life.

According to global analytical reports [1], the global market for functional foods was valued at USD 280.7 billion in 2021 and is projected to grow annually by 8.5% until 2030. In this context, natural ingredients rich in bioactive compounds – such as Japanese green tea matcha – are gaining increasing attention.

Matcha is a powdered form of green tea that ensures full consumption of the ground Camellia sinensis leaves, unlike traditional brewing methods. This ingredient is a source of valuable bioactive compounds such as catechins, theanine, and chlorophyll, which provide antioxidant, anti-inflammatory, and neuroprotective effects [2]. The versatility of matcha allows it to be used in a wide range of food products, from beverages and desserts to dairy products and baked goods. Of particular relevance is the incorporation of matcha into traditional Ukrainian recipes [3], such as syrnyky (cottage cheese pancakes), which – due to their soft texture and neutral taste – are a promising base for enhancement.

The prospects of this direction are confirmed by market dynamics: according to forecasts [4], the tea market in Ukraine is expected to grow by 4.34% during the period 2024–2029, reaching a volume of USD 0.47 billion. The matcha market also shows positive trends, with increasing sales of powder, ready-to-drink products, and premixes [5]. These developments create favorable conditions for introducing new functional foods enriched with tea-based ingredients [6], especially those adapted to local culinary traditions.

**Relevance of the research topic.** The successful adaptation of experience from Japan, South Korea, the United States, and EU countries in the use of matcha opens up broad opportunities for Ukrainian producers – both in expanding the range of functional dishes and in enhancing their competitiveness on domestic and international markets.

Practical studies of matcha use in food products – for example, in cookies – demonstrate high consumer appeal even with low dosages (2 g per 100 g of flour) [7]. At the same time, questions remain regarding the stability of matcha's bioactive compounds under the influence of heat treatment, pH changes, and interactions with other ingredients. Research [8] has shown that catechins are more stable at a pH of around 4 and may partially degrade at high temperatures. However, under moderate heat conditions typical for syrnyky preparation (about 180–200°C), a significant proportion of catechins is retained, making matcha suitable for use in fermented dairy-based dishes.

Particular relevance is given to studying the antioxidant potential of matcha in water-alcohol systems, which serve as one possible method of extracting functionally active substances from raw materials.

Therefore, the topic of this research is highly relevant in the context of globalization, growing demand for healthy nutrition, and the reorientation of Ukrainian foodservice establishments toward innovative technologies [9–11].

**The aim of the study** is to investigate the antioxidant properties of matcha green tea powder and to assess its impact on the quality and functional characteristics of fermented milk dishes, particularly syrnyky, in order to enhance their nutritional and biological value as well as sensory appeal.

**Materials and methods.** Plant-based raw materials used in the study included green tea and matcha powder. The control sample was a water–alcohol mixture with a strength of 40% vol. The antioxidant capacity of the water–alcohol infusions prepared from the tea samples was assessed using pH-metry and redox potentiometry methods [12–17].

To evaluate the quality of the infusions made with different raw materials (green tea, matcha), an organoleptic analysis was conducted using a point-based scoring system [18]. The evaluation was based on four key parameters: clarity and color, aroma, taste, and overall impression. Each parameter was rated on a scale divided into three qualitative categories: “excellent,” “good,” and “unsatisfactory.”

The “clarity and color” parameter was rated within a range of <1.8 to 2.0 points. Values between 1.9 and 2.0 were classified as excellent, 1.8–1.9 as good, and those below 1.8 as unsatisfactory. Similar scales were applied to the parameters “aroma” and “taste”: scores of 3.8–4.0 indicated excellent quality, 3.6–3.8 good quality, and values below 3.6 were deemed unsatisfactory. The overall score was determined by summing the points for all parameters. A total score of 9.5–10.0 was considered excellent, 9.0–9.5 good, and scores below 9.0 unsatisfactory [18].

The application of this methodology [18] enables an objective assessment of how specific raw materials influence the organoleptic properties of the infusion and allows for generalized conclusions regarding its consumer acceptability.

**Results and Discussion.**

1. Organoleptic Parameters. Figures 1–4 present the results of the sensory evaluation of water–alcohol infusions of green tea and matcha compared to the solvent (water–alcohol mixture used as the control).

