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Microbial Analysis and Sensory Acceptability of Squash Donuts

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ABSTRACT

This study investigated the utilization of squash (Cucurbita maxima) in donut product development to enhance microbial safety and sensory acceptability of the product. The study aimed at determining the needed formulae with required sensory characteristics and keeping the accepted level for the quality of the food products. An experimental and descriptive design was used in the study and three formulations with different level of S pf were prepared and tested by 25 evaluators from Cagayan State University – Andrews Campus, food courses, which consists of faculty and students. Flavor profiles were evaluated by 9- point hedonic scale and microbiological analysis included total plate count, yeast and mold count and coliform count. The results showed that a formulation 2 met the acceptable microbial criteria and consequently the products were safe for consumption. Formulation 2 consisting moderate amount of squash among the others had received highest sensory scores with mean scores of "Like Very Much" for appearance, aroma, texture, taste and overall acceptability. Analysis statistics revealed a statistically significant difference in between formulations in all attributes (especially taste and texture). the research showed that incorporation of the squash into donuts improved the nutritional and sensory properties and ensured food safety; Formulation 2 was the best. These results indicate that donuts made from squash can be a healthy and acceptable substitute for conventional donuts, indicating advances in local food product development.

Keywords: *Squash (cucurbita maxima) peel, Sensory Acceptability, Microbial Analysis.*

INTRODUCTION

Squash (*Cucurbita spp.*), a vegetable native to South and Central America, has long been a staple crop in many parts of the world. Squash was introduced globally through the Columbian Exchange, spreading to Asia, Africa, and Europe following the voyages of Columbus in the 15th century (Ferriol & Picó, 2008). In the Philippines, *Cucurbita maxima*, known locally as Kalabasa, is widely cultivated and consumed. It is a rich source of essential nutrients, including vitamins A, C, and B, as well as antioxidants such as beta-carotene, which contribute to its potential health benefits, such as supporting eye health, reducing oxidative stress, and lowering the risk of chronic diseases, including cancer (FAO, 2016). Given its widespread availability and nutritional value, squash represents an untapped resource in the development of novel food products.

The donut, a beloved pastry enjoyed by people across the globe, has a long history dating back to the 19th century. The origins of the donut are debated, but it is generally believed that the modern donut was popularized in the United States in the mid-1800s. Dutch settlers are credited with introducing a version of the "olykoeks" (oil cakes), which were deep-fried pastries. The donut became increasingly popular through its mass production, particularly after the development of donut-making machines in the early 20th century (Fellows, 2009). In contemporary society, donuts have become a ubiquitous snack, available in diverse forms across various markets, from local bakeries to international chains like Dunkin' and Krispy Kreme. The versatility of the donut, with its variety of fillings, toppings, and preparation methods, has ensured its lasting appeal.

Despite their popularity, traditional donuts, often deep-fried and laden with sugar, have raised concerns due to their high calorie and fat content. With the growing shift toward healthier eating habits, consumers are seeking alternatives that satisfy their craving for familiar foods while offering improved nutritional profiles. The bakery industry has responded to this demand by developing new variations of baked goods, including donuts, with healthier ingredients and reduced sugar content. minerals, and dietary fiber, which could enhance the nutritional value of the donut

Moreover, the Utility Models in the Philippines related to donut production mainly focus on technological innovations for mass production, such as automatic donut-making machines, but few address the innovation of ingredient alternatives that improve the nutritional profile of the product. The utility model under the names of Daisy Tamayo and James Tamayo with an application number 2/2021/050367 focuses on a binangkal doughnut enriched with squash puree and carabao's milk. Binangkal is typically a small, round doughnut covered in sesame seeds. The formulation involves combining boiled squash puree, flour, sugar, baking soda, baking powder, salt, oil, vanilla, and carabao's milk. In contrast, the researchers would like to focus specifically on squash-filled donuts (rather than just incorporating squash into the dough itself). The filling aspect of the donut is a unique feature in this study, which has not been explored in the existing Utility Model. Additionally, the focus on squash peelings (often discarded) as an ingredient in the dough could be a sustainability and waste-reduction aspect that has not been addressed in the existing model. This makes your research distinct as it not only incorporates squash as an ingredient in the dough but also uses it as a filling, which is a significant variation.

This study intends to fill this gap by not only incorporating squash as a dough and filling ingredient but also by exploring its sensory attributes, nutritional benefits, and consumer acceptance.

