Evaluation of Physicochemical and Sensory Characteristics of Bottled Star Fruit (*Averrhoa carambola)*

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Abstract

Averrhoa carambola, commonly known as star fruit, is a highly valued tropical fruit due to its unique flavor and numerous health benefits. This study examines the effects of several heat treatments on the physicochemical properties, sensory qualities, and oxalic acid concentration of bottled star fruit (Averrhoa carambola). Pasteurized juice at 60 ± 02 0C for 5 min were poured into pre sterilized jars with star fruit pieces. Sensory aspects were evaluated of the product using a nine-point hedonic scale to rate its general acceptability. The oxalic acid content of raw, mature and ripe were 215.4 mg/L, 196.9 mg/L and 174.7 mg/L respectively while ascorbic acid content was reported as 3.21 mg/L, 3.21 mg/L and 6.42 mg/L. After blanching at 1, 2 and 3 min with 80ºC for ascorbic acid content and oxalic acid content results were recorded as 6.42 mg/L, 3.21 mg/L and 3.21 mg/L and 96.1 mg/L, 84 mg/L and 80.5 mg/L respectively. The fresh and bottled star fruit contained characteristics such as pH of 3.87 and 3.93, titratable acidity of 0.40 % and 0.36 %, brix value of 10 and 09 (TSS), Oxalic acid content 567 ± 26.62 mg/L and 341 ± 5.58 mg/L, ascorbic acid content 6.42 mg/L ± 1.28 mg/L and 3.21 ± 1.28 mg/L were recorded respectively. According to the WHO guidelines that oxalic acid content was got the safer level (50 mg/day) and because of that it can be used for susceptible individuals as well.

Keywords: Own juice, Physicochemical, Sensory, Star fruit, Storage

I. INTRODUCTION

The tropical fruit known as star fruit, or *Averrhoa carambola* in scientific parlance, is grown in Sri Lanka. Because of its star-like appearance when cut crosswise, it is also frequently known as "carambola". It is a member of the Oxalidaceae family (Litz *et al.*, 1989). Numerous star fruit cultivars are grown in Sri Lanka. These come in both tart and sweet versions, with different levels of sourness. In Sri Lanka, some of the most well-liked cultivars include "Fanton," "B10," and "Honey Sweet"(*(Star Fruit)*, n.d.) (Department of Agriculture, Sri Lanka, 2024). In Sri Lanka, star fruit trees are usually grown as ornamental trees or in residential gardens or small orchards and can be considered as organic fruit. When star fruit is completely ripe, it is typically harvested. Harvesting should be timed to suit the desired flavor; some people like their fruit slightly acidic and green, while others prefer it entirely golden and sweet (Pereira *et al.*, 2020). Star fruit is usually eaten raw, but it can also be added to salads, juices, chutneys, and desserts, among other cooked dishes. It is frequently used in fruit platters and salads in Sri Lankan cuisine. Antioxidants, fiber, and vitamin C are all present in star fruit (Pereira *et al.*, 2020). It is regarded as a healthy supplement to a diet because it is low in calories(Lakmal *et al.*, 2021). Like many other tropical nations, Sri Lanka values star fruit not only for its flavour but also for its culinary variety and possible health advantages.

The possible anti-diabetic effects of star fruit have been studied. Star fruit may help people with diabetes, while it is not a replacement for medical care or a diabetes management strategy. Compared to foods with a high glycemic index (GI), star fruit has a comparatively low GI, meaning that it affects blood sugar levels more gradually. Low GI foods can lessen the likelihood of sudden blood sugar spikes and crashes. Dietary fiber (Lakmal *et al.*, 2021) which is present in star fruit, may aid to stabilize blood sugar levels by slowing the body's absorption of sugars and carbohydrates. Antioxidants found in star fruit nclude vitamin C and a variety of polyphenols (Narain *et al.*, 2009). Antioxidants can assist in

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lowering inflammation and oxidative stress, both of which are frequently increased in diabetics (Leivas *et al.,* 2016). According to certain research, polyphenolic chemicals found in star fruit may have anti-diabetic effects. These substances could lessen insulin resistance and increase insulin sensitivity. Potassium, a mineral essential to controlling blood pressure, can be found in star fruit. Potassium encourages blood vessel walls to relax and helps offset the effects of sodium on blood pressure. Dietary fiber, found in star fruit, may support heart health. Lower blood pressure and a lower risk of hypertension are linked to a high-fiber diet. It is an essential component of the nation's culinary heritage and gives a distinctive flavour and aesthetic appeal to a variety of foods (Wang *et al.,* 2021). Star fruit can benefit from thermal treatments that improve its texture, flavour, and safety.

Oxalate is a naturally occurring substance found in star fruit that may be hazardous to those who have certain medical disorders, especially kidney impairment (Akhtar *et al.,* 2011). Besides the sensory, nutritional, and medicinal benefits of star fruits, their high oxalic acid content has aroused serious concerns (Hönow and Hesse, 2002; Massey, 2007; Sorensen, 2014; Sá *et al.,* 2019). The consumption of oxalic acid increases the formation of insoluble calcium oxalate salts which get deposited in the small blood vessels or to the units in the kidneys that clean blood (Chen *et al.,* 2001; Wijayaratne *et al.,* 2018). Excessive consumption of star fruit has been associated with the development of oxalate nephropathy in patients with both normal and

As a common fruit in many tropical and subtropical countries, including Southeast Asia, star fruit (*Averrhoa carambola*) is grown in household gardens in Sri Lanka. Although it is a well-liked fruit in the area, Sri Lanka typically does not cultivate it extensively for commercial purposes. During the fruiting season, the majority of starfruits are wasted owing to improper usage and fear of the oxalic acid concentration of starfruit. Value addition of Carambola fruits will improve the consumption by different communities and also reduce the postharvest losses of the unexploited fruit, apart from promoting several health benefits. Various strategies have been used for the reduction of oxalates in foods. An attempt to reduce the oxalates content by different methods such as washing, soaking (with $CaCl_2$, NaCl), and blanching has been reported, (Dahal and Swamylingappa, 2006; Hefter *et al.,* 2018; Rofi'ana *et al.,* 2018; Savage and Dubois, 2006; Thapa *et al.,* 2017). This study evaluated how different heat treatments alter the physicochemical qualities and sensory characteristics of bottled star fruit. (*Averrhoa carambola*) in its own juice offers important information about the product's quality and safety. This study adds significant knowledge to the field of fruit juice processing and advances the creation of consumer-friendly, premium, and safe products.