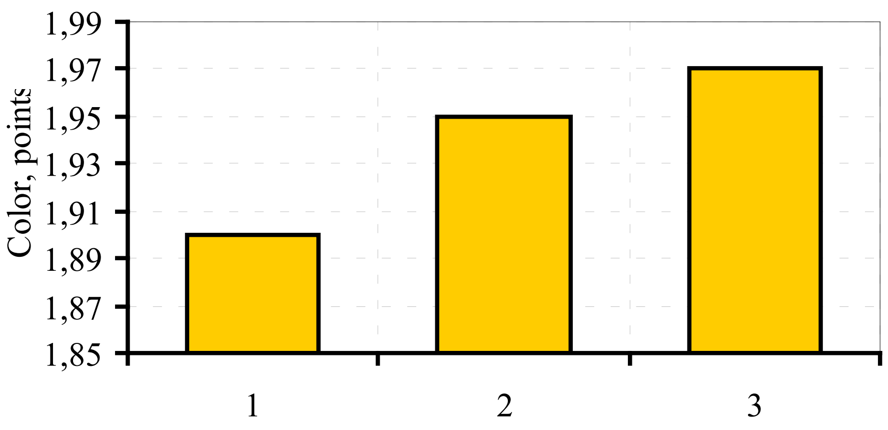


Figure 1. Clarity and color characteristics of water-alcohol infusions:
1 – control sample (water-alcohol mixture); 2 – infusion of green tea in water-alcohol solution;
3 – infusion of matcha in water-alcohol solution

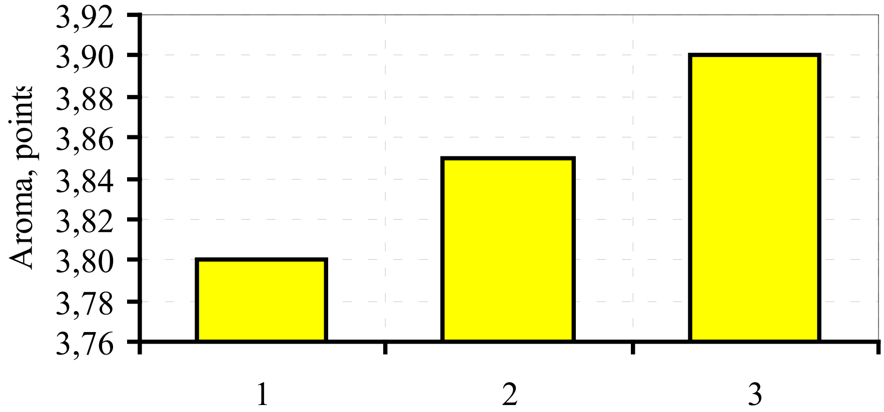


Figure 2. Aroma characteristics of water-alcohol infusions:
1 – control sample (water-alcohol mixture); 2 – infusion of green tea in water-alcohol solution;
3 – infusion of matcha in water-alcohol solution

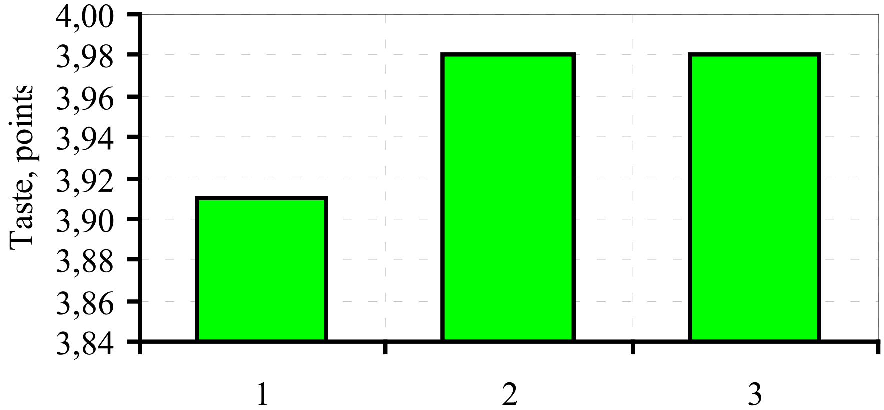


Figure 3. Taste characteristics of water-alcohol infusions:
1 – control sample (water-alcohol mixture); 2 – infusion of green tea in water-alcohol solution;
3 – infusion of matcha in water-alcohol solution

