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Maintaining Hygiene Standards in Panko Bread Production: Insights into Equipment Cleaning Processes

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ABSTRACT: This study examines the hygiene standards essential for producing Panko bread, a popular breadcrumb known for its light and crispy texture. Ensuring high hygiene standards is critical to maintaining both product safety and quality. The research evaluates the hygiene and safety of Panko bread by assessing its physical characteristics to detect impurities and foreign objects, alongside sensory evaluations to determine its sensory attributes. The study encountered challenges in maintaining consistent hygiene practices throughout production, as any lapse could lead to contamination risks. Additionally, thorough inspections for physical impurities added complexity to the workflow, requiring meticulous quality control. The findings indicate that the produced Panko bread is free from harmful contaminants such as dirt, insects, and biological matter, demonstrating adherence to stringent hygiene standards. Sensory evaluations further confirm its desirable qualities, including a soft texture and pleasant baked flavor, without off-tastes or odors, enhancing consumer appeal. The study concludes that effective hygiene practices and rigorous quality control measures are crucial in Panko bread production, ensuring both product safety and high consumer acceptance.

Keywords: Panko Bread, Hygiene, Sensory Attributes, Pesticides, Chemical Parameters.

INTRODUCTION

Bread is a staple food for many people worldwide, with an average annual consumption of 59 to 70 kilogrammes per person. This is because of its high calorie content, relative affordability, and diversity in preparation. The main ingredients are flour, water, yeast, and salt, yet numerous pastries have been created based on the ingredients and baking techniques utilised in each area or culture. According to Salinas and Pippo (2018) bread is a solid, heterogeneous, and unstable foam made up of crust and crumbs, with starch granules as its primary constituents arranged in a continuous proteic matrix. These macromolecules include amylose and amylopectin. While amylopectin is a branching polymer with α-1,6 links, amylose is a linear polymer made up of glucose monomers connected by α-1,4 glycosidic linkages (Korompokis *et al*., 2021). Cereals have amylose concentrations between 18 and 33% and amylopectin values between 70 and 80% (Lal *et al.*, 2021). Bread is a widely consumed staple food with significant nutritional value (Dahiya *et al*., 2019). Recent research has focused on improving bread quality and reducing waste. Wasted bread can be repurposed into flour, with crust and crumb flours exhibiting different properties that could be utilised in various food products (Fernández-Peláez *et al*., 2021). When preparing bread, the kind of flour and leavening agent used are crucial in determining the final product's quality. Compared to refined flour, whole grain flour exhibits superior overall nutritional quality because of its high fibre content, minerals, and bioactive substances (Venturi *et al*., 2021). Wheat flour produces a dough with the required rheological qualities when combined with yeast (Scheuer *et al.*, 2014), making it the most popular grain for breadmaking **(**Calvo Carrillo *et al.*, 2020; Rai *et al.*, 2012). Additionally, due to its vital nutrients, wheat is consumed by about 40% of the world's population (Giraldo *et al.*, 2019). Because of its capacity to adapt to a wide range of climatic conditions, this grain accounts for 27% of the world's cereal production (Heshe *et al*., 2016).
Wheat (Triticum aestivum) is such a significant cereal in Europe that it is the primary producer, with 123 million tonnes produced per year, followed by China (96 million tonnes) and India (72 million tonnes). Bread, cakes, spaghetti, and biscuits are all made from wheat flour (Sakandar *et al*., 2019). With almost nine billion kilograms consumed annually, bread is a mainstay of the world's diet (Li *et al*., 2021). The

average annual intake in affluent nations is 70 kg per person (De Boni *et al.*, 2019). Ensuring food safety and quality is a top priority across the global agri-food sector, from farm production to food enterprises. In the panko bread industry, strict adherence to food safety standards is crucial to prevent contamination and maintain product excellence (Sahani *et al.,* 2024). Wheat's high production makes it an inexpensive cereal, further contributing to its widespread global consumption (Sakandar *et al.,* 2019).