II. MATERIALS AND METHODS

Perhaps the easiest way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. When using this as a template, you do not need to worry about page layout, fonts, etc. The main body of the paper should be organized into sections, as Introduction, Background/ Literature review, Problem specification, Methodology and Experimental design, Results, Discussion and Conclusion, Acknowledgement and References.

A. Ingredients and Equipment

Fresh star fruit (*Averrhoa carambola*), Water, Sterilized glass bottles or jars with tight-fitting lids, cutting board and knife, Saucepan, mixing spoon, Funnel, Boiling water bath, Retort

B. Sample preparation for analysis - Preparation of starfruit juice

Ripe but firm star fruits were selected for the processing. The fruits were washed thoroughly under potable, running water and sliced. The slices were placed in sterilized glass bottles and juice was extracted from additional star fruit slices. Juice was heated in a water bath to 60°C, and poured over the fruit slices to cover them completely. The bottles were exhausted in a water bath at 80°C for 5 minutes. After securely tightening the lids, the samples were sterilized in a retort at 100°C for 25 minutes under 1 bar of pressure. Bottles were allowed to cool to room temperature before storing in a cool, dark place. All equipment utensils used were properly sanitized to prevent contamination.

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C. Testing of physicochemical properties

1) Oxalic acid level measurement:

Diluted samples were titrated for the oxalic acid content determination purpose. A burette was used and titrated the standard oxalic acid solution and sample with Potassium permanganate solution (Narain *et al.*, 2009).

2) Brix value:

Juice was extracted from the star fruits by crushing and filtering the pulp to obtain a clear liquid sample. Refractometric Method was used for the brix level evaluation purpose (AOAC Official Method 932.12).

3) Ascorbic acid level measurement:

Ascorbic acid content was obtained using titration of the samples with iodine solution. Each samples were diluted and starch solution was added for titration (Iodine titration) (Ruvini *et al.*, 2018).

4) pH Measurement:

Star fruit sample was prepared by extracting juice or creating a homogenized mixture. pH was recorded by using pH meter (AOAC Official Method 981.12).

5) Acidity measurement:

One of the most widely used methods is the titration method using sodium hydroxide (NaOH) as the titrant (AOAC Official Method 942.15 - Titratable Acidity).

6) Sensory evaluation:

Sensory evaluation on star fruit pieces in own juice bottle was conducted with nine-point hedonic scale during the time period. Moderate level of preference (07) was obtained from the trained panelists.

7) Microbial evaluation:

Microbial evaluation was performed using the plate count method (AOAC Official Method 966.23). Samples were diluted, plated onto Standard Plate Count Agar, incubated at 35°C for 48 hours, and colonies were counted to determine CFU/g.

8) Statistical analysis:

The results are the mean ± standard deviation (SD) of triplicate evaluations. Analysis of data was carried by one-way analysis of variance (ANOVA) and the mean comparisons were done by the Tukey-HSD test where necessary. analyses were performed by using SPSS-16 for Windows program.

III. RESULTS AND DISCUSSION

A. Physicochemical properties with different maturity stages

1) Oxalic acid content:

According to the maturity stages, immature star fruits were contained low oxalic acid content than the ripe star fruits. Overall, the chart demonstrates that oxalic acid content decreases as the samples move from the immature stage to the ripe stage.

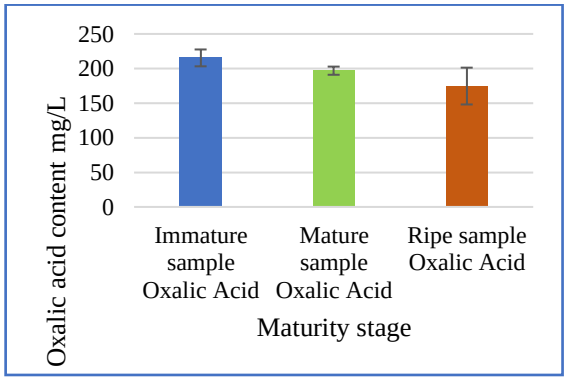

Figure 01. Oxalic acid content on different maturity stages

2) Brix value:

Ripe star fruits were contained high brix value than immature fruits. This bar graph displays the Brix values of samples at different maturity stages: immature, mature, and ripe. Brix is a measure of the sugar content in an aqueous solution, typically used in the context of fruits to gauge their sweetness and ripeness.

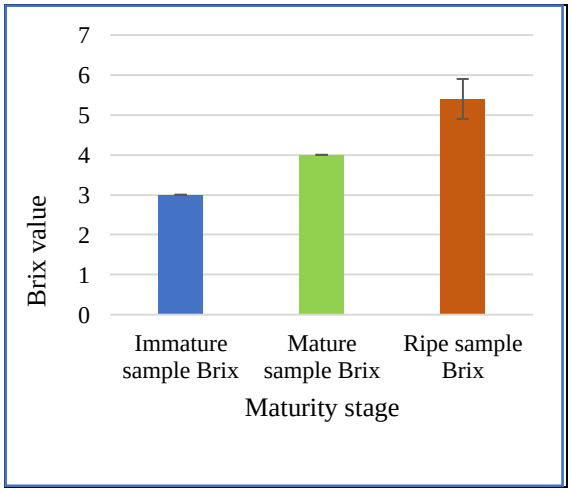

Figure 02. Brix value on different maturity stages

3) Ascorbic acid content:

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This bar chart displays the ascorbic acid (vitamin C) content in mg/L at different maturity stages of a sample. The ascorbic acid content increases from the immature to the ripe sample. Ascorbic acid content was highly contained in ripe star fruits.

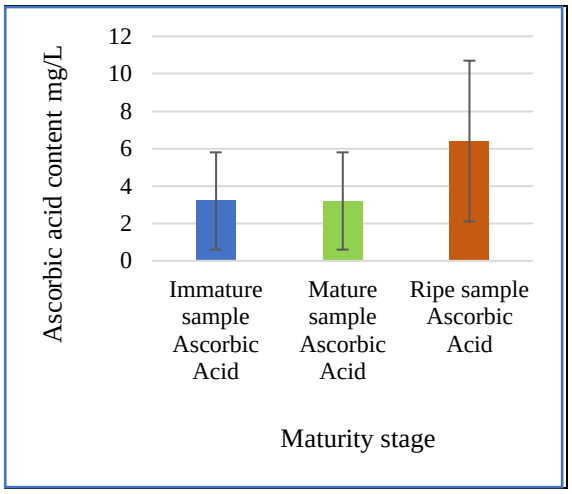

Figure 03. Ascorbic acid content on different maturity stages

4) pH level:

This bar chart depicts the pH levels of samples at different maturity stages: immature, mature, and ripe. The pH level increases as the sample matures from the immature to the mature stage and then stabilizes as it remains constant from the mature to the ripe stage. Acidity level was increased in the ripe star fruits than immature fruits.