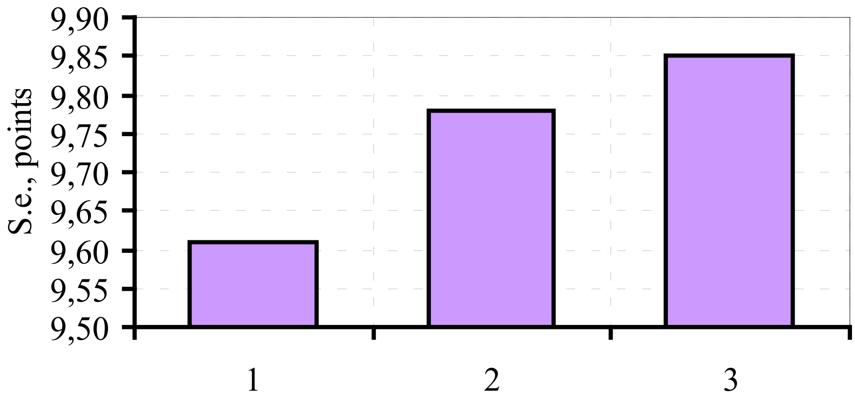


Figure 4. Overall score characteristics (S.e. – sensory evaluation) of water-alcohol infusions:
1 – control sample (water-alcohol mixture); 2 – infusion of green tea in water-alcohol solution;
3 – infusion of matcha in water-alcohol solution

Interpretation of Sensory Properties:

Water–alcohol mixture (control): Clarity and color: 1.90 → good; aroma: 3.80 → good; taste: 3.91 → excellent; overall score: 9.61 → excellent. The sample demonstrated good clarity and color, a pleasant alcoholic aroma, and excellent taste. However, a "hollow" flavor was noted due to the absence of additional ingredients, which limited the sensory completeness of the infusion.

Water–alcohol infusion of green tea: Clarity and color: 1.95 → excellent; aroma: 3.85 → excellent; taste: 3.98 → excellent; overall score: 9.78 → excellent. The green tea infusion exhibited a brownish hue and a pronounced tea aroma. The taste was described as sour-bitter, with notable astringency and natural bitterness, resulting in a lasting aftertaste and giving the beverage a distinctive profile.

Water–alcohol infusion of matcha: Clarity and color: 1.97 → excellent; aroma: 3.90 → excellent; taste: 3.98 → excellent; overall score: 9.85 → excellent. The matcha infusion featured a bright green color, intense grassy aroma, and a well-balanced flavor combining slightly bitter and sweet notes. A particularly pleasant creamy sensation in the aftertaste enhanced the overall sensory appeal of the drink.

Sensory evaluation results from other studies [19, 20] also indicate the high attractiveness of matcha as a food ingredient, providing finished products with a pleasant green color, characteristic mild herbal taste and aroma, and contributing to a positive consumer experience.

The organoleptic assessment of water–alcohol infusions revealed a significant enrichment of the sensory profile due to the addition of plant materials. The matcha infusion proved to be the most appealing overall, owing to its vibrant color, rich aroma, and balanced taste with a smooth, creamy aftertaste. Therefore, the use of green tea, particularly matcha, substantially enhances sensory properties.

2. Antioxidant Parameters. Figures 5–9 present a description of the antioxidant capacity for each sample, focusing on their pH, theoretical redox potential ($Eh_{min}$), actual redox potential ($Eh_{act}$), reduction energy of the water–alcohol infusion of plant raw materials ($RE_{inf}$), and antioxidant capacity of the plant material ($RE_{plant}$).