The advantages of this research are manifold. First, the study offers a healthier alternative that could help mitigate the risks associated with diet-related health issues. Second, the use of squash peelings, which are often discarded, promotes sustainability and reduces food waste. Third, this research can support local farmers in Cagayan Valley by creating new demand for locally grown squash, potentially boosting agricultural income and encouraging sustainable farming practices. Furthermore, by introducing an innovative product to the

bakery market, the study could provide bakery producers with a competitive edge, allowing them to meet the growing consumer demand for healthier snack options. Finally, the study will fill a significant gap in existing literature, as few studies have explored the use of squash, particularly in donut formulations, despite the increasing interest in incorporating vegetables into baked goods.

This research also holds significant marketability potential. As consumers continue to prioritize health and nutrition, products that offer both indulgence and health benefits are becoming more appealing. The combination of a familiar product, the donut, with the added nutritional benefits of squash, makes it an attractive option for health-conscious individuals who are looking for guilt-free snacks. With the rise of health-focused food trends, this innovative donut could appeal to a broad consumer base, from fitness enthusiasts to families seeking healthier snack alternatives.

By addressing a gap in the literature and exploring the market potential for squash-based donuts, this study contributes to the development of nutritious bakery products. Moreover, it provides an opportunity to foster sustainability and promote local economic growth in areas like Cagayan Valley, where squash production is abundant.

Objectives of the Study

The present study is interested in investigating the possibility of using squash-based donuts with various formula and to examine the acceptability of its product.

Specifically, the researchers would like to answer the following: (1) (percent, df) for squash donuts with respect to: (1.1) Appearance (1.2) Aroma (1.3) Texture (1.4) Taste (2) Evaluate the acceptability of squash donuts according to consumers' sensorial acceptance in: (2.1) Appearance (2.2) Aroma (2.3) Texture (2.4) Taste (3) Identify if there are significant differences among the three squash donut formulations in terms of sensory attributes (appearance, aroma, texture, and taste). (4) Determine the microbial content of squash donuts by conducting laboratory analysis for: (a) Total Coliform Count (b) Total Aerobic Plate Count (c) Yeasts and Molds Count

MATERIALS AND METHODS

Research Design

This study used descriptive surveys to assess sensory evaluation and the level of acceptability. An experimental method was used to develop the different formulations of the squash donuts. The researchers used three formulations in developing the product. This determined the sensory evaluation and level of acceptability of the product.

Sampling Technique

The mentioned panel of tasters were selected using a purposive sampling procedure in the study. There were twenty-five (25) panelists from Cagayan State University-Andrews Campus that tested (sensory) the squash donut formulations. There were five (5) faculty members from food-related departments (College of Teacher Education – CTED and College of Hospitality Management – CHM), and twenty (20) students.

Panelists were recruited based on predetermined inclusion and exclusion criteria to maintain the quality of sensory evaluation. Participants included only those who: (1) Were not experiencing colds, flu, or any illness that could affect their sense of taste or smell, (2) Were non-smokers, Were not excessively hungry or overly full at the time of tasting. (3) Individuals who did not meet all the inclusion criteria were excluded from participation in the sensory testing.

This purposive approach ensured that only qualified and capable evaluators provided feedback on the sensory attributes and acceptability of the product.

Locale of the study

The study was conducted at the kitchen laboratory of the College of Teacher Education (CTE) at Cagayan State University-Andrews Campus in Tuguegarao City,

Cagayan. Meticulous product preparation and formulation were the primary focus. Sensory evaluation and acceptability testing were carried out in the designated CTE classrooms, ensuring a comprehensive assessment of the product's appeal. Microbial analysis was conducted at the Department of Science and Technology Carig Norte in Tuguegarao City, Cagayan, providing essential data on the product's nutritional composition.

Research Instruments

A sensory score questionnaire was adapted by the researchers, consisting of two parts. Part one, a sensory evaluation score sheet to evaluate the sensory attributes of the different formulations, was evaluated by five (5) faculty members (CTED, CHM) specializing in food-related subjects. Part two was evaluated by twenty (20) students for the general acceptability of the product. The parameters used to evaluate the appearance, color, aroma, taste, and texture of the donut were based on a 9-point Hedonic Scale adapted from Mekiva Culinary (2021), with 9 points representing "Like Extremely," down to 1 point representing "Dislike Extremely." For the general acceptability of the squash donut, evaluators used a 5-point Likert Scale, with 5 points representing "Highly Acceptable," down to 1 point representing "Not Acceptable."