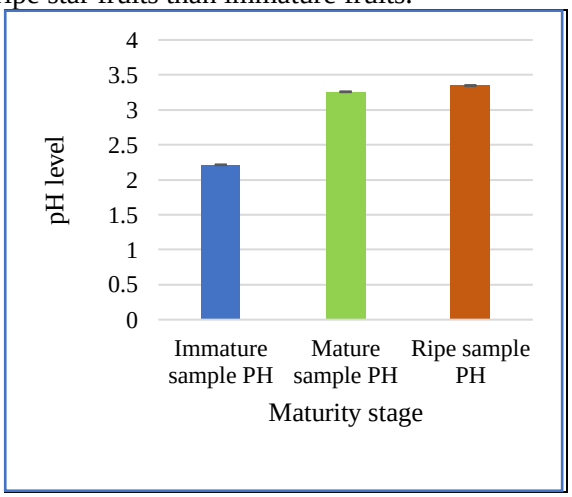

Figure 04. pH level on different maturity stages

A. Physicochemical properties with effect of thermal treatments:

1) Oxalic acid content:

With different blanching times, 03 minutes of blanching time was reduced the oxalic acid content than 01 minutes blanching time.

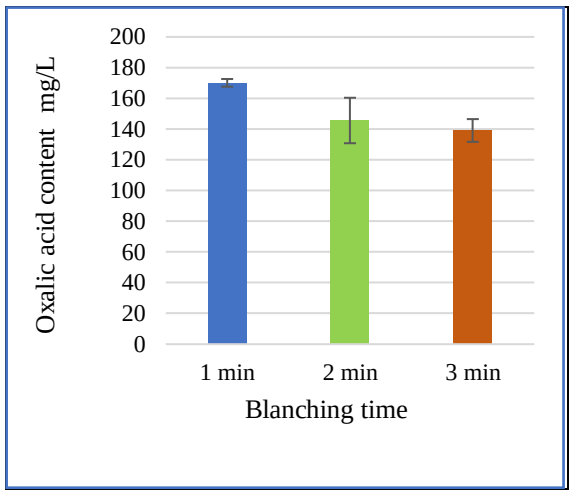

Figure 05. Oxalic acid content on different blanching times

Ascorbic acid content was reduced after the blanching, because that ascorbic acid is water soluble and heat sensitive at the same time. Oxalic acid and ascorbic acid are heating sensitive and available content can be reduced using the heat treatments.

Testing for oxalic acid contents were generated positive results on the evaluation. Final results were obtained after the calculation of final readings. Fresh star fruit juice was resulted 923 mg/l of oxalic acid content according to the process. Water blanched for 01 min sample was obtained 942 mg/l of oxalic acid content. Water blanched for 02 minute and 03minute samples were obtained 749 mg/l, 539 mg/l of oxalic acid contents respectively. Sterilization was done at the final stage of the sample preparation process. Before that, juice pre-heating and exhausting were conducted according to the process. Bottled sample with 03 minutes blanched pieces of star fruits were obtained 317 mg/l of oxalic acid content according to the data.

2) Ascorbic acid content:

Ascorbic acid or vitamin C content is some kind of nutrient included in the fruits or vegetables. In star fruit, it can be available with different values and it depends on the environmental conditions and maturity indices accordingly. In the bottling process, fresh star fruit was obtained 6.42 mg of ascorbic acid value. After processing of star fruit, that ascorbic acid content can be reduce from the materials. Because that ascorbic acid is heat sensitive and water soluble (Narain *et al.*, 2009).

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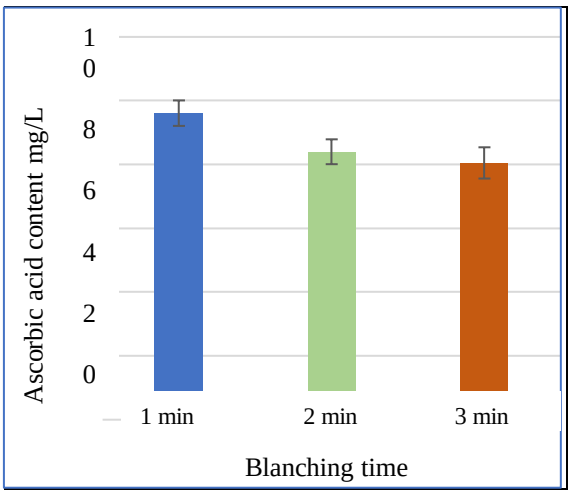

Figure 06. Ascorbic acid content on different blanching times

C. Physicochemical properties result with effect of pre-treatments

1) Oxalic acid content:

Pre-treatments with different acids can significantly alter the physicochemical properties of substances, impacting their stability, solubility, and overall performance in various applications. Comparing the two acids, oxalic acid has a stronger impact on the physicochemical properties of star fruit juice, which could be leveraged in applications requiring significant modification of these properties.

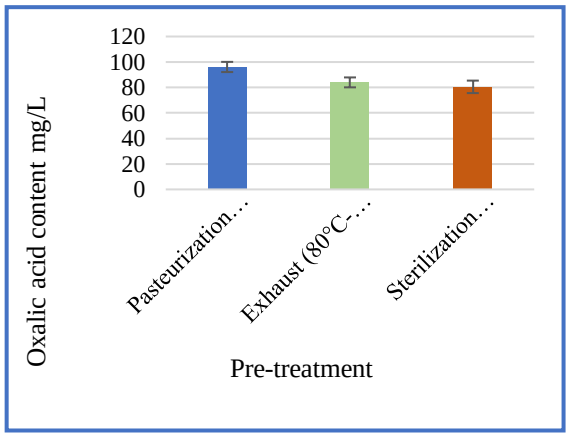

Figure 07. Oxalic acid content on different pre-treatments

2) Ascorbic acid content:

The study demonstrates that oxalic acid and ascorbic acid pre-treatments distinctly influence the physicochemical properties of star fruit. Oxalic acid has a more pronounced effect, which may be beneficial in specific industrial applications.