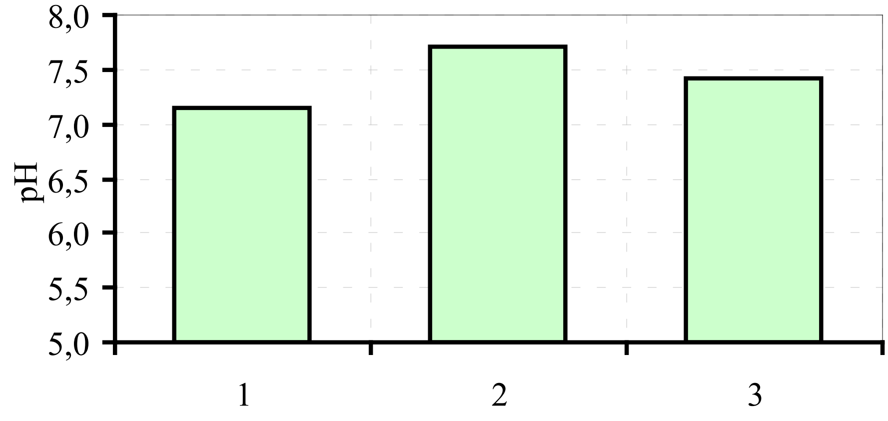


Figure 5. Active acidity (pH) of water–alcohol infusions:
1 – control sample (water–alcohol mixture); 2 – green tea infusion in a water–alcohol solution;
3 – matcha infusion in a water–alcohol solution

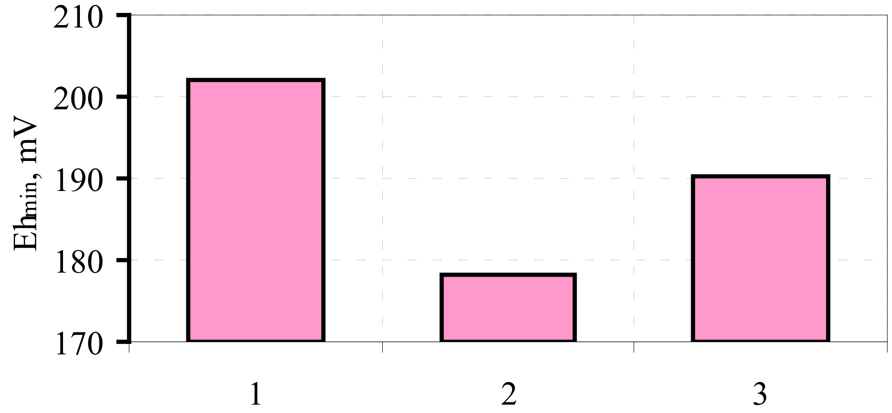


Figure 6. Minimum theoretical redox potential ($Eh_{min}$) of water–alcohol infusions:
1 – control sample (water–alcohol mixture); 2 – green tea infusion in a water–alcohol solution;
3 – matcha infusion in a water–alcohol solution

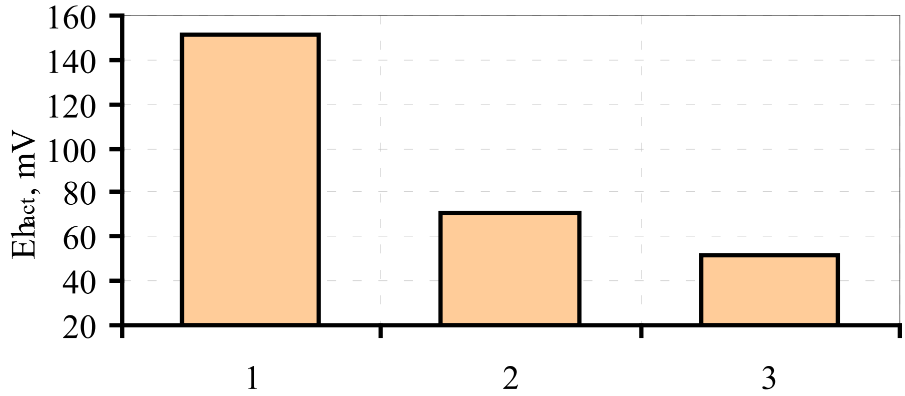


Figure 7. Actual measured redox potential ($Eh_{act}$) of water–alcohol infusions:
1 – control sample (water–alcohol mixture); 2 – green tea infusion in a water–alcohol solution;
3 – matcha infusion in a water–alcohol solution

