DEVELOPMENT OF KALAMANSI POWDER IN DIFFERENT VARIANTS USING THE SPRAY DRYING METHOD

EDELYN S. ALBISO
SPAMAST, Institute of Agricultural Technology and Entrepreneurial Studies

Corresponding Authors: planning@spamast.edu.ph

ABSTRACT

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This study was conducted to determine the acceptability of spray-dried Kalamansi powder in different variants (Kalamansi with cucumber, carrots, and ginger) and promote product innovation in the powder form of Kalamansi using the Spray-Drying Method. Sensory evaluation was done, and products were subjected to nutrient and microbial analyses. The results of the sensory evaluation were auspicious, with the Kalamansi juice using Spray-dried kalamansi powder in different variants found to be highly acceptable in terms of color, odor, taste, and overall acceptability. The carrot variant, in particular, stood out for its color and overall acceptability, instilling confidence in the product's quality. Nutrient Analysis was done in all three variants and contained considerable nutrients and minerals essential to human health. Cucumbers contained the highest amount of most of the nutrients tested, specifically, calories that reached up to 370 kcal/100g, carbohydrates (87.96%), crude fat (0.04%), crude protein (4.41%), magnesium (µg/g), and Phosphorus (950 µg/g). On the other hand, spray-dried kalamansi powder with carrots contained the highest amounts

of Sodium (269 µg/g), Calcium (662 µg/g), Potassium (10,243 µg/g), and Iron (16.73 µg/g). The highest moisture content was found in spray-dried kalamansi powder with ginger. They contain some calories and carbohydrates for one's energy needs. Traces of crude fat and crude protein were also available. Microbial Analysis using MPN shows a satisfactory MPN of < 3 without growth for 45 days, indicating a longer shelf-life. The cost and return analysis, with a 20% mark-up based on cost, determines the price per pack (160 grams) for the different variants. Spray-dried powder with ginger had the highest price at P378.54. Carrots were priced at P306.54, whereas cucumbers had the lowest price of P228.50. Each pack can be mixed with approximately 8 liters of water, producing about 32 glasses of Kalamansi Juice, costing P7 to P12 per glass.

INTRODUCTION

Kalamansi and ginger, like any other agricultural commodities, are seasonal. Hence, prices may be meager during peak seasons but very high during the slack season. In some instances, they disappear from the market. Moreover, these are perishable commodities that may last only briefly, even before they are sold. It leads to significant losses since the prices do not compensate for the production costs, and its short life may cause losses to farmers and traders. An alternative to mitigate the inconveniences faced by lemon producers and consumers is processing the fruits during the high-production season, such as through drying. The introduction of the spray-dried Kalamansi powder variants presents a potential solution to these economic challenges, offering a marketable product with an extended shelf-life.

The project was an offshoot of the previous studies conducted on Kalamansi Nip. It started with the aim of producing a healthy beverage from Kalamansi. Later, innovations were introduced to enhance the product's nutritional value and explore other variants that would suit customer tastes. From the plain Kalamansi, the original mixture was added with ginger and was found to be acceptable, healthier, and with a twist in taste. This process of continuous innovation and exploration of new variants, such as carrots, chayote, and cucumber, opens up a world of possibilities for the spray-dried Kalamansi powder, inspiring new product ideas and market opportunities. However, the product's shelf life only lasted for an average of 1 month as it started to form molds and bubbles, and changes in odor and taste. It hinders mass production even when the supply of kalamansi and ginger is high.

Moreover, a problem with the current packaging of the liquid form creates inconvenience in the transport of the product since the bottles are bulky and breakable. The proposed powder form may be packed in sachets, plastic, or boxes more quickly, making it easy and convenient for transport and delivery. This enthused the proponent to innovate the Kalamansi Nip to a new form that may extend its shelf-life and improve marketability through better

packaging, thus, the powder form.