MATERIAL AND METHODS

This research was conducted in a workstation laboratory located at Ludhiana, Punjab, India. The formulation for the product included a variety of ingredients aimed at enhancing texture, flavour, and nutritional quality. The primary components were wheat flour, water, and sugar, providing the base and essential carbohydrate source. Gluten was added to improve dough elasticity, while yeast facilitated leavening through fermentation (Cukier de Aquino *et al*., 2012). Additional ingredients like lactic acid and malt extract were incorporated for flavour enhancement and preservation. The formulation included iodised salt, rice bran oil, and edible vegetable fat to enhance taste, mouthfeel, and nutritional value. Soya flour, wheat bran, garlic powder, and tuity fruity were used to add fibre, flavour, and distinct sensory qualities. Multigrains were integrated to enhance the product's nutrient profile. Class II preservatives, such as calcium propionate and sorbic acid, were utilised to extend shelf life (Saini *et al*., 2021), while permitted emulsifiers (E481i) and acidity regulators (E260) were added for product stability and flavour consistency. Antioxidants, including ascorbic acid and E300, were also incorporated to maintain product freshness. Fumaric acid was added to adjust pH and improve texture.

The process begins with the receipt of incoming raw materials, primarily wheat flour, which is subjected to quality control (QC) sampling and testing to verify compliance with set standards. If the material passes the QC check, it is cleared for the next step; if not, it is labelled as "rejected" and returned to the supplier. Once approved, the raw material is stored until needed for further processing. At this stage, the stored flour is shifted to a designated sieving room, where it undergoes sieving to remove impurities and ensure a refined product. During this process, any waste and foreign materials, such as threads, maida lumps, insects, paper, and other contaminants, are separated out and disposed of. The sieved refined wheat flour is then poured into a bowl, measured according to the specific batch size required for production. This measured flour is combined with minor and major ingredients per the recipe, and treated UV-filtered water is added to aid in the dough-making process, ensuring both the texture and quality of the dough meet required standards. Finally, the prepared dough moves to a divider, which portions the dough based on specified weight requirements. This prepares the dough for the next stages in production, which may include shaping, baking, or packaging. The entire flow ensures quality control, efficient waste management, and consistent batch preparation, vital for maintaining product quality and safety throughout the production line.

The bread manufacturing process involves several critical stages, each essential to ensure a high-quality final product.

Formulation: The first stage involves precise measurement and mixing of ingredients, including flour, water, yeast, salt, and any additional ingredients (e.g., sugar, fats, or improvers) as per the desired bread formulation. The accuracy of formulation is crucial to achieving consistent dough quality.

Mixing: In this step, ingredients are combined in a mixer to develop the dough. Mixing helps hydrate the flour and develop gluten, a protein that gives bread its structure. The dough must be kneaded to the correct consistency, ensuring a smooth texture and the right level of elasticity.

Fig. 1. Panko White Crumbs.

Moulding: The mixed dough is then divided into portions and shaped or moulded into the desired form. This can include shaping the dough into loaves, rolls, or other shapes, depending on the type of bread being produced. Moulding plays a crucial role in bread making, influencing aeration and rheology throughout the process (Campbell and Martin 2020). The use of baking moulds has ancient origins, with evidence from archaeological contexts in the Near East revealing early bread-making techniques and tools (Balossi and Mori 2014).

Proofing (Fermentation): The shaped dough portions are then placed in a controlled environment, usually a proofing chamber with specific temperature and humidity levels, to allow fermentation. During proofing, the yeast ferments the sugars in the dough, producing carbon dioxide gas, which causes the dough to rise and develop flavour. Carbon dioxide production during proofing has been correlated with fermentation parameters and final bread quality (Istudor *et al.,* 2020).

Fig. 2. Panko Loaf.

Baking: The proofed dough is placed in an oven, where it undergoes a baking process at a set temperature and duration. Baking causes the dough to expand further, and the heat kills the yeast, solidifies the dough structure, and gives the bread its characteristic texture and crust. The baking stage is critical for setting the final bread structure, but it can also affect the stability of certain compounds. For instance, ochratoxin A, a mycotoxin that can contaminate wheat flour, shows high stability during fermentation but lower stability during baking (Milani and Heidari 2017).

Depanning: After baking, the bread is removed from the pans or moulds (if used). This step must be done carefully to avoid damaging the bread's shape or texture.

Cooling: The freshly baked bread is transferred to cooling racks to allow it to cool to room temperature. Proper cooling is essential, as it allows moisture and gases within the bread to escape, which prevents sogginess and ensures a better texture. Cooling is a critical process in bread making that affects product quality and shelf life (Kinner *et al*., 2021).

Slicing: For sliced bread, the cooled loaves are fed through an automatic slicer, which cuts them into uniform slices according to the desired thickness. This step is typically skipped if the product is unsliced or in a whole loaf format. Traditional methods using standard knives are less effective for small to medium-scale bakers**.** Automated cutting machines can improve efficiency, with one design capable of slicing a loaf in 38 seconds (Rahmawati *et al.,* 2023). The slicing process affects bread quality and consumer preference, with factors like moisture content and cell structure influencing sensory characteristics (Marinopoulou *et al.,* 2020).