Data Gathering Procedure

All materials required for the production of squash donuts were carefully prepared by the researchers. These included an oven (used as an alternative to sun-drying squash peelings), knives, a chopping board, rolling pin, mixing bowls, wire whisk, measuring cups and spoons, piping bag, frying pan, and a food processor. The ingredients used in the donut production were meticulously selected to ensure high quality and consistency across formulations. The control recipe was adapted from Dikla's (2022) "Bavarian Cream Donuts Recipe" published on One Sarcastic Baker. Three formulations were developed by varying the ratio of bread flour to powdered squash flour: Formulation 1 (25:75), Formulation 2 (50:50), and Formulation 3 (75:25). In all variations, the dough consisted of bread flour, powdered squash flour, brown sugar, yeast, salt, eggs, water, and unsalted butter.

The filling ingredients also varied in terms of squash puree and unsalted butter, while the amounts of vanilla extract, egg yolks, all-purpose flour, sugar, and whole milk remained constant across all formulations. To prepare the dough, the dry ingredients were first mixed together—bread flour, sugar, yeast, and salt. Eggs and warm milk were added, followed by the gradual incorporation of softened butter until a smooth, elastic dough formed. After kneading, the dough was left to rise in a warm area for 1 to 2 hours.

Sensory Evaluation

The researchers randomly selected respondents to participate in the evaluation. They ensured participants were informed about the study, any potential allergens, their rights, and obtained their consent. The squash donut products were presented in a standardized manner using a controlled and comfortable tasting environment, free from strong odors, distractions, and noise. Clear instructions were provided on how to evaluate the samples, explaining the specific attributes, the use of the scales, and the tasting procedure. Respondents tasted the control product, spitting it out (trash bags were provided), then waited 1–5 minutes before evaluating the next formulation. Crackers and water were provided to cleanse palates between tastings, which followed the same procedure for all three squash donut formulations. The identity of the products was kept hidden to avoid bias; respondents were unaware of which formulation they were tasting. The order in which samples were presented was randomized to mitigate order effects.

Microbial Analysis

Microbial analysis of the product was conducted in a laboratory to detect, identify, and quantify microorganisms present in the sample. This analysis ensured the product met safety and quality standards by

assessing microbial contamination that could pose health risks or affect product stability. The total coliform count, total aerobic count, and yeasts and molds counts were determined.

Analysis of the Data/ Statistical treatment

The following statistical used in the study in order to analyze the data. weighted mean was used to assess the acceptability of the squash donuts in terms of texture, aroma, appearance, color, and flavor using the Hedonic Scale (9 = "Like Extremely," 1 = "Dislike Extremely"). For general acceptability, evaluators used a 5-point Likert Scale (5 = "Highly Acceptable," 1 = "Not Acceptable").

The 9-point Hedonic Scale was used to assess how much the participants liked the different formulations of Squash Donut, based on their personal preferences for appearance, aroma, taste, and texture.

Scale Value	Descriptive Scale	Mean Range
9	Like Extremely	8.12- 9.00
8	Like Very Much	7.23- 8.11
7	Like Moderately	6.34- 7.22
6	Like Slightly	5.45- 6.33
5	Neither Like or Dislike	4.56- 5.44
4	Dislike Slightly	3.67- 4.55
3	Dislike Moderately	2.78- 3.66
2	Dislike Very Much	1.89- 2.77
1	Dislike Extremely	1.00- 1.88

A 5-point Likert Scale was used to measure the level of acceptability of the best formulation of Squash Donut, based on participants' overall impression of the product.

Scale	Mean Range	Descriptive Rating
5	4.20 – 5.00	Very Highly Acceptable
4	3.40 – 4.19	Highly Acceptable
3	2.60 – 3.39	Moderately Acceptable
2	1.80 – 2.59	Fairly Acceptable
1	1.00 – 1.79	Not Acceptable

Also, ANOVA was used to determine the significant difference of control and the three formulations based on the acceptability.

Laboratory Testing. After determining the best formulation for Squash Donuts, the next crucial step is determining its microbial content. It will be tested at the Department of Science and Technologies.