The spray drying method was chosen for this study due to its ability to dry quickly compared to other methods. However, it is important to note that the process may alter the nutrient contents in the product. Therefore, the project also includes a nutrient analysis on the liquid and dry forms to compare if there is any significant difference as a result of drying. A sensory evaluation will also be done to test the acceptability of the juice from the dilution with the dry and liquid form of kalamansi nip in terms of taste, odor, color, and general acceptability.

Finally, the cost and return analysis was computed for pricing and future entrepreneurial undertakings.

Significance of the Study

Kalamansi Nip is a mixture of pure kalamansi juice mixed with sugar and vegetable extracts in different variations (ginger, carrots, cucumber, chayote). Packed in 350 ml bottles (glass), it is produced and sold as a concentrate ready to be mixed in cold or hot water for consumption as a healthy juice or beverage. The product in liquid form could last for 2 to 4 weeks only. Moreover, the use of bottles makes it inconvenient, as it is not allowed by some couriers, and it is prone to breakage, even if properly handled, which limits the product market.

The project aimed to promote innovation in the Kalamansi Nip, which primarily involved the improvement in terms of the form of the product from a sticky liquid form product into a solid form using a spray drying method; in this form, the product was packed using safer, more convenient, and efficient materials such as in sachet ready for single consumption anytime, and anywhere. Moreover, the project extended the shelf life of the Kalamansi Nip, making the product available at any time.

Moreover, the processing of Kalamansi Nip into its dry form enables mass production during peak seasons, which would benefit producers and traders, promote a stable price for agricultural commodities like Kalamansi and ginger to compensate for their cost of production, and optimize their income. This development of Kalamansi Nip in Dry form presents an opportunity to generate or provide additional income to target beneficiaries and, most of all, to the farmers. It also opens up possibilities for entrepreneurs interested in food processing and product innovation.

Conceptual Framework

The figure below shows the relationship between the variables of the study. The acceptability, shelf-life, nutrient contents, microbial analysis, and economic benefit (Cost and Return) of the Kalamansi Nip were the study's dependent variables, which vary between the forms of Kalamansi Nip.

Figure 1
Schematic Diagram showing the relationship between the Independent and Dependent variables of the study.

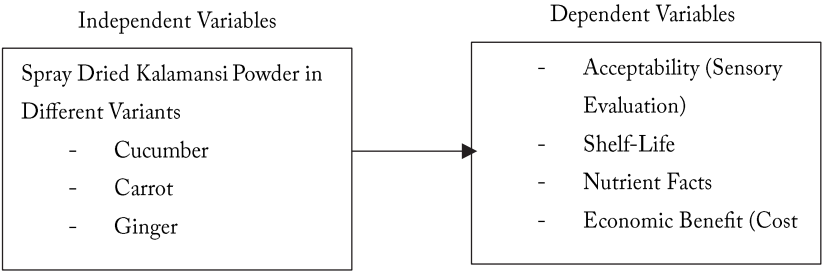

Figure 2
Technology Road Map for Kalamansi Nip

The project aimed to improve the product's shelf-life, enhance its packaging, and provide consumers with healthy products (Kalamansi Nip in Different Variants) made available at all times.

MATERIALS AND METHODS

Variables measured, evaluated, or analyzed.

Acceptability. The sensory evaluation determined the acceptability of Kalamansi juice from the spray-dried Kalamansi powder in different variants: ginger, cucumber, and carrots. The products were evaluated in terms of their taste, color, odor, and general acceptability by 30 evaluators using a 9-point Hedonic Scale. They were subjected to an Analysis of Variance (ANOVA) to test significant differences.

Nutrient Analysis. Samples of the products were subjected to laboratory analysis to determine the nutrients available in the products.

Microbial Analysis. Samples of the products were also subjected to laboratory analysis to determine the microbial contents at 15, 30, and 45 days

after the spray-drying of the Kalamansi.

Cost and Return Analysis. Cost and return were determined in all the variants of spray-dried kalamansi. It was done to determine the economic benefits of producing the products.

Treatments Used and their layout.

Three variants of Kalamansi powder were produced: cucumber, carrots, and ginger. A ratio of 3 parts of kalamansi for every part of the vegetable extract was used, following the ratios used in previous studies (Albiso et al., 2018), except for sugar, which was not included in the mixture.