Packaging: The bread is then packaged in suitable packaging material to maintain freshness, protect it from external contaminants, and extend its shelf life. Packaging is often done in plastic bags, but other options, such as paper wraps, may be used for speciality or artisan breads. Modified atmosphere packaging (MAP) and active packaging (AP) have gained attention for their ability to prolong shelf life and prevent fungal growth naturally (Subramaniyan *et al*., 2022).

Metal Detection: To ensure food safety, the packaged bread is passed through a metal detector to check for any metal contaminants that may have entered the product during the manufacturing process. This step is crucial to comply with food safety standards. Recent studies have investigated heavy metal contamination in bread across different countries. While some essential trace metals like Cu, Zn, and Mn were found at safe levels in Nigerian bread (Akpambang and Onifade 2020), other research revealed concerning levels of certain metals. In Iran, Al, Fe, and Na exceeded permissible limits in traditional flatbreads, with children facing higher non-carcinogenic risks (Khodaei *et al*., 2023).

Stacking: The packaged bread is then organized and stacked appropriately to prepare for storage or transportation. Stacking ensures that the packages are handled efficiently and prevents damage during handling.

Storage and Shipping: Finally, the packaged and stacked bread is stored in a controlled environment until it is ready for distribution. It is then shipped to retail outlets, ensuring that it reaches consumers while still fresh. Proper bread type selection and good sanitary practices are simple ways to prolong bread storage (Alpers *et al.,* 2021).

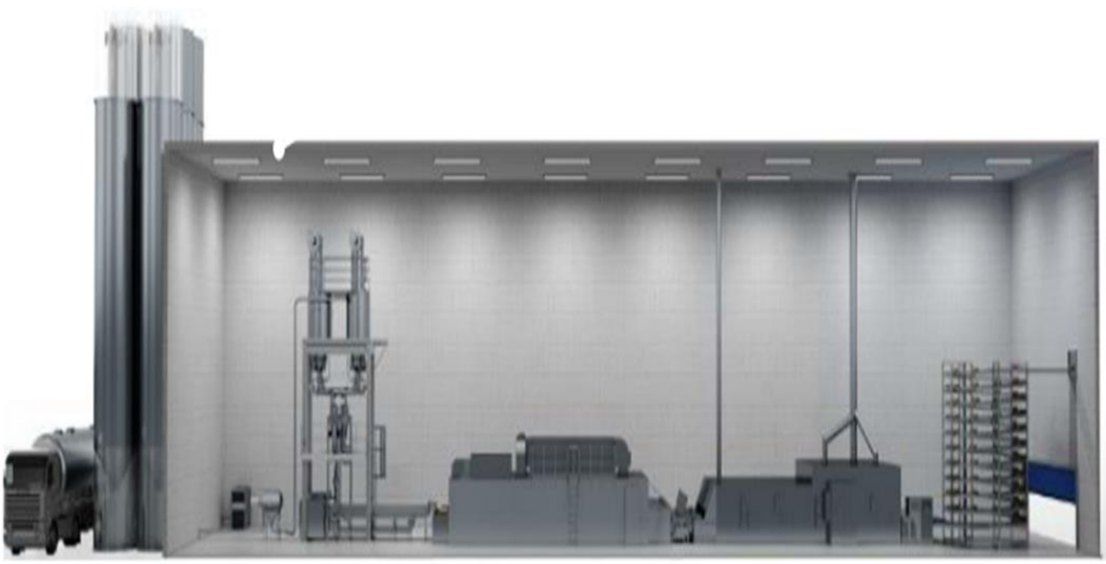

Fig. 3. Bread Production Line.