RESULTS AND DISCUSSION

Table 1 presents the hedonic test results, showing sensory evaluation scores for appearance, aroma, texture, taste, and overall acceptability for the various formulations. Based on the data, Formulation 2 achieved the highest scores across all attributes, particularly excelling in taste (8.4) and overall acceptability (7.02). In comparison, Formulations 1 and 3 received similar moderate scores, with average ratings of 5.672 and 5.78, respectively. These scores suggest that both formulations were acceptable but not as well-liked as Formulation 2. The strong preference for Formulation 2 may be attributed to a balanced combination of ingredients that enhanced not only the flavor but also aroma and texture. The study of Auvray & Spence (2008) supports these findings as they review how flavor is perceived through the interaction of gustatory (taste), olfactory (smell), and somatosensory (texture, temperature) inputs.

Table 1. Best Formulation of Squash Donut

	Appearance	Aroma	Texture	Taste	Average Score	Descriptive Interpretation
Formula 1	5.90	5.70	5.40	5.90	5.72	Light Slightly
Formula 2	6.40	6.48	6.80	8.40	7.02	Like Moderately
Formula 3	5.80	6.00	5.60	5.80	5.78	Light Slightly

Acceptability of various Squash donut recipe was judged on a basis of appearance, aroma, texture and taste. Doughnut Formulation 2 was rated the highest for most of its' attributes, in which had scores "Acceptable" appearance (4.2), aroma (3.92), texture (3.92) and taste (4.16) indicate that formulation was very close desirable qualities of doughnut as compared to traditional ones, indicating this dough formulation is near to the idealistic characteristic found in a good quality donut cake handles.

The lowest, for all characteristics and attributes obtained Formulation 3 (even back point behind appearance as aroma (2.2) and taste (2), that means, needs to refine also in its visual appeal, which includes the flavor so that it better meets consumer preference). (Brueckner, 2009) emphasized that the nature of a product must match with ones subjective preferences and future experience.

Table 2. Acceptability of Squash Donuts

	Appearance	Aroma	Texture	Taste	Overall Acceptability	Descriptive Interpretation
Formula 1	2.72	2.52	2.20	2.32	2.43	Fairly Acceptable
Formula 2	4.20	3.92	3.92	4.16	4.12	Highly Acceptable
Formula 3	2.48	2.20	2.24	2.00	2.23	Fairly Acceptable

Formulation 2 obtained "Acceptable" scores in the appearance, odor, texture and flavor tests on the product evaluated. This implies that the latter formulation was visually more attractive to participants, probably due to its appearance and color. Contrastingly, Formulation 1 and 3 both scored a worst score in appearance, aroma, texture and taste does denote that they are required to be improved visually as well as eating qualities like donut.

Studies on Iberian Jamon and edamame demonstrate that color and overall appearance can dictate acceptability and willingness to pay, highlighting the importance of visual appeal in food products. (Lee et al., 2022) (Carneiro et al., 2022).

All sensory attributes (Appearance, Aroma, Texture, Taste) show statistically significant differences across formulas ($p < .001$). Formula 2 consistently achieves the highest mean rating in each category, making it the strongest performer in sensory quality. Formulas F1 and F3 yield similar but lower sensory scores. This shows that the hypothesis is rejected due to the significant difference between the formulations.

Table 3. Significant Differences Among the Formulations

Sensory Evaluation	Formula	Total	Mean	F-Value	P-Value	Decision
Appearance	F1	148	2.72	19.803	<.001	reject H_0
	F2	161	4.20			
	F3	147	2.48			
Aroma	F1	143	2.54	18.976	<.001	reject H_0
	F2	162	3.92			
	F3	150	2.20			
Texture	F1	148	2.20	21.463	<.001	reject H_0
	F2	170	3.48			
	F3	146	2.24			
Taste	F1	136	2.32	32.819	<.001	reject H_0
	F2	212	4.16			
	F3	140	2.00			

The squash donut sample underwent microbial testing and was assessed against the FDA Philippines reference criteria for baked goods. The evaluation focused on Total Coliform Count, Aerobic Plate Count, and Yeast & Mold Count to determine the product's microbial quality and safety.

The results showed a Total Coliform Count of 1100 MPN/g, which exceeds the FDA's maximum acceptable limit of 100 CFU/g (10^2) for baked goods. This high coliform content indicate that the product is probably contaminated, introducible at time of sundrying, when the product is left to dry as an open commodity. Presence of coliforms is not necessarily an immediate indication that the product is unsanitary, but emphasizes the need for clean sanitary and controlled conditions during drying and handling to minimize microbial hazards.