Research Design

Descriptive and experimental research designs were employed. The descriptive research method was used to describe the laboratory analysis results and the sensory evaluation responses. The experimental research design was used to determine the significant differences in the acceptability of the different variants of spray-dried Kalamansi.

Statistical Analysis

One-way ANOVA (Analysis of Variance) was used to determine if a significant difference exists in the acceptability of Kalamansi Juice using different variants of spray-dried Kalamansi powder.

Descriptive statistics were used to describe nutrient contents, the shelf-life, and the cost and return data in the production of spray-dried kalamansi powder.

Evaluation methods and observations were conducted, and strategies for implementation were developed.

Sensory evaluation was conducted on the acceptability of the juice made from the different sprayed kalamansi powder variants using a 9-point Hedonic Scale.

Laboratory Analysis was conducted on the nutrient contents of the different variants of the spray-dried kalamansi powder. Samples were also submitted for a microbial analysis, specifically E. coli, at 0, 15, 30, and 45 days after spray-drying.

Cost and return data were also collected and analyzed from the different variants of spray-dried kalamansi powder.

RESULTS AND DISCUSSIONS

The Development of Spray-Dried Kalamansi Powder in Different Variants. The processing of the spray-dried kalamansi powder in different variants started with mixing the kalamansi extract and the vegetable extracts at a ratio of 3:1, following the ratio used in the processing of kalamansi nip (Albiso et al., 2018; Albiso et al., 2020). However, sugar was not included

since the first samples subjected to spray drying had caused a problem in the processing.

According to Bhandari and Howes (2005), as cited by Muzaffar, Nayik, and Kumar (2015), sticky food like sugar generally gets stuck on the dryer wall or may get transformed into unwanted agglomerates in the dryer chamber and conveying system, which leads to operating problems and low product yield.

The mixture produced eight liters for each treatment (with cucumber, carrots, and ginger). Samples of the mixtures were brought to the Food Processing and Innovation Center (FPIC), Davao City, for spray drying on January 12, 2022.

Table 1 shows the percentage of powder recovered from submitted liquid samples. It was noted that the highest recovery was found in kalamansi with a cucumber of 24%. Kalamansi with ginger and carrots had the same recovery of 20%.

Table 1. *Percentage of powder recovery from the liquid mixture of Kalamansi and different vegetable extracts*

Particulars/Variants	Liquid Mixture (L)	Powder Recovered (g)	% of Powder Recovered
Spray-dried Kalamansi with Ginger	8	1,920	24
Spray-dried Kalamansi with Cucumber	8	1,600	20
Spray-dried Kalamansi with Carrots	8	1,600	20

Nutrient Analysis

Spray-dried kalamansi powder packed in flexible plastic was submitted to the University of Immaculate Conception (UIC) Science Resource Center on January 11, 2022, for nutrient analysis. The method used was the official analysis method of AOAC International, 19th edition. Results of the analysis were reported on February 11, 2022.

The following tests were conducted: Moisture (%), Ash (%), Calories (kcal/100g), Carbohydrates (%), Crude Fat (%), Crude Protein (%), Sodium (µg/g), Calcium (µg/g), Magnesium (µg/g), Potassium (µg/g), Phosphorus (µg/g), and Iron (µg/g). These are among the nutrients and minerals that are essential for human health. Results of the nutrient analysis show that kalamansi powder with ginger, carrots, and cucumber contains all the essential nutrients and minerals required by the human body.

Cucumbers contained the highest amount of most of the nutrients tested, specifically, calories that reached up to 370 kcal/100g, carbohydrates (87.96%), crude fat (0.04%), crude protein (4.41%), magnesium (µg/g), and phosphorus (950 µg/g). On the other hand, spray-dried kalamansi powder with carrots contained the highest amounts of sodium (269 µg/g), calcium (662 µg/g),

potassium (10,243 µg/g), and iron (16.73 µg/g). The highest moisture content was found in spray-dried kalamansi powder with ginger. They contain some calories and carbohydrates for one's energy needs. Traces of crude fat and crude protein were also available.