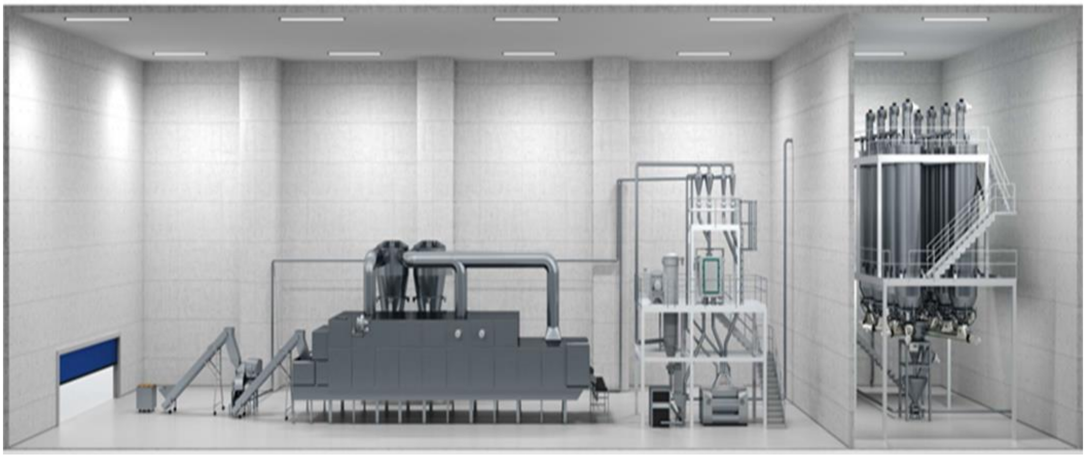

Fig. 4. Bread Crumbs Production Line.

Storage and Handling Guidelines. Before dispatch, the product should be stored in a cool, dry, and hygienic environment, away from direct sunlight. After dispatch, it is important to maintain similar conditions: keep the product cool, dry, and hygienic, also avoiding exposure to direct sunlight. Ensure that the storage area is free from odours to preserve product quality.

Organoleptic Characteristics (Sensory Properties). The product was shaped like a rectangle, featuring a golden-brown crust and a white or brown crumb. It was soft and had fine grains. It possessed a typical baked goods flavour, free from any off-taste or off-odour.

Chemical Characteristics (External Testing). The moisture content and crude fiber were determined by using AOAC method (Gopalan *et al*., 2009) mineral analysis by ICP-OES and pH was determined by pH meter. Alcoholic acidity and acid insoluble ash were also determined. Water activity (aw) is an important factor in evaluating the quality and safety of a product. It measures the availability of free water within a system, which can influence microbial growth, chemical reactions, and physical properties. In this study, a standard water activity meter (Aqua Lab water activity meter) was employed to assess the water activity of the extrudates developed.

Microbiological Characteristics (External Testing). All bread samples were tested to determine the total bacterial count, coliform count, yeast & mold count, salmonella, E. coli and S. aureus were carried out on the bread samples to determine the microbial load of the samples (Harrigan, 1998).

Pesticides Residue. All bread samples underwent testing for pesticide residues utilizing liquid chromatography mass spectrometry. This method ensures accurate detection and quantification of any harmful substances present in the samples.

RESULT AND DISCUSSION

Physical Parameters. The product was thoroughly evaluated for physical impurities and foreign matter, and the results showed that no dirt was detected, indicating complete absence. Additionally, a careful inspection revealed that neither insects nor any insect fragments were present. The assessment also confirmed that no larvae were found, as they were entirely absent. Furthermore, a detailed examination showed that there were no traces of rodent hair within the product. It was noted that there were no added colouring substances, as these were completely absent. Finally, the analysis indicated that harmful or injurious foreign matter was not detected, demonstrating that the product is free from any physical contaminants. Overall, these results ensure that the product adheres to stringent hygiene and safety standards.

Table 1: Physical And Chemical Parameters of Panko Bread.

Sr. No.	Parameter(s)	Unit(s)	Result(s)
1.	Dirt	—	Absent
2.	Insect & Insect Fragments	—	Absent
3.	Larvae	—	Absent
4.	Rodent Hair	—	Absent
5.	Added Colouring Matter	—	Absent
6.	Harmful/Injurious Foreign Matter	—	Absent

Chemical Parameters. The chemical parameters of the product indicate a moisture content of 7.50%, which points to the amount of water present, and a salt concentration of 0.90% (as NaCl), reflecting the salt levels, and together these values suggest the product's overall chemical quality in relation to its moisture and salt content. Proximate analysis of bread samples reveals protein content between 9.13-9.79%, fat 1.64-4.50%, and moisture 27.22-29.05% (Adeoye *et al.*, 2021). Salt plays important roles in bread-making, including improving dough quality, flavor, and shelf life (Nahar *et al*., 2019), excessive intake is linked to hypertension and other health issues (Jafari *et al.*, 2016).