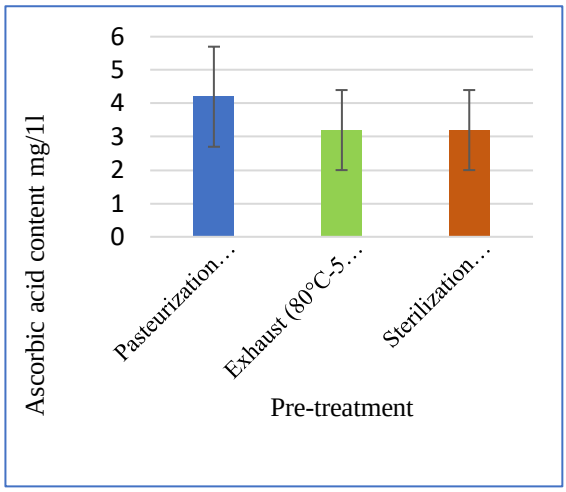

Figure 08. Ascorbic acid content on different pre-treatments

D. Physiochemical properties during storage period

Samples were tested for the ascorbic acid content, pH level, brix value, acidity, microbial count and sensory evaluation with the shelf-life testing. Sample preparation for shelf-life evaluation was conducted using the mature level of star fruits. Fresh star fruit juice was contained 634 mg/l of oxalic acid content at the processing time. Sterilized final product was obtained 341 mg/l of oxalic acid content. During the storage period, samples were resulted reduction of oxalic acid content levels according to the data generated.

Fresh sample was obtained 3.87 pH level and after preparation of the bottles, 3.79 was the pH reading. it can be happening, because that inside bottle was filled with processed and unprocessed materials. Equilibrium level will be process inside bottle during storage period. Level of pH was changed normally after the bottling process.

Brix value of the star fruit was obtained 10 in fresh fruits and after processing, it was gradually decreased with the storage period.

Acidity level was obtained periodically with fresh and bottled samples evaluation.

D. Sensory evaluation results

Sensory evaluation was done during the four-month storage period with 05 trained panelists. Sweet taste increasing idea was concluded finally by the sensory panelists. Additional of value with vitamins, sweeteners like things will commercially valuable in the star fruit-based productions. Moderate level (07) of acceptances were obtained for every month (04) with the positive feedbacks.

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Table 01: Physiochemical properties of Star Fruit juice sample during storage period

Time	Parameter					
	Oxalic Acid content (mg/L)	**Ascorbic Acid content (mg/L)**	**PH**	**Brix (TSS)**	**Acidity (%)**	**Microbial total plate count (TPC)**
Fresh	634	6.42	3.87	10	0.4	Detected
Initial	341	3.21	3.79	9	0.39	Not Detected
Month 01	403	3.21	3.64	8	0.33	Not Detected
Month 02	425	3.21	3.81	7	0.47	Not Detected
Month 03	398	3.21	3.6	7	0.49	Not Detected

E. Sensory evaluation results

Sensory evaluation was done during the four-month storage period with 05 trained panelists. Sweet taste increasing idea was concluded finally by the sensory panelists. Additional of value with vitamins, sweeteners like things will commercially valuable in the star fruit based productions. Moderate level (07) of acceptances were obtained for every month (04) with the positive feedbacks.

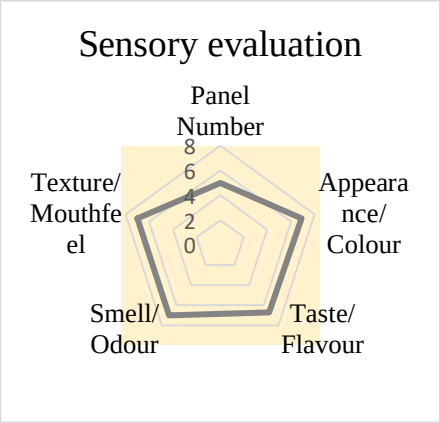

Figure 09. Sensory evaluation data

F. Microbiological results

Microbes were not detected after the bottling process with sterilization.

IV. CONCLUSION

The investigation into how various heat treatments affect the oxalic acid concentration, physicochemical properties, and sensory attributes of bottled star fruit (Averrhoa carambola) offers important information about the product's quality and safety. The star fruit juice was significantly impacted in a number of ways by the heat treatments, such as pasteurization and sterilization. First off, the product's safety and consumption may be enhanced by the reported decrease in oxalic acid content following heat treatments. Excessive concentrations of oxalic acid can be hazardous to human health. Heat treatments have been shown to reduce oxalic acid levels, indicating that these techniques may be useful in reducing the risk. Second, the physicochemical modifications such as variations in pH, colour, and texture are important elements that impact the star fruit juice's overall quality when it is packaged. The study emphasizes how important it is to give these factors considerable thought throughout the heat treatment process in order to preserve desired qualities and create a product that lives up to customer expectations.

REFERENCES

Akhtar, M. S., Israr, B., Bhatty, N., Ali, A., Shoaib, M., Israr, B., Bhatty, N., Ali, A., Akhtar, M. S., Israr, B., Bhatty, N., & Ali, A. (2011). Effect of Cooking on Soluble and Insoluble Oxalate Contents in Selected Pakistani Vegetables and Beans OXALATE CONTENTS IN SELECTED PAKISTANI VEGETABLES AND BEANS. 2912. https://doi.org/10.1080/10942910903326056

Ave, C., Litzi, R. E., & Griffis, J. L. (1989). 1.5 Carambola. 5.

Biology, P., & Group, H. P. (1993). Postharvest physiology and storage of carambola (starfruit)" a review. 2, 257–267.

Darkwa, I. (2023). The Preparation of Jam : Using Star Fruit. September 2016. https://doi.org/10.5296/gjes.v2i2.10032

Devi, P. V., Mishra, A., Sharma, D., & Islam, J. (2023). Therapeutic Properties of Averrhoa carambola L and Its Utilization in Development of Value-added Food Products. January.

Dos, L., & Lima, S. (2001). PHYSICOCHEMICAL CHARACTERISTICS OF BILIMBI (Averrhoa bilimbi L .) 1. 421–423.

Ergönül, P. G., & Nergiz, C. (2010). Determination of Organic Acids in Olive Fruit by HPLC. 28(3), 202–205.

