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Effects of biologically-active preparation on physical and chemical parameters of minced meat

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ABSTRACT

The introduction of biologically-active preparations (BAP) in Konskaya Varenaya (Horse and cooked sausage) significantly alters the functional processing and structural-mechanical properties of minced meat, thereby affecting the quality of the final product. This study aimed to determine the optimal formulation of combined cooked sausage with BAP by examining the influence of varying amounts of the preparation on minced meat and sausage quality. Key functional and processing characteristics, including water-binding power (WBP), moisture content, pH level, yield, and water activity, as well as structural-mechanical properties such as yield value, adhesiveness, and plasticity, were assessed using standard laboratory methods. The results indicated that WBP is significantly influenced by both the quantity of BAP and cutting time. Additionally, the inclusion of egg-derived BAP positively affected the protein system of minced meat, leading to an increased pH and enhanced WBP.

Keywords: Biologically active preparation (BAP), Minced meat; Water-binding power (WBP), Moisture, pH, Structural-mechanical properties.
Article type: Short Communication.

INTRODUCTION

The ongoing pursuit to elevate the quality and enhance the nutritional value of processed meat products has driven significant innovations in food technology (Langyan *et al.* 2022; Tachie *et al.* 2023). One particularly noteworthy approach involves the incorporation of biologically-active preparations (BAPs) into meat formulations (Sánchez & Vázquez 2017; Chernukha *et al.* 2019; Kulczyński *et al.* 2019; Chernukha *et al.* 2020; Zaky *et al.* 2022). This method aims to introduce beneficial compounds into meat products, potentially improving their nutritional profile and functional properties (Mustafa *et al.* 2020; Zaky *et al.* 2022). Such initiatives not only demonstrate the food industry's commitment, but also inspire with its dedication to leveraging scientific advancements to offer consumers healthier and more versatile food options (Sánchez & Vázquez 2017; Pogorzelska-Nowicka *et al.* 2018). BAPs play a crucial role in meat processing as they encompass substances that have the ability to significantly influence and enhance various biological processes (Kulczyński *et al.* 2019). These preparations often consist of enzymes, probiotics, or other bioactive compounds that have been demonstrated to exert specific effects on the characteristics of minced meat (Corrêa *et al.* 2023; González-Osuna *et al.* 2024; Mishra *et al.* 2024). For instance, they can improve water-binding capacity, moisture retention, and pH stability, all of which are key factors in determining the quality and shelf life of meat products (Devi *et al.* 2023; McKee & Alvarado 2004). By leveraging these functional attributes, biologically active preparations contribute to maintaining the overall quality of minced meat, extending its shelf life, and ultimately ensuring greater satisfaction among consumers. In the

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specific context of the Konskaya Varenaya sausage, the incorporation of BAPs (bioactive peptides) is anticipated to bring about discernible alterations in various critical parameters. The functional-processing characteristics of minced meat, such as water-binding power (WBP), moisture content, pH level, yield of the finished product, and water activity, are all pivotal in determining the texture, juiciness, and overall palatability of the sausage (Sandulachi 2012; Bogart 2018; Olaimat *et al.* 2020; Qiao *et al.* 2024). These factors directly impact the sensory experience of consumers. Moreover, the structural-mechanical properties, which encompass yield value, adhesiveness, and plasticity, are of utmost importance in achieving the desired mouthfeel and consistency in the final product. These parameters are essential in ensuring high-quality and enjoyable eating experiences for consumers. This study is dedicated to examining the traditional delicacy known as "Konskaya Varenaya," which is horse and cooked sausage. This particular product is highly esteemed not only for its distinct flavor, but also for its nutritional value. The focus of this study is to investigate the potential benefits of incorporating BAPs (biologically active substances) as a substitute for the primary raw material in the production of this sausage. The primary goal is to assess how the introduction of BAPs can enhance the functional-processing and structural-mechanical properties of the sausage, leading to improvements in overall quality indicators of the finished product. The outcomes of this study are anticipated to have far-reaching implications for the meat processing industry. Specifically, the findings may pave the way for the development of healthier and more appealing products that are better aligned with evolving consumer preferences. By deepening our understanding of the effects of BAPs on horse sausage production, this study aimed to generate valuable insights that can contribute to the implementation of innovative practices in meat technology. Furthermore, the insights gained from this research are expected to play a significant role in advancing food quality and safety standards within the industry.