S. No.	Parameter(s)	Unit(s)	Result(s)
1	Moisture	%	7.50
2	Salt	%	0.90
3	Fibre	%	3.7

Heavy Metals. The examination of heavy metals indicates that the levels of mercury, lead, copper, arsenic, and tin are all below the detection thresholds, specifically less than 0.1 mg/kg for mercury, lead, and arsenic, less than 1.0 mg/kg for copper, and less than 5 mg/kg for tin, confirming the product's safety for consumption. Studies found metal concentrations below permissible limits set by FAO/WHO (Rasheed, 2022), others reported levels exceeding these limits, particularly for aluminum, iron, and sodium (Khodaei *et al.,* 2023). The highest concentrations of heavy metals were typically found in bran bread samples (Abou-raya *et al.*, 2007).

Table 2: Heavy Metals in Panko Bread.

Sr. No.	Parameter(s)	Unit(s)	Result(s)
1.	Mercury (as Hg)	mg/kg	< 0.1
2.	Lead (as Pb)	mg/kg	< 0.1
3.	Copper (as Cu)	mg/kg	< 1.0
4.	Arsenic (as As)	mg/kg	< 0.1
5.	Tin (as Sn)	mg/kg	< 5.0
6.	Cadmium (as Cd)	mg/kg	< 0.1
7.	Methyl Mercury	mg/kg	< 0.01

Microbial Analysis. The microbiological analysis of the product indicates robust safety and quality, as evidenced by the Total Plate Count of 3.6×10^3 cfu/g, which falls within safe limits and suggests good hygiene during processing and storage; the absence of E. coli confirms no faecal contamination, while the very low level of Total Coliforms (<10 cfu/g) further supports hygiene standards; notably, Staphylococcus aureus and Shigella were both absent, indicating no risk of food poisoning from these pathogens; similarly, the absence of Salmonella ensures the product is free from one of the most common foodborne illness causes; the Yeast and Mould count of 78 cfu/g, though present, remains low and does not significantly compromise food quality or safety; additionally, the absence of Clostridium perfringens confirms no risk of food poisoning, and the non-detection of Listeria monocytogenes signifies a critical safeguard against listeriosis, particularly for vulnerable populations; collectively, these findings affirm the microbiological integrity of the product, rendering it safe for consumption. Post-baking contamination significantly affects bread's microbial quality (György and Laslo 2024). Total viable bacterial counts in commercial breads range from 10 to 395 CFU/g, with variations between crust and crumb (György and Laslo 2024).

Table 3: Microbial Analysis in Panko Bread.

Sr. No.	Parameter(s)	Unit(s)	Result(s)
1.	Total Plate Count	cfu/g	3.6×10^3
2.	E. Coli	per g	Absent
3.	Total Coliforms	cfu/g	< 10
4.	S. Aureus	per 25g	Absent
5.	Shigella	per 25g	Absent
6.	Salmonella	per 25g	Absent
7.	Yeast & Mold	cfu/g	78
8.	Clostridium Perfringens	per 25g	Absent
9.	Listeria Monocytogenes	per 25g	Absent

Pesticides Residue. In the study most pesticides were detected at levels below their quantification limits (<0.001 to <0.005 mg/kg). These include commonly used pesticides such as Cypermethrin, Chlorpyrifos, and Pyrethrins. Pesticides like Tridemorph, Heptachlor, and Carbaryl were detected at levels as low as <0.0001 mg/kg, indicating stringent adherence to safety standards. Compounds like Hydrogen cyanide and Phosphide show detectable levels below 0.01 mg/kg, suggesting minimal risk from post-harvest treatments. Residues such as 2,4-D and Pendimethalin remain under the permissible detection limit (<0.002 to <0.005 mg/kg). Major agricultural chemicals, including Carbendazim, Triadimefon, and Propiconazole, are within acceptable residual limits. The results demonstrate significant compliance with food safety standards such as Codex Alimentarius and FSSAI, ensuring consumer safety from pesticide residues. Residues of dichlorodiphenyltrichloroethane and chlorpyrifos are reported globally, while illegal and counterfeit pesticides further compromise food safety (Zikankuba *et al*., 2019).

Table 4: Pesticides Residue in Panko Bread.