Herath, N., Kodithuwakku, G., & Dissanayake, T. (2021). Acute Kidney Injury Following Star Fruit Ingestion : A Case Series Acute Kidney Injury Following Star Fruit Ingestion : A Case Series. Wilderness & Environmental Medicine, January. https://doi.org/10.1016/j.wem.2020.11.003

Huynh, N. K., & Nguyen, H. V. H. (2017). Effects of Juice Processing on Oxalate Contents in Carambola Juice Products. 1–7. https://doi.org/10.1007/s11130-017-0615-4

Kaddumukasa, P. P., Nakavuma, J. L., Imathiu, S. M., & Mathara, J. M. (2017). Influence of physicochemical parameters on storage stability : Microbiological quality of fresh unpasteurized fruit juices. February, 1098–1105. https://doi.org/10.1002/fsn3.500

Kaur, R., Kumar, P., Dehradun, N. S., Nehra, M. V, & Tokusoglu, O. (2021). Process parameter optimization for development of beer : Star fruit fortified approach. August. https://doi.org/10.1111/jfpp.15838

Kesavanath, J., Premakumar, K., & Inthujaa, Y. (2015). Nutritional and Sensory Characteristics of Star Fruit and Sweet Orange Juices Blend Fruit Cordial. In International Journal of Multidisciplinary Studies (IJMS) (Vol. 2, Issue 2).

Kidney, P., & Formation, S. (2020). Dietary Recommendations for Bariatric Patients to.

Kovačec, M., Pilipović, A. N. A., & Štefanić, N. (n.d.). Impact of Glass Cullet on the Consumption of Energy and Environment in the Production of Glass Packaging Material. 187–192.

Lakmal, K., Yasawardene, P., Jayarajah, U., & Seneviratne, S. L. (2021). Nutritional and medicinal properties of Star fruit (Averrhoa carambola): A review. In Food Science and Nutrition (Vol. 9, Issue 3, pp. 1810–1823). John Wiley and Sons Inc. https://doi.org/10.1002/fsn3.2135

Leelarungrayub, J., Laskin, J. J., Bloomer, R. J., & Pinkaew, D. (2016). Consumption of star fruit juice on pro-inflammatory markers and walking distance in the community dwelling elderly Consumption of star fruit juice on pro-in fl ammatory markers and walking distance in the community dwelling elderly. Archives of Gerontology and Geriatrics, 64(December), 6–12. https://doi.org/10.1016/j.archger.2015.12.001

Leivas, C. L., Nascimento, L. F., Barros, W. M., Santos, A. R. S., Iacomini, M., & Cordeiro, L. M. C. (2016). International Journal of Biological Macromolecules Substituted galacturonan from starfruit : Chemical structure and antinociceptive and anti-inflammatory effects. 84, 295–300.

Li, S., Xie, A., Shen, Y., Yu, X., & Hu, G. (2010). Colloids and Surfaces B : Biointerfaces Biogenic synthesis of calcium oxalate crystal by reaction of calcium ions with spinach lixivium. Colloids and Surfaces B: Biointerfaces, 78(2), 229–236. https://doi.org/10.1016/j.colsurfb.2010.03.005

Liyanage, R., Jayathilake, C., Visvanathan, R., & Wimalasiri, S. (2018). Effect of different drying methods on antioxidant activity of star fruits (Averrhoa carambola L .). May.

Mandal, S., Munsi, P. S., & Deb, P. (2008). Fruiting Behaviour , Fruit Growth and Development of Carambola (Averrhoa carambola L .) under Red and Lateritic Areas of Eastern India. 150–157.

Massey, L. K. (2007). Food Oxalate : Factors Affecting Measurement ,. 1191–1194. https://doi.org/10.1016/j.jada.2007.04.007

Massey, L. K., Palmer, R. G., & Horner, H. T. (2001). Oxalate Content of Soybean Seeds (Glycine max : Leguminosae), Soyfoods , and Other Edible Legumes. 4262–4266.

Mazlina, M. K. S., Ghani, L. A. A., & Aliaa, A. R. N. (2008). Comparison on Optimization of Star Fruit Juice Using RSM between Two Malaysian Star Fruit Varieties (B11 and B10). 16(1), 1–13.

Munsi, P. S., Mandal, S., & Deb, P. (2010). Effect of Stage of Harvest , Storage Temperature and Packaging on Shelf Life and Quality of Carambola (Averrhoa carambola L .). 1989, 139–145.

Navis, M. S., & Subila, S. (2017). Study on the presence of oxalate ions in guava and sapota fruits. 2(1), 15–17.

Nguefack, N., Borel, M., Foba-tendo, J., Yufanyi, D. M., Etape, E. P., Eko, J. N., & Ngolui, L. J. (2014). Averrhoa carambola : A Renewable Source of Oxalic Acid for the Facile and Green Synthesis of Divalent Metal (Fe , Co , Ni , Zn , and Cu) Oxalates and Oxide Nanoparticles. 2014.

Pal, R., & Sarkar, T. (2014). Visible Light Induced Knoevenagel Condensation Catalyzed by Starfruit Juice of Averrhoa carambola. June, 106–115.

Pereira, J. C., Sivakanthan, S., & Vasantharuba, S. (2020). Effect of Star Fruit (Averrhoa carambola L .) By-product on Oxidative Stability of Sesame (Sesamum indicum) Oil under Accelerated Oven Storage and during Frying. 849(8), 837–849.

Pothasak, Y., Leelarungrayub, J., Natakankitkul, S., & Singhatong, S. (2020). Prototype Star Fruit-Honey Product and Effectiveness on Antixidants , Inflammation and Walking Distance in Participants with Stable Chronic Obstructive Pulmonary Disease (COPD). 12(5), 1121–1134.

Rahman, M. M., Niimi, M., & Kawamura, O. (2007). Simple method for determination of oxalic acid in forages using high-performance liquid chromatography. 201–204. https://doi.org/10.1111/j.1744-697X.2007.00093.x

REAL TIME VISUAL SYSTEM FOR STARFRUIT MATURITY INDEX CLASSIFICATION. (n.d.).