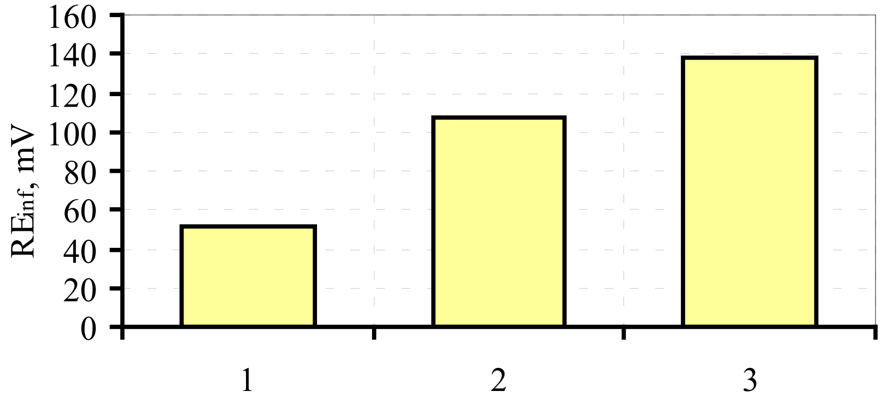


Figure 8. Recovery energy of infusions ($RE_{inf}$):
1 – control sample (water–alcohol mixture); 2 – green tea infusion in a water–alcohol solution;
3 – matcha infusion in a water–alcohol solution

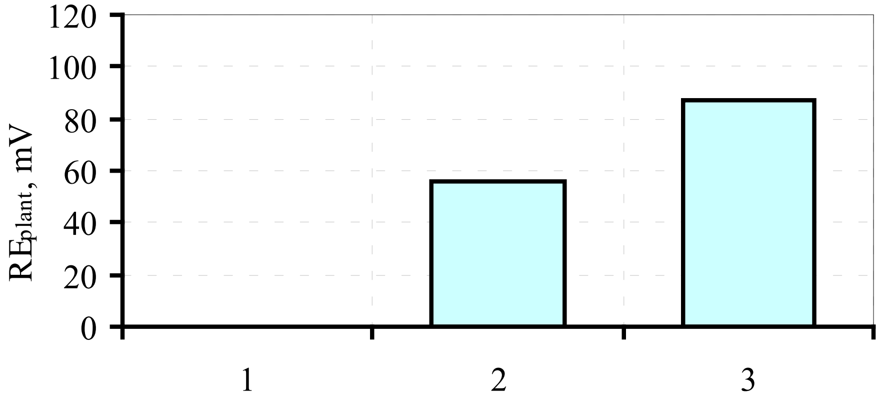


Figure 9. Redox energy of plant materials ($RE_{plant}$):
1 – control sample (water–alcohol mixture); 2 – green tea infusion in a water–alcohol solution;
3 – matcha infusion in a water–alcohol solution.

Interpretation of Antioxidant Parameters:

The water–alcohol mixture (control) has a pH level of 7.14, which is close to a neutral environment, and a theoretical redox potential calculated as $Eh_{min}$ = 202.12 mV, reflecting the baseline redox behavior of the solvent depending on the pH level. The actual redox potential is $Eh_{act}$ = 151 mV, which is lower than the theoretical value, resulting in a difference of $RE_{inf}$ = 51.12 mV, representing the intrinsic redox effect of the solvent ($RE_{sol}$). Since no plant material is present, $RE_{plant}$ = 0 mV, confirming the absence of antioxidant contribution as expected for the control sample. This sample serves as a reference for assessing the antioxidant properties of plant infusions.

The green tea infusion has a slightly higher pH (7.71) than the control sample, indicating a mildly more alkaline environment. The theoretical redox potential calculated as $Eh_{min}$ = 178.18 mV is lower than that of the control due to the higher pH. The actual redox potential ($Eh_{act}$ = 71 mV) is significantly lower than the theoretical, resulting in $RE_{inf}$ = 107.18 mV, indicating a substantial reduction in redox potential due to green tea. After subtracting the solvent's redox effect ($RE_{sol}$ = 51.12 mV), the net antioxidant potential is $RE_{plant}$ = 56.06 mV. The positive $RE_{plant}$ value confirms that green tea exhibits antioxidant properties, likely due to compounds such as catechins that donate electrons and reduce the system's redox potential.