Table 2. *Summary results of the nutrient analysis of Kalamansi Power in different variants*

PARTICULARS	Kalamansi with Ginger	Kalamansi with Carrot	Kalamansi with Cucumber
Moisture %	13.84	6.99	5.28
Ash %	1.41	2.31	2.31
Calories, kcal/100g	339	363	370
Carbohydrates, %	82.43	87.21	87.96
Crude fat, %	0.02	0.02	0.04
Crude protein, %	2.3	3.47	4.41
Sodium, µg/g	142	269	149
Calcium, µg/g	428	662	361
Magnesium, µg/g	591	669	959
Potassium, µg/g	4,984.00	10,243.00	9,091.00
Phosphorus, µg/g	651	905	950
Iron, µg/g	11.5	16.73	10.31

Microbial Analysis

Spray-dried Kalamansi Powder in different variants was also subjected to Microbial Analysis (E. coli, MPN/g) by the FDA Bacteriological Analytical Manual, 6th edition, and Rapid Test by 3M Petri film in MPN Most Probable Number.

According to the "Guidelines for the microbiological examination of ready-to-eat foods (2001)," the presence of E. coli in ready-to-eat foods is undesirable because it indicates poor hygienic conditions, which have led to contamination or inadequate heat treatment. Ideally, E. coli should not be detected, and as such, a level of < 3 per gram, which is the limit of the Most Probable Number (MPN) test, has been given a "Satisfactory" rating, indicating an excellent microbiological quality.

Microbial testing for E. coli was done at 0, 15, 30, and 45 days to determine the presence or growth after spray-drying. Results show that all treatments met the satisfactory rating criteria with an MPN of less than 3 and showed no significant growth from day 0 to day 45.

Table 3. *Microbial Analysis (E coli) Results*

Particulars	Day 0	Day 15	Day 30	Day 45
Spray-Dried Kalamansi with Ginger	< 3	< 3	< 3	< 3
Spray-Dried Kalamansi with Cucumber	< 3	< 3	< 3	< 3
Spray-Dried Kalamansi with Carrots	< 3	< 3	< 3	< 3

Source: UIC Science Resource Center, February 09, 2022

Acceptability of Kalamansi Juice Using Different Ratios of Spray-Dried Powder

Sensory evaluation was conducted on the Kalamansi Juice made from spray-dried Kalamansi powder in different variants to determine the most acceptable ratio of spray-dried Kalamansi powder per serving, with sugar being constant among all treatments. The exact amount of sugar, 80 grams per liter of water, was used in all treatments, whereas the amount of powder varied from 8 (T1), 12 (T2), 16 (T3), and 20 grams (T4) per liter of water.

Table 4 shows that T4, with a ratio of 20 grams per liter of water, had the highest acceptability rating in all treatments. However, ANOVA showed no significant difference among the treatments except for ginger, where T4 (20 grams of powder per liter) had a higher acceptance than T1, which was significantly different.

Table 4. *Acceptability of Kalamansi Juice in different variants using different ratios of spray-dried powder per liter of water*

Particulars	Cucumber	Carrot	Ginger
T1 - 8 grams for 1 liter of water	6.43	6.33	6.1
T2 - 12 grams for 1 liter of water	5.97	6.57	6.77
T3 - 16 grams for 1 liter of water	6.5	6.7	6.83
T4 - 20 grams for 1 liter of water	6.77	6.83	7.4

Acceptability of Kalamansi Juice with Different Variants of Spray-Dried Kalamansi Powder

Sensory evaluation was also conducted to test which variant was most acceptable in terms of color, odor, taste, and overall acceptance. Table 5 shows the acceptability of juice using different variants of Spray-dried Kalamansi powder.

Results show that the juice from Spray-Dried Kalamansi powder with Carrots was the most acceptable in all parameters. Analysis of Variance

shows a significant difference in color and overall acceptability. Moreover, the treatment with carrots was significantly more acceptable than cucumber and ginger, and ginger was more acceptable than cucumber in terms of color and overall acceptability. In Albiso et al.'s (2020) study on kalamansi nip with different variants, carrots were the most acceptable variant.