Reports, C. (2001). Acute Oxalate Nephropathy After Ingestion of Star Fruit. 37(2), 418–422. https://doi.org/10.1053/ajkd.2001.21333

Toledo, J., Malo, E. D. I. A., Gomez, J., Lo, J. U., Santiesteban, A., & Rojas, J. C. (2015). Carambola Cultivar , Fruit Ripeness , and Damage by Conspecific Larvae Influence the Host-Related Behaviors of Anastrepha obliqua (Diptera : Tephritidae). 2003, 1–9. https://doi.org/10.1093/jee/tov280

Wang, Z., Li, J., Crane, J. H., & Wang, Y. (2021). Rapid Structure-Based Annotation and Profiling of Dihydrochalcones in Star Fruit (Averrhoa carambola) Using UHPLC / Q-Orbitrap-MS and Molecular Networking. January. https://doi.org/10.1021/acs.jafc.0c07362

Weller, A., Sims, C. A., Matthews, R. F., Bates, R. P., & Brecht, J. K. (1997). Browning Susceptibility and Changes in Composition During Storage of Carambola Slices. 62(2), 256–260.

Zealand, N. (2005). Food Chemistry Content of nitrates , nitrites , and oxalates in New Zealand spinach. 89, 235–242. https://doi.org/10.1016/j.foodchem.2004.02.030

Consumer Purchasing Behaviour on Spicy Products in Matara District, Sri Lanka

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Abstract

Various factors influence the consumption of spicy products, making it essential to identify their significance for satisfactory consumption levels. The purpose of this study is to identify the elements that influence customer purchase decisions in the Matara district, as well as their awareness of available spicy items and future demand trends. A semi-structured questionnaire was administered to a sample of 384 spicy product consumers, collecting data across eight dimensions: price, quality, brand name, convenience, availability, packaging, nutritional value, and recommendations. Descriptive and multiple regression analyses revealed that quality, nutritional value (16.15% for both), and price (15.89%) significantly influence purchasing decisions, while other factors were not statistically significant at 0.05. Preference hierarchy among consumers shows that chilli pieces are the most preferred, followed by curry powder and chilli powder. The study found high consumer awareness of Freelan's spicy products, with 95.05% of participants familiar with the brand. The most commonly used spices include chilli pieces, curry powder, and chilli powder, with awareness rates of 17.71%, 15.89%, and 15.63%, respectively. Consumers primarily learn about Freelan products through Freelan outlets and supermarkets, which capture 23.96% and 23.44% of awareness, respectively. This research provides valuable insights for marketers and producers of spicy products, highlighting the importance of competitive pricing strategies and brand development to meet consumer preferences and enhance market share in the Matara district.

Keywords: Consumer Awareness, Matara District, Purchasing Decisions, Regression Analysis, Spice Consumption, Spices

I. INTRODUCTION

Spices grown on our own soil and its group of food products. It has a very complex composition and varies effects. Spices as products of plant origin, and is the case with seasoning mixes. Spices are commonly used in the kitchen to give spice to food and as a remedy. Asians mostly utilise spices or spice mixtures to make food fragrant, spicy, savoury, and sweet. Spices vary in nutritional content and provide numerous health advantages. Some spices include cinnamon, garlic, cloves, cumin, basil, star anise, galangal, ginger, coriander, turmeric, cilantro, pepper, and ajowain Balasubramanian *et al*., 2015). The several ranges of spicy products are available in the market. For example: - Chilli powder, Chilli pieces, Curry powder, Pepper and Turmeric and etc. Curry is one of the most common spicy foods. Curry powder is a blend of spices (including turmeric, cumin, coriander, paprika, cardamom, and others) and herbs. It contains fat, protein, minerals (such as iron, calcium, and salt), carbs, fibre, and phytochemicals. Spices have a high antioxidant property. Due to this antioxidant property spices are play very special role in the medicine industry. Spices are essential as both medicine and nourishment. The medicinal value of spices is inhibiting the cancer, reduce fever, malaria, stomach offset, nausea, benefit for heart health, immune system and many more. The Ceylon spices are very popular. One of the reasons for it our spices have a taste. Ceylon spices were well-known throughout the world as far back as the 15th century. The spicy industry has a diverse product range. It consists of cinnamon, pepper, cloves, cardamom, nutmeg, mace, and vanilla. In the Sri Lanka the crop production is consist of mix home garden agroforest system. Examples include pepper, cloves, nutmeg, and cardamom. However, 70% of cinnamon is farmed as a pure crop on tiny farms. Sri Lanka is a lower middle-income country with a tiny economy. Consumer purchases are more sophisticated. Consumer purchases are

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influenced by various factors. Some of they are sociological, physiological and psychological factors. People's previous experiences shape their views and attitudes towards specific types of goods, commodity brands, and retail places. According to that, the selection of a good becomes vital for consumers due to the huge variety of consumer goods available on the market (Frewer, and Trijp, 2007). Customers are required to obtain information on the many sources of supply for the items, the brand name, product advantages and disadvantages, the uses and value of their characteristic features, and the services provided. Consumers obtain information from a variety of sources, including markets, advertising media (television, radio, and newspapers), friends, recommendations from others, local retailers, store displays, and product labels. The research area is Matara district in southern province, Sri Lanka. So, this study focusses on what are the factors influence for purchase decision of spicy products in Matara district because there are no more studies done in Matara district related to this area. The study is helpful to the marketers as they can create various marketing programs such as customer promotion programs and that they believe it will be help of interest to the consumers. And also, it can also boost their marketing strategy. The current study tries to analyse the factors influencing consumers' purchase decisions regarding spicy products, focusing on consumer awareness, preferred types of spicy products, the media channels that raise awareness, and the key label considerations that impact purchasing choices.

II. METHODOLOGY

A. Location of this Study

This study was conducted in Matara district, accompanied by Matara Freelan (Pvt) Ltd, Sri Lanka from August, 2023.

B. Description of the Research Area

This investigation was carried out in the Matara district, located in the southern region of Sri Lanka. This district is one of the 25 administrative divisions of Sri Lanka. It has a population of 873,000 people, according to the final result of the Census of Population and Housing (2021).

C. Sampling Technique

The sample size consists of 384 consumers who use spiced products in the Matara district. The sampling approach employed is cluster sampling. It signifies the segmentation of the population into subgroups or clusters based on different areas within the Matara district.

D. Pilot Survey

A pilot survey looks at the validity of each question. In the pilot survey, 10% of the full-scale survey sample size was used. Therefore, 35 spiced consumers were used to conduct the pilot survey.

E. Research Tool

In this research, a semi - structured questionnaire was used. The questionnaire consists five sections. The first section discusses the demographics of the consumers. The second section consist spicy usage also third section include about perceptions of spiced products and fourth section consist of intentions to purchase spiced products and last section consist about Freelan products.