The water–alcohol infusion of matcha has a pH of 7.42, which is intermediate between the control and green tea infusion. The theoretical redox potential calculated as $Eh_{min}$ = 190.36 mV is higher than that of green tea due to the lower pH. The actual redox potential ($Eh_{act}$ = 52 mV) is the lowest among all samples, resulting in $RE_{inf}$ = 138.36 mV, indicating a significant reduction in redox potential due to matcha. After subtracting the solvent's redox effect ($RE_{sol}$ = 51.12 mV), the net antioxidant potential is $RE_{plant}$ = 87.24 mV. This is the highest $RE_{plant}$ value among the samples, indicating the strongest antioxidant capacity of matcha, likely due to a higher concentration of antioxidant compounds such as catechins compared to green tea.

The analysis of antioxidant characteristics of the water–alcohol samples demonstrated a significant increase in reducing potential upon the addition of plant raw materials. The highest antioxidant activity was observed in the matcha infusion ($RE_{plant}$ = 87.24 mV), indicating a higher concentration of reductively active substances in this sample. The matcha infusion also exhibited the lowest actual Eh value, further confirming its ability to reduce the redox potential of the system.

Studies by other authors [2] show that the chlorophyll content in matcha is 5.65 mg/g, which significantly exceeds the corresponding value in regular green tea (4.33 mg/g). Catechins are also present in higher concentrations in matcha, contributing to its potent antioxidant effect.

Therefore, based on antioxidant activity indicators, matcha is the most promising raw material for developing functional products with enhanced biological value.

3. Technology and recipe of innovative syrnyky with matcha powder. Syrnyky, a traditional Ukrainian dish, are characterized by a soft texture and delicate flavor, which provide broad opportunities for improving their quality by enriching them with functional ingredients. One such ingredient is matcha green tea powder, which not only diversifies the organoleptic properties but also significantly enhances the functional and biological value of the product.

To determine the optimal dose of matcha powder in the syrnyky recipe, a series of experimental bakes was conducted, varying the amount within 1–3% of the semi-finished product's mass. This approach allowed for selecting the best balance between sensory attributes, dough structural properties, and the visual appeal of the finished product. The main evaluation criteria included taste, aroma, color, texture, and the dough's ability to retain shaping properties.

The baseline recipe for classic syrnyky was taken from recipe No. 186 "Baked Syrnyky" [21], and an improved innovative version with matcha powder was adapted based on it.

Improved technology for preparing syrnyky with matcha powder. The innovative technology involves incorporating matcha green tea powder as a functional ingredient into the traditional syrnyky recipe. This ingredient imparts a characteristic greenish hue, a subtle grassy note in the aroma, and additional antioxidant properties to the dish.

At the first stage, the quark cheese (5–9% fat content) is mashed to a homogeneous consistency. Semolina, chicken eggs, vanilla, chopped dried apricots or raisins, and matcha powder are added to the cheese mass. All components are thoroughly mixed until a viscous, uniformly colored mass is obtained. Due to the addition of matcha, the dough acquires a pleasant greenish tint, which intensifies during baking.

The baking form is greased with butter. To create a surface crust, a mixture of sour cream and whole grain flour is evenly applied to the formed syrnyky. This allows for a pleasant golden crust to form after heat treatment.

Baking is carried out in a combi-steam oven using a "dry heat" mode at 170 °C for 25–30 minutes until fully cooked. After cooling, the syrnyky are cut into portions and served with sour cream or berry sauce.

The advantages of the improved recipe include not only the addition of a functional ingredient but also a reduction in simple carbohydrates: partially decreasing the amount of raisins and flour makes the product healthier for school meals. Adding matcha significantly improves the color and aroma of syrnyky as well as increases their biological value.

Rationalization of matcha dosage in the recipe. Gradual increase in the amount of matcha powder (up to 3%) enhances the flavor intensity, deepens the green color, and enriches the product with antioxidant compounds, particularly catechins. However, excessive dosage (above 3%) results in bitterness, deterioration of texture, and a decrease in the overall palatability of the dish.

**Conclusions**. The study confirms that matcha powder is a promising functional ingredient for enhancing traditional Ukrainian dishes, particularly syrnyky (cottage cheese pancakes). The presence of bioactive compounds in matcha ensures the preservation of antioxidant properties even after thermal processing. The improved recipe for syrnyky with added matcha contributes to increased nutritional value, enhanced organoleptic appeal, and aligns with current healthy eating trends, opening new opportunities for the implementation of innovative solutions in food service establishments.

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