Table 5. *Acceptability of Kalamansi Juice with Different Variants of Spray-Dried Kalamansi Powder*

Particulars	Color	Odor	Taste	Overall Acceptability
Spray-dried Kalamansi with Cucumber	6.93	6.43	6.77	7.07
Spray-dried Kalamansi with Carrots	7.83	6.6	7	7.93
Spray-dried Kalamansi with Ginger	6.77	6.3	6.67	7.3
Total	7.18	6.44	6.81	7.43

Cost and Return Analysis

Table 6 shows the production data and cost-benefit analysis of spray-dried Kalamansi powder processing. Cucumbers yielded the highest powder recovery of approximately 1,920 grams, whereas carrots and ginger produced approximately 1,600 grams of spray-dried powder. The powder was packed in 160 grams per pack, producing 12 packs for cucumber and 10 packs each for carrots and ginger, respectively.

The cost of processing includes the cost of the raw materials (kalamansi, ginger, and carrots), the labor, which was assumed at 420 per day, and the equipment rental for the spray-drying process. The rental cost may still be reduced if used at a total capacity of 20 liters per batch.

The selling price was computed at a mark-up of 20% based on cost.

Spray-dried powder with ginger had the highest price at P378.54. Carrots were priced at P306.54, whereas cucumbers had the lowest price of P228.50.

Each pack can be mixed with approximately 8 liters of water, producing about 32 glasses of kalamansi juice, costing P7 to P12 per glass.

Table 6. *Cost-Benefit analysis in the Production of Kalamansi powder*

Particulars	Qty	Unit	Cost/ Unit	Spray-Dry Kalamansi with Cucumber	Spray-dried Kalamansi with Carrots	Spray-Dry Kalamansi with Ginger
Yield (Powder) 160 grams per pack @ 20% mark-up						
Cucumber	12	pk	228.5	2,742.00		
Carrots	10	pk	306.54		3,065.40	
Ginger	10	pk	378.54			3,785.40
GROSS SALES				2,742.00	3,065.40	3,785.40
Kalamansi Juice	20	kg	50	1,000.00	1,000.00	1,000.00
Different Variants						
Cucumber	4	kg	50	200		
Carrots	4	kg	50		200	
Ginger	8	kg	100			800
Rental						
Cucumber	1.9	hrs	350	665		
Carrots	2.67	hrs	350		934.5	
Ginger	2.67	hrs	350			934.5
Labor	1	day		420	420	420
TOTAL COST				2,285.00	2,554.50	3,154.50
NET INCOME				457	510.9	630.9
Cost / Benefit Ratio				20%	20%	20%
Number of Packs Produced				12	10	10
Cost to Produce Per Pack @ 160 grams per pack				190.42	255.45	315.45
Price per pack @ 20% Mark-up				228.5	306.54	378.54
				7.14	9.58	11.83

Note: Each Pack can produce approximately 8 liters of Kalamansi Juice in Different Variants, or 32 glasses of juice, or 7 to 12 pesos per serving.

CONCLUSIONS

Based on the results and findings of the study, spray-dried kalamansi powder in different variants is a viable and acceptable product that addresses the study's objectives. It promotes innovation in the Kalamansi Nip in terms of the form of the product, from the liquid to the dry form, using the spray-drying method. The powder form can provide a better alternative, more convenient, safer, and more efficient materials for product packaging. Moreover, the spray-dried Kalamansi powder contains a considerable amount of nutrients and minerals that are essential for human health. MPN for Microbial analysis had passed the satisfactory rating of <3 For 45 days without growth.

Implications

The author recommends conducting further studies to prepare for the possible commercialization of the product. The study may use the spray-drying method to process other vegetable and fruit extracts for product innovation and technology generation.

In this time-constrained study, the author proceeded with the shelf-life analysis and was limited to the microbial analysis of the products; hence, it is recommended that future studies be focused on determining and extending the product's shelf-life.

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