F. Data Collection and Analysis

Data were gathered using in-depth interviews and questionnaires. It included open - ended questions and close-ended questions. Quantitative research collects and analyses data using numbers, and statistics are expressed as numbers and graphs. This was used to test or confirm hypotheses and assumptions. Qualitative research focusses on words and their meanings. These help people understand concepts, thoughts, and experiences. Data analysis is the systematic application of statistical and logical approaches to describe and visualise data. Different tests were performed to analyse the different aspects of the study. Descriptive analysis was carried out for to analyse the demographic factors and sample profile. SPSS 25 (Statistical Package for the Social Sciences) was used to analyse the data. The variables' relationships were determined using multiple linear regression analysis. The present study used regression analysis to determine the association between consumers' purchasing decisions of spicy products (dependent) vs. price, quality, brand name, packaging, previous, availability, convenience, nutritional value, and recommendations from others (independents).

III. RESULTS AND DISCUSSION

The Table 01 is shows to there are 384 individuals in total, with those aged 18-29 being the most represented at 120 individuals (31.3% of the sample). The next largest group is those aged 30-39, comprising 101 individuals (26.3%), followed

by the 40-49 age group with 59 participants (15.4%). The under 18 category and the 50 and above category are the least represented with 58 (15.1%) and 46 (12.0%) individuals respectively. This table shows that females are the majority, which accounts for approximately 80.99 of the totals. Males represent a smaller fraction, 19.01% of the sample. Out of the 384 respondents, a significant majority, the 85.2%, reported being employed ("yes" to doing a job), while a minority 14.8% reported not being employed ("no" to doing a job). Table 01 shows the distribution of monthly household income among the participants of the study. The majority of respondents fall within the middle-income brackets. The 28.13% respondents earn between 15,000-24,999, and the largest group 29.69%, earn between 25,000-49,999. The next highest category is 50,000-99,999 with 23.70% respondents. The lowest income bracket, under 15,000, is represented by 11.20% respondents, and the highest income bracket, above 100,000, has the fewest number of individuals as a 7.29%. The Table 01 shows that the majority of participants, 334 individuals, identify as Sinhala, making up 87.0% of the sample. The Tamil ethnicity represents a smaller portion with 39 individuals, accounting for 10.2% of the respondents. Those who identify with ethnicities other than Sinhala or Tamil are the least represented, with 11 individuals or 2.9% of the sample.

The Figure 01 is indicating that quality and nutritional value are the most valued factors, each accounting for 16.15% of respondents. Price is the next most considered factor at 15.89%. The factor of packaging concerns 14.58%. Next factor of brand name 13.54%. Convenience is considered by 10.42% showing a moderate level of importance. Availability is important to 7.55%. Which is relatively less compared to other factors. The least considered factor, according to this chart, is recommendation, which influences only 5.73%. Figure 02 displays a pie chart detailing the common use of specific spices in the kitchen by respondents. The most commonly used spice is chili Pieces, with 17.71% reporting its use. Following closely Curry powder, by 15.89% then next Chilli powder 15.63%. Turmeric powder is used by 13.02%, and pepper by 11.96%. Lesser-used spices include Roasted curry powder by 10.94%, Meat curry by 7.03% and Cumin by 4.43%. The least common is Cloves reported by only 0.78%.

The Figure 03 shows that the largest group of respondents, 23.96%, learned about Freelan products through Freelan Outlets. A close second is the 23.44% who became aware via Super markets. Retail shops is the third most common source of awareness, accounting for 19.53% of the responses. Learned about Freelan products via Advertisement 17.45%, Other recommendations, possibly including word of mouth or social media, informed 15.63% of the respondents about Freelan products.

Table 01: Demographic Features of the Respondents

Factors	Description	Frequency	Percent	Valid %	Cumulative%
Age	Under 18	58	15.1	15.1	15.1
	18-29	120	31.3	31.3	46.4
	30-39	101	26.3	26.3	72.7
	40-49	59	15.4	15.4	88.0
	50 above	46	12.0	12.0	100.0
Gender	Male	73	19.0	19.0	19.0
	Female	311	81.0	81.0	100.0
Occupation	Yes	327	85.2	85.2	85.2
	No	57	14.8	14.8	100.0
Income	Under 15000	43	11.2	11.2	11.2
	15000-24999	108	28.1	28.1	39.3
	25000-49999	114	29.7	29.7	69.0
	50000-99999	91	23.7	23.7	92.7
	Above 100000	28	7.3	7.3	100.0
Ethnicity	Sinhala	334	87.0	87.0	87.0
	Tamil	39	10.2	10.2	97.1
	Other	11	2.9	2.9	100.0

(Source; Survey, 2023)

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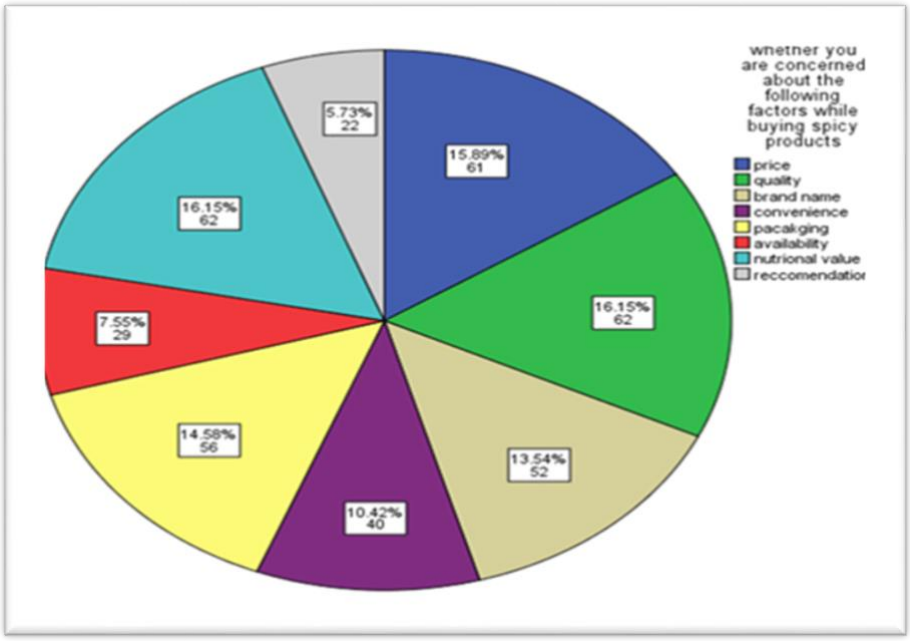