Sr. No.	Parameter	Unit	Result
1.	Cypermethrin	mg/kg	< 0.0001
2.	Methyl chloro-phenoxy-acetic acid	mg/kg	< 0.0001
3.	Tridemorph	mg/kg	< 0.0001
4.	Propiconazole	mg/kg	< 0.0002
5.	Sullfosulfuron	mg/kg	< 0.0001
6.	Trifluralin	mg/kg	< 0.001
7.	Chlorimuron-ethyl	mg/kg	< 0.0005
8.	Dichlofop-methyl	mg/kg	< 0.0001
9.	Pendimethalin	mg/kg	< 0.0005
10.	Metasulfuron-ethyl	mg/kg	< 0.001
11.	Methabenzthiazuron	mg/kg	< 0.0001
12.	Triallate	mg/kg	< 0.0002
13.	Fenox-prop-p-ethyl	mg/kg	<0.001
14.	Triadimefon	mg/kg	<0.002
15.	Isoproturon	mg/kg	<0.002
16.	Tebuconazole	mg/kg	<0.003
17.	Aldrin	mg/kg	< 0.0001
18.	Dieldrin	mg/kg	<0.0001
19.	Carbaryl	mg/kg	<0.0001
20.	Chlordane	mg/kg	<0.0003
21.	Diazinon	mg/kg	<0.0002
22.	dichlorvos	mg/kg	<0.01
23.	Fenitrthion	mg/kg	<0.0001
24.	Heptachlor	mg/kg	<0.0001
25.	Hydrogen cyanide	mg/kg	< 0.01
26.	Hydrogen phosphide	mg/kg	<0.001
27.	Inorganic bromide	mg/kg	<0.02
28.	Gamma – isomer (Lindane)	mg/kg	<0.001
29.	Matathion	mg/kg	<0.001
30.	Phosphamidon residues	mg/kg	< 0.003
31.	Pyrethrins	mg/kg	<0.0003
32.	Chlrienvinphos	mg/kg	<0.0001
33.	Chlorpyrifos	mg/kg	<0.004
34.	2,4 D	mg/kg	<0.0002
35.	Ethion	mg/kg	<0.0001
36.	Monocrotophos	mg/kg	<0.0003
37.	Paraquat dichloride	mg/kg	<0.001
38.	Trichlorfon	mg/kg	<0.0001
39.	Thiometon	mg/kg	<0.0003
40.	Carbendazin	mg/kg	<0.001
41.	Bejomyl	mg/kg	<0.002
42.	Carbofuran	mg/kg	<0.001
43.	Decamethrin / Deltamethrin	mg/kg	<0.003
44.	Fenthion	mg/kg	<0.004
45.	Dithiocarbamates	mg/kg	<0.0001
46.	Phenthoate	mg/kg	<0.005
47.	Phorate	mg/kg	<0.003
48.	Pirimiphos-methyl	mg/kg	<0.002
49.	Bitertanol	mg/kg	<0.001
50.	Oxydemeton methyl	mg/kg	<0.001
51.	Chlodinafop propanyl	mg/kg	<0.003

CONCLUSIONS

The research on Panko bread production highlights the critical importance of maintaining hygiene standards and effective production practices. The findings confirm that the bread was free from harmful contaminants, including dirt and insects, ensuring compliance with stringent hygiene standards. Additionally, there were no biological contaminants such as larvae or rodent hair, indicating successful measures to prevent contamination.

The careful selection of ingredients, including refined wheat flour, water, sugar, gluten, and yeast, enhances the bread's texture, flavor, and nutritional quality, contributing to overall product safety. The study also measured moisture content and water activity, which are vital in assessing quality and potential microbial growth.

Sensory evaluations revealed that the Panko bread had a desirable soft texture and typical baked flavor without off-tastes or odors, appealing to consumers. Furthermore, the production process emphasized quality control and efficient waste management, crucial for maintaining product safety throughout.

In summary, the research underscores the significance of stringent hygiene practices, thoughtful ingredient selection, and efficient production processes in ensuring the safety and quality of Panko bread, serving as a valuable guideline for other food production processes aiming to uphold high hygiene standards.

FUTURE SCOPE

The future scope of research in Panko bread production hygiene standards encompasses a multifaceted approach aimed at enhancing product safety and quality. Key areas for exploration include the development of advanced automated cleaning protocols to minimize human error, implementation of long-term monitoring systems for contaminant detection, and innovation in ingredient selection to improve nutritional profiles and sensory qualities. Additionally, consumer acceptance studies will be vital for aligning products with market preferences, while sustainable practices in production and packaging can help address environmental concerns. Investigating technological advancements, such as IoT devices for real-time monitoring, alongside improvements in fermentation techniques and cross-contamination prevention measures, can further bolster hygiene standards. By focusing on these areas, future research will ensure that Panko bread production not only meets regulatory requirements but also adapts to evolving consumer demands and global market trends.

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Conflict of Interest. None.

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