On an Aerobic Plate Count basis, the count was 1.0×10^5 CFU/g, which is at the upper allowable limit according to FDA requirements. This represents a fairly high rate of general bacterial contamination but is within limits. This may be due to natural microbial exposure from natural processing techniques. Regular checking and adequate storage conditions are however necessary to avoid spoilage and maximize shelf life.

Conversely, Yeast and Molds Count was below 100 CFU/g ($<10 \times 10^1$), which is far from the FDA's specified limit of 1000 CFU/g (10^3).

Table 4. Microbial Analysis of Squash Donut

Sample Code	Sample Description	Test Method	Result
MIC-0661	Squash Donuts	Total Coliform Count	1100 MPN/g
		Aerobic Plate Count	$1.0x10^{50}$ CFU/g
		Yeast and Molds Count	$<10x10^{10}$ CFU/g

This suggests that the product was effectively dried and maintained a low moisture content, limiting fungal growth and contributing to its overall preservation quality.

These results indicates that while the product may still be safe to eat, there is a need to improve hygiene and sanitation practices, particularly during the sun-drying and post-processing stages. With enhanced safety measures, the microbial quality of the product can be significantly improved, supporting both consumer safety and product shelf stability.

CONCLUSION

Based on the findings of the study, formulation 2 received the highest rating in terms of appearance, aroma, texture, and taste based on sensory evaluation, which denotes as the best formulation. For general acceptability, formulation 2 was acceptable. And there is a significant difference between the control and the three formulations

along appearance, aroma, texture, and taste. The microbial assessment of the squash donut evaluated its safety based on FDA Philippines standards for baked goods, focusing on Total Coliform Count, Aerobic Plate Count, and Yeast and Molds Count. The Total Coliform Count was exceeding the FDA limit, indicating possible contamination during sun-drying. The Aerobic Plate Count was still within the acceptable range but at its upper limit, suggesting a need for improved handling or storage. In contrast, the Yeast and Molds Count was below the limit, demonstrating good resistance to spoilage and effective moisture control during drying.

RECOMMENDATION

1. **Sensory Evaluation**

For further evaluations of products, it is recommended to have a trained sensory panel to create more objective and consistent evaluations of organoleptic qualities including taste, texture, aroma, and appearance of the product.

2. **Microbial Control and Shelf-Life Extension**

Further studies should explore methods for microbial load reduction and increased shelf life of squash donuts, for instance, the use of natural preservatives, vacuum-sealed packaging, oven-baking, and others.

3. **For Students and Academic Institutions**

This research can serve as a guide for students and educators in all fields of food science, technical-vocational education, and nutrition programs. They would be encouraged to explore the availability of local, indigenous ingredients processing methods-as in air-frying or baking-to prepare healthier versions of traditional snacks while retaining appeal within cultural contexts.

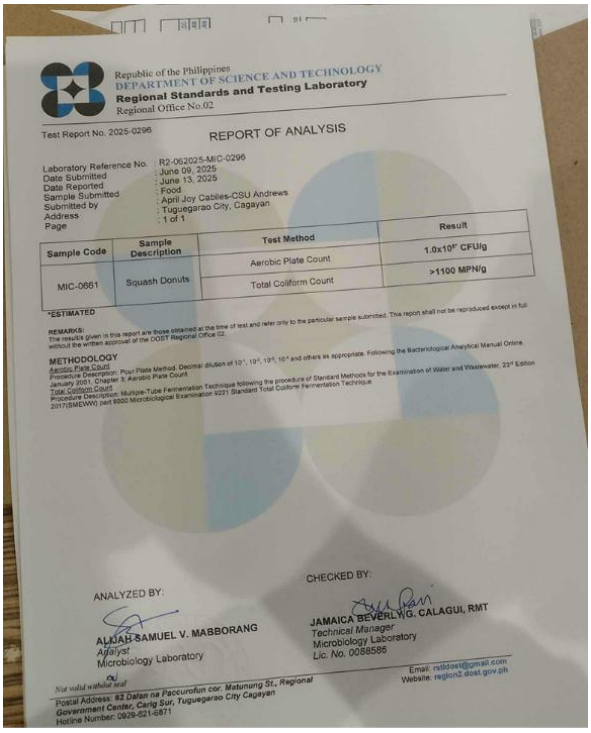
4. **For Government Agencies**

Organizations such as the DepEd, DOST and DTI might help to promote community-based product development projects where application of indigenous crops, including squash are used. By creating an enabling environment through financial resources and technical support, as well as food safety knowledge and information dissemination, such investments could drive innovation, entrepreneurship and health at the community level.