Figure 01: The Factors Affecting the Purchasing Spicy Products

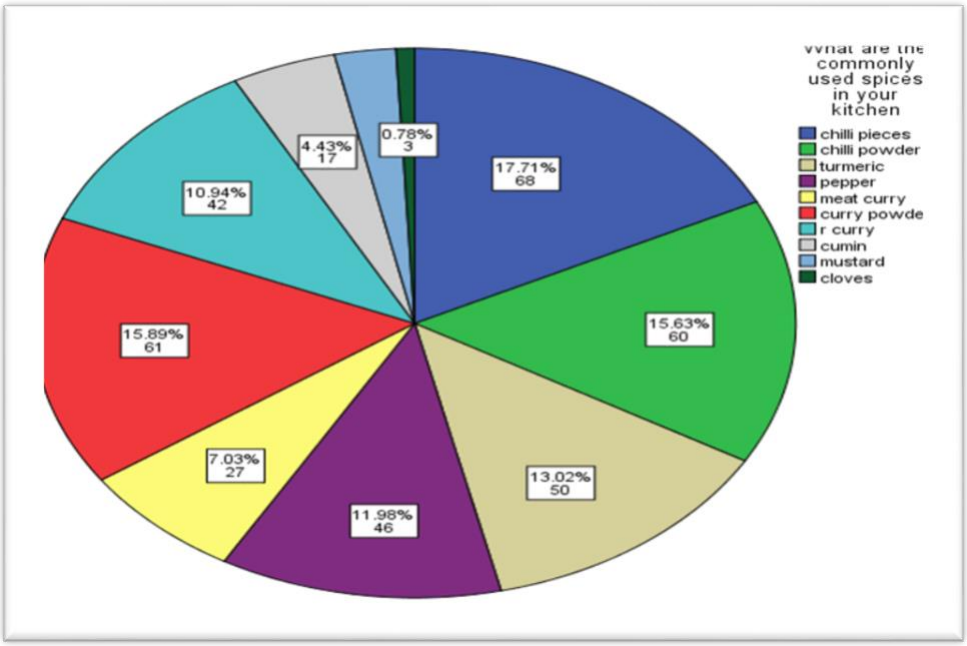

Figure 02: Type of Spicy Products and Consumption

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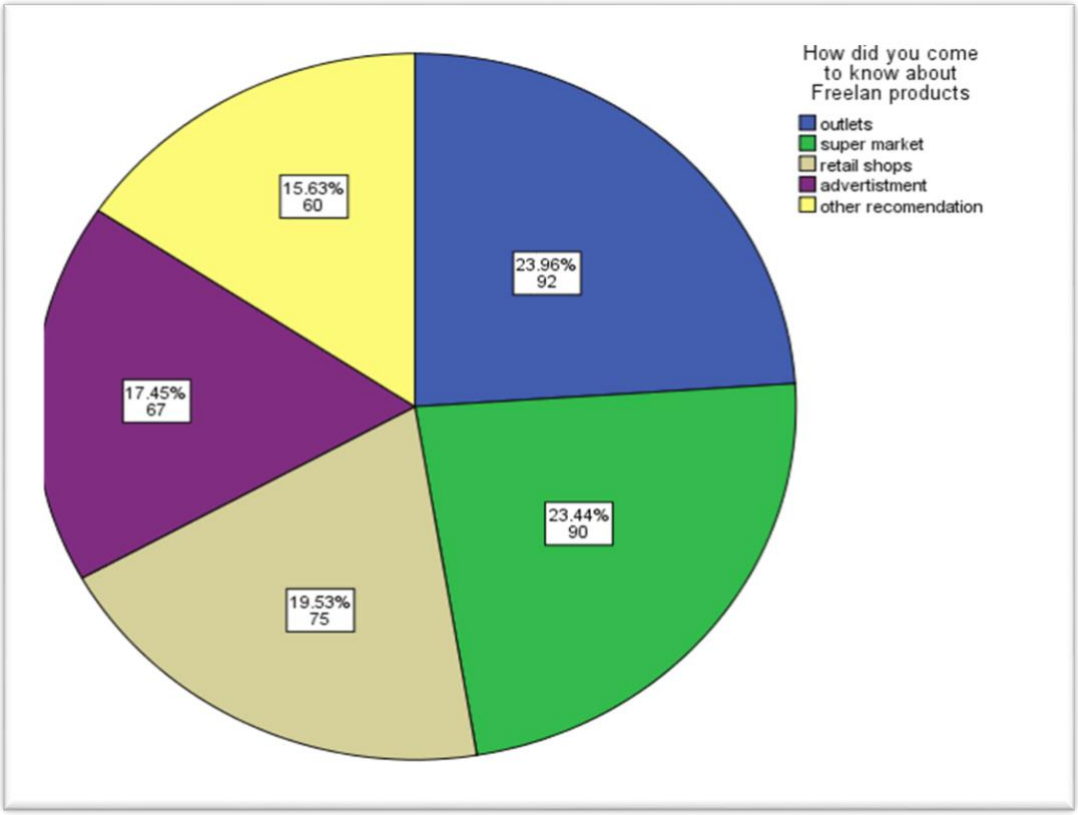

Figure 03: Media and Consumer Awareness

a. Reliability

Table 02: Reliability Analysis

Reliability Statistics	
Cronbach's Alpha	N of Items
.827	27

The Table 02 displays reliability statistics for a scale used in a study. The Cronbach's Alpha value is .827, which indicates a high level of internal consistency among the 27 items in the scale. In research, a Cronbach's Alpha value greater than .7 is generally considered acceptable.

Table 03: Model summary

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.804[a]	.647	.639	.503

a. Predictors: (Constant), recommendations for others, availability, packaging, nutrional value, brand name, convenience, price, quality

Table 03 shows a model summary for a multiple regression study. The R value, or correlation coefficient, is 0.804, suggesting a high positive correlation between the independent factors and the dependent variable. The R Square value of 0.647 indicates that the model's predictors can explain about 64.7% of the variance in the dependent variable. The Adjusted R Square score is somewhat lower, at 0.639, which takes into account the number of predictors in the model and provides a more accurate estimate of the variance explained when applied to the larger population.

The Table 04 indicates that the regression model has a Sum of Squares of 173.134 with 8 degrees of freedom, resulting in a Mean Square (the average squared deviation from the mean) of 21.642. This model yields an F-statistic of 85.661, which is statistically significant (