MATERIALS AND METHODS

To systematically evaluate the impact of varying amounts of BAP on both minced meat and the resultant sausage, comprehensive studies were conducted in the laboratory of the Department of Meat, Dairy, and Food Technology. Standardized methods were employed to assess the aforementioned parameters rigorously. By analyzing these functional and structural-mechanical characteristics, this research aimed to identify an optimal formulation for combined cooked sausage that not only meets quality standards, but also enhances nutritional value through the strategic use of biologically active preparations.

RESULTS AND DISCUSSION

Due to the fact that the water-binding power of the minced meat depends not only on the amount of the introduced preparation, but also on the cutting/chopping time, we conducted an experiment to establish this relationship (Zielbauer *et al.* 2016). The method of three-dimensional interpolation in the Mathcad system was used, where the solution to this problem was carried out by the graphical method, and the matrix of experimental points at interpolation was expressed as a plane. As a result, a graph was obtained that allows one to determine the value of water-binding power (at any point within the considered range of variables, in our case, cutting time and the amount of introduced preparation. The data is presented in Fig. 1.

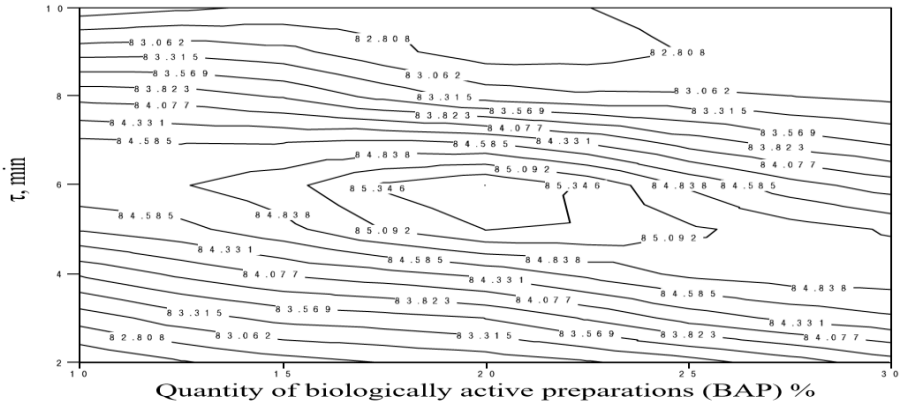

Fig. 1. Dependency of WBP on the cutting time and the amount of introduced biologically active preparation (BAP).

From the graph, it is evident that the maximum value of water-binding power (WBP) = 85.346% is achieved when

the preparation is introduced in the range of 17.5 to 22.5 units and cutting time ranges from 5 to 6.6 minutes. However, we consider the optimal point to be the peak of WBP, which occurs at 20% introduction of the additive and 6 minutes of cutting time. During the cutting process, there is a fine longitudinal and transverse grinding of horse meat fibers, which results in the release of enzyme systems that accelerate the processes of interaction between the components of the mixture, thereby enhancing the water-binding power of minced meat and facilitating subsequent structure formation. Thus, the obtained results allowed us to determine the optimal cutting time for the samples under study. The results of studies on the influence of the quantity of introduced BAP on moisture content, pH, yield of the finished product, and water activity are shown in Table 1. Based on the experimental data, graphs depicting the relationship between the functional-processing properties of the minced meat and the quantity of introduced BAP were plotted. Regression equations were derived from these graphs, enabling the prediction of the behavior of functional-processing characteristics based on the quantity of additives introduced.

Table 1. Influence of the quantity of added BAP on the changes in functional-processing properties of the studied sausages.

s under study		Values of functional-processing properties			
		Moisture content of the finished product (%)	**pH of the finished product**	**Finished product yield, (%)**	**Water activity of the finished product**
Control		64.22 ± 1.00	5.84 ± 0.01	110.0 ± 1.2	0.962 ± 0.002
Substitution of main raw materials (%)	5	64.58 ± 0.90	5.91 ± 0.03	112.0 ± 1.6	0.965 ± 0.001
	10	64.97 ± 0.80	6.02 ± 0.04	114.8 ± 1.7	0.967 ± 0.001
	15	65.32 ± 0.12	6.15 ± 0.03	115.4 ± 1.5	0.973 ± 0.003
	20	65.84 ± 0.01	6.20 ± 0.02	115.9 ± 1.7	0.982 ± 0.002
	25	66.18 ± 0.80	6.19 ± 0.04	116.1 ± 1.7	0.987 ± 0.002
	30	66.40 ± 0.70	6.18 ± 0.02	116.2 ± 1.7	0.999 ± 0.003

The moisture content of the minced meat is an important functional-processing characteristic that ultimately determines the quality and yield of the finished product (Suchenko *et al.* 2017; Borisenko *et al.* 2021). Since BAP has a relatively high moisture content and its introduction leads to changes in the internal structural composition of the minced meat, our task was to monitor the moisture content changes in experimental samples during the substitution of the main raw material. From the results of the experimental research, it is evident that the most optimal moisture content, closely resembling the control sample, occurs when BAP is introduced in quantities ranging from 15% to 25% (see Fig. 2). Decreasing or increasing the moisture content of the experimental samples relative to the control is undesirable, since it would lead to changes in the heat capacity of the minced meat and, consequently, alter the thermal processing conditions of the product. The active acidity of the environment (pH) is particularly important for the condition of proteins, affecting the shelf-life stability of meat products, the structure of the minced meat, and the quality of the finished products (Jankowiak *et al.* 2021; González-Osuna *et al.* 2024). Shifting the pH of minced meat towards acidic and alkali side from the isoelectric point of muscle proteins (pH 5.4-5.5) increases their ionization, thereby hydration. During thermal processing, the denaturation of protein substances is accompanied by a shift in pH away from the isoelectric point towards the alkali side, leading to an elevation in water-binding power (WBP) of the minced meat. All this is due to changes in the electric charge of acidic groups, cleavage of peptide chains and formation of new compounds. The established dependence is characteristic for BAP and horsemeat with intramuscular fat content. Taking into account that BAPs are most active in minced meat, as its pH is close to the optimum of enzyme action, this fact shall be taken into account during minced meat preparation. Comparing the formula data - chemical and structural properties of the meat batter when prepared with the addition of BAP, the established formula suggests using such additives at early stages of minced meat preparation due to the shorter stabilization periods of its quality indicators. Introduction of a specific quantity of BAP from eggs into the minced meat formula (Fig. 3) results in qualitative and quantitative changes in its protein system: the pH shifts towards neutral from the isoelectric point of muscle proteins, thereby

increasing the ability to hydrate and solubilize the actinomyosin protein complex. Initially, the pH of BAP from eggs is higher than the pH of horsemeat (6.8 compared to 5.93). This difference is attributed to the presence of connective tissue proteins and egg yolks, which contribute to the higher pH level.

The pH of the raw minced meat increases by 0.06 to 0.34 units compared to the control sample. For traditional cooked sausage products, the pH of the mined meat typically ranges from 6.0 to 6.3. Further increase in pH towards the alkali side is undesirable because it leads to excessive increase in the porosity of the finished product and promotes the growth of putrefactive microorganism.

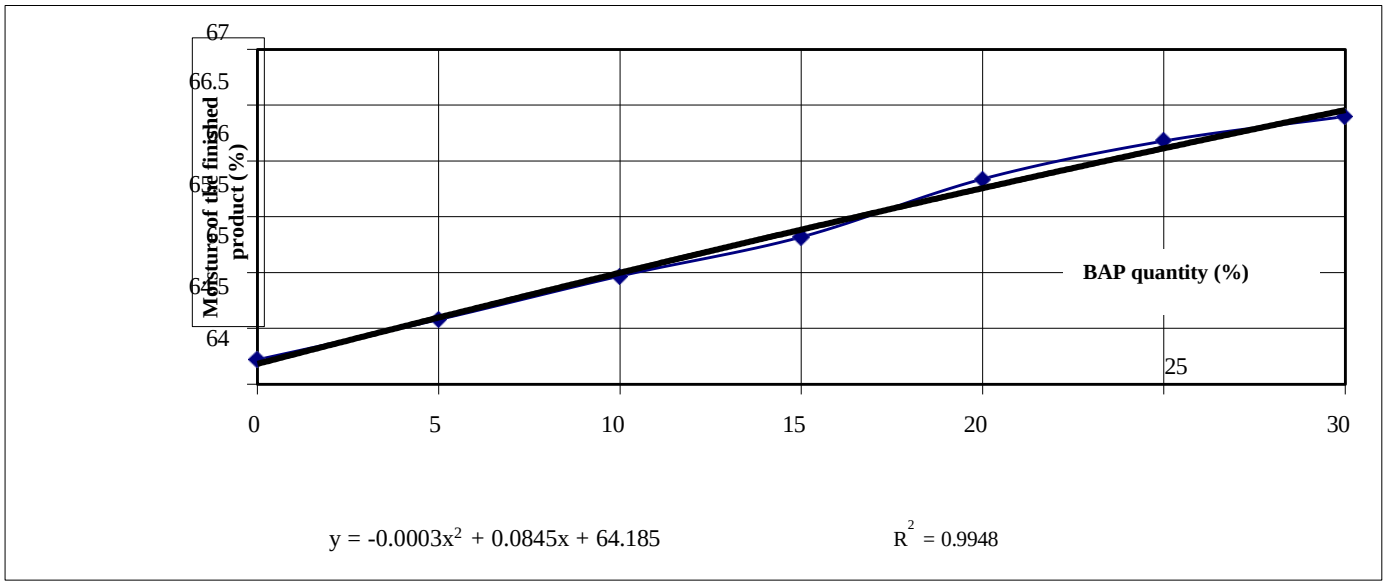

Fig. 2. Dependency of the moisture content of the finished product on the quantity of added biologically active preparation.

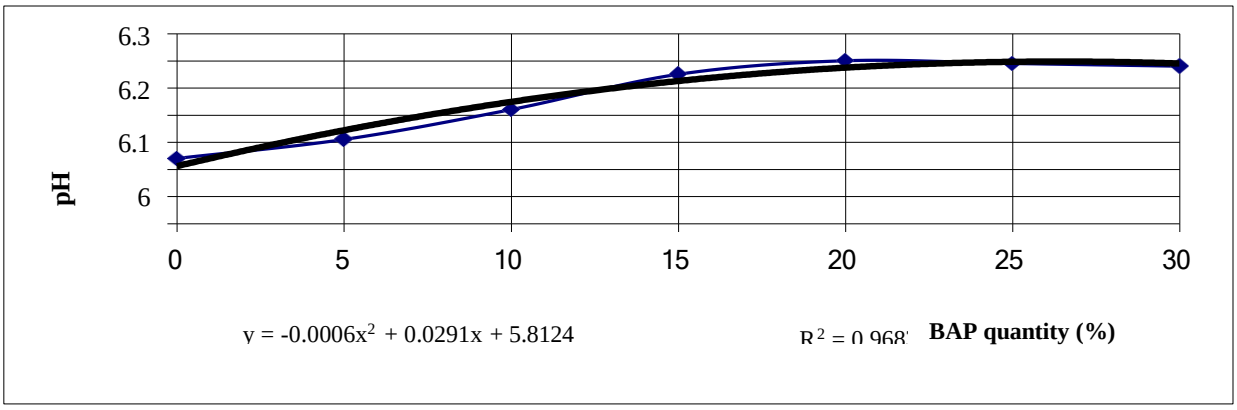

Fig. 3. Dependency of pH of the finished product on the quantity of BAP.

From the data in Table 1 and Fig. 3, it is evident that the pH of the minced meat with added BAP shifts towards the alkali side from the pH 5.84 of the control sample. It enters the range typical for traditional cooked sausage products, starting from the initial level of BAP introduction. It has been established that the biologically active preparation not only affects the moisture content but also influences the yield of the finished products. When substituting a portion of meat with a BAP, there is an absorption and retention of moisture due to the swelling of proteins. By the increase in water-binding power (WBP) of the minced meat batter, the yield of experimental samples of meat products with BAP increases by 5-6% compared to the control (see Fig. 4). In Fig. 4, the dependence of the yield of the studied sausage products with BAP is presented, clearly showing an increase in yield when the content of the BAP is between 15% to 25%. Further increase in the quantity of the introduced preparation leads to a reduction in the yield of the product due to decreased water-binding power (WBP) and increased pH of the mined meat. The data on the study of the influence of the quantity of introduced preparation on weight loss after heat treatment and the moisture content of the finished products are presented in Table 2 and

Fig. 5.

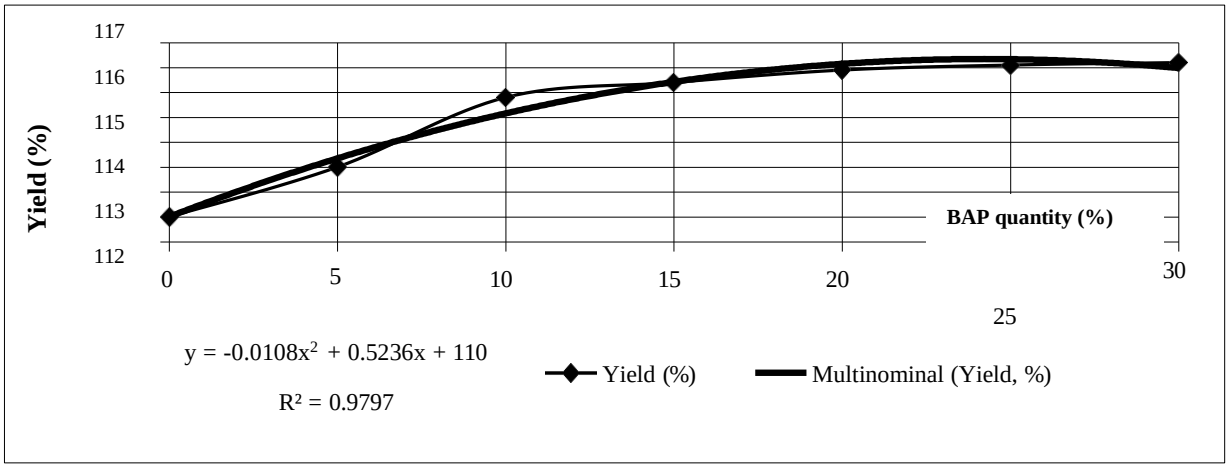

Fig. 4. The dependence of the yield of the studied samples on the BAP quantity

Table 2. The influence of the biologically active preparation on the ability of sausage minced meat retain moisture during heat treatment.

BAP quantity (%)	Loss in weight (%)
Control	14.15 ± 1.24
5	13.06 ± 1.09
10	12.60 ± 1.12
15	12.05 ± 1.16
20	11.50 ± 1.10
25	10.90 ± 1.12

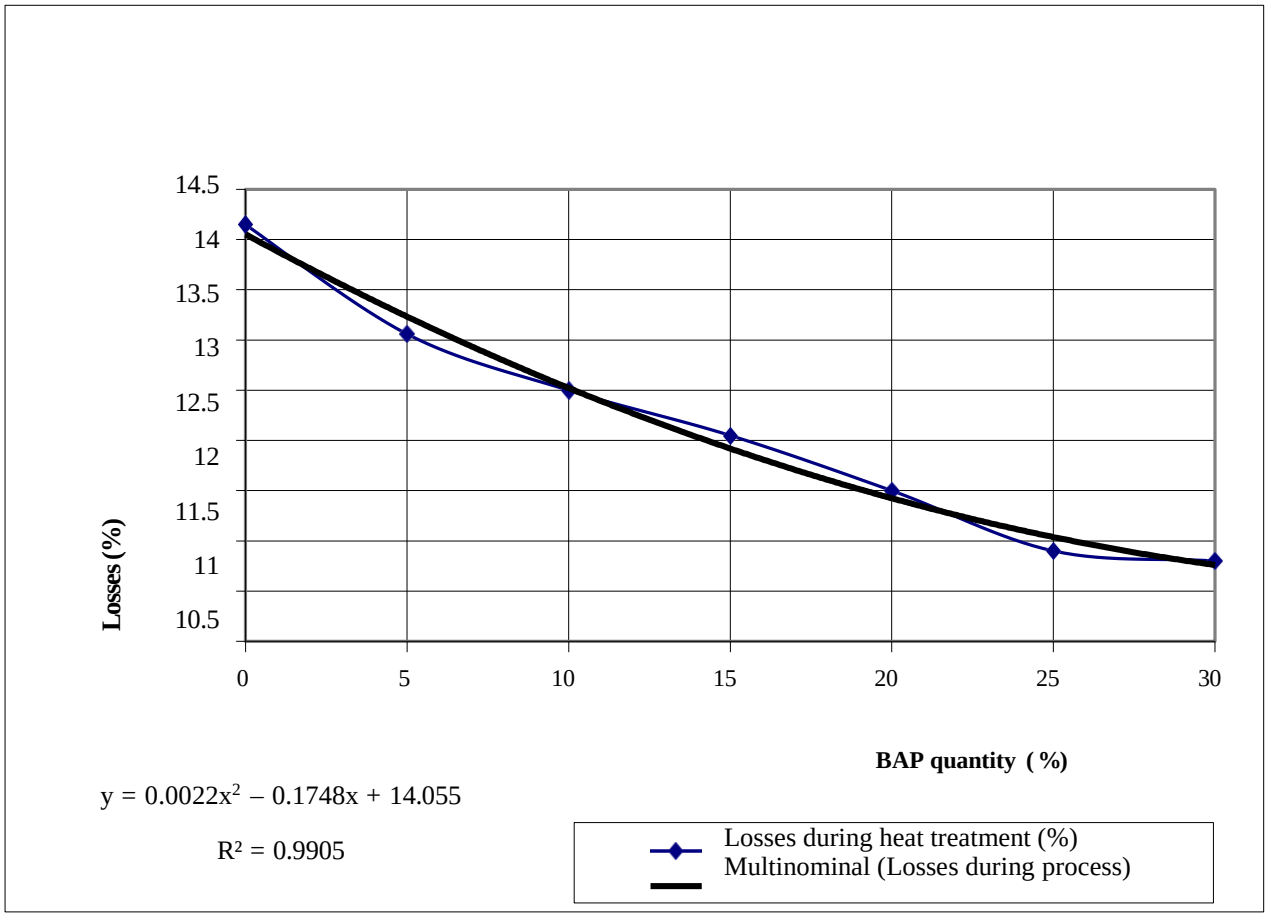

Fig. 5. Dependency of losses on the BAP quantity.

As would be expected, the addition of a biologically active preparation to the minced combined meat product contributes to a marked improvement in moisture retention during heat treatment. Losses of weight in experimental samples of combined meat product of BAP are reduced in comparison with the control and make up to 5.32 % at introduction of the last 20 %, which is about 0.8 % less than losses during production of the control sample.

CONCLUSION

The conducted experiment established the relationship between minced meat's water-binding power (WBP) and preparation amount and cutting time. Using three-dimensional interpolation in the Mathcad system, we graphically determined the optimal conditions for maximizing WBP to be a preparation range of 17.5 to 22.5 units and a cutting time of 5 to 6.6 minutes. The highest WBP of 85.346% is achieved with 20% preparation and 6 minutes of cutting time. The findings provide valuable insights for optimizing the processing conditions for Konskaya Varenaya. The study demonstrated the significant impact of biologically active preparation (BAP) on the properties of minced meat. The introduction of BAP led to notable changes in the internal structural composition of the minced meat, affecting its moisture content, pH, yield, and water activity. The findings highlight the importance of optimizing the quantity of BAP to enhance the functional-processing properties of minced meat, improving the quality and yield of the final product. The optimal moisture content for minced meat is achieved by a BAP in quantities ranging from 15% to 25%. Adjusting the pH away from the isoelectric point enhances hydration and water-binding power during thermal processing. BAPs are most effective when introduced early in the minced meat preparation process for improved functional and structural properties of the meat batter. Adding BAP from eggs to minced meat changes its protein system significantly, shifting the pH towards neutral and improving hydration and solubilization of proteins. Careful control of BAP amount is crucial to optimize finished product quality. The study confirms that using a BAP in meat products increases moisture content and yield. Replacing a portion of meat with BAP enhances moisture absorption and retention, resulting in a 5-6% elevation in yield. The most effective BAP content range is between 15% and 25%, as exceeding this range reduces yield. It's essential to optimize BAP content to maximize product yield and quality.

The study shows that adding BAP to minced meat products improves moisture retention during heat treatment. Samples with BAP had up to 5.32% less weight loss compared to the control sample, indicating its effectiveness in maintaining quality and yield during processing.

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