5. **For Local Communities and Entrepreneurs**

Local farmers, home-based bakers, and cooperatives in areas such as Cagayan are urged to consider squash-based donuts as a viable product. Given proper training in food safety, shelf-life extension, and eye-catching packaging, these groups can make local crops into viable and income-generating food products—while also supporting nutritional value and economic development.

Appendix A. Laboratory testing for the Squash Donut



Republic of the Philippines
DEPARTMENT OF SCIENCE AND TECHNOLOGY
Regional Standards and Testing Laboratory
Regional Office No.02

Test Report No. 2025-0296

REPORT OF ANALYSIS

Laboratory Reference No. : R2-062025-MIC-0296
Date Submitted : June 09, 2025
Date Reported : June 13, 2025
Sample Submitted : Food
Submitted by : April Joy Cables-CSU Andrews
Address : Tuguegarao City, Cagayan
Page : 1 of 1

Sample Code	Sample Description	Test Method	Result
MIC-0661	Squash Donuts	Aerobic Plate Count	$1.0x10^{6}$ CFU/g
		Total Coliform Count	>1100 MPN/g

*ESTIMATED

REMARKS:
The results given in this report are those obtained at the time of test and refer only to the particular sample submitted. This report shall not be reproduced except in full without the written approval of the DOST Regional Office 02.

METHODOLOGY
Aerobic Plate Count
Procedure Description: Pour Plate Method. Decimal dilution of 10^{1}, 10^{2}, 10^{3}, 10^{4} and others as appropriate. Following the Bacteriological Analytical Manual Online, January 2001, Chapter 3, Aerobic Plate Count
Total Coliform Count
Procedure Description: Multiple-Tube Fermentation Technique following the procedure of Standard Methods for the Examination of Water and Wastewater, 23rd Edition 2017(SMEWW) part 9000 Microbiological Examination 9221 Standard Total Coliform Fermentation Technique

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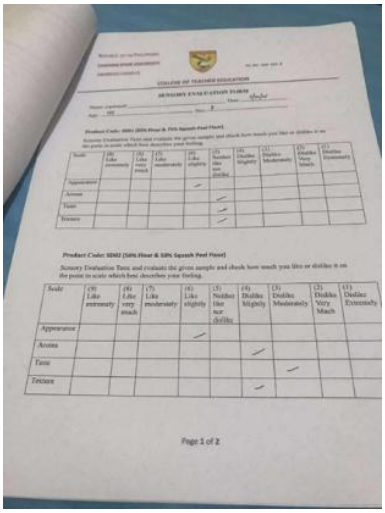
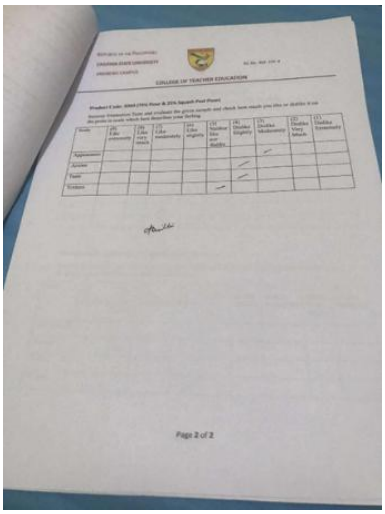
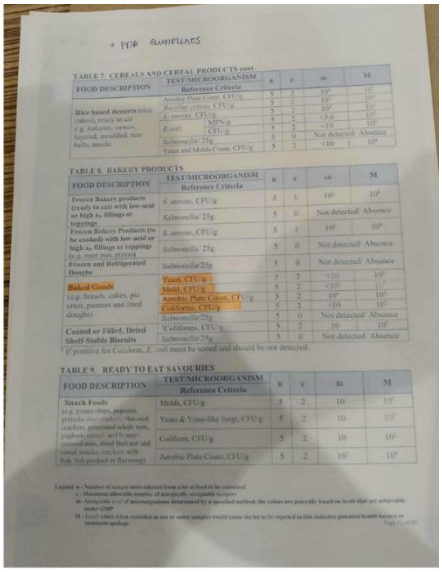
Email: rstldost2@gmail.com
Website: region2.dost.gov.ph

Appendix B. Sensory Evaluation





Appendix C. Guidelines for Laboratory testing for Baked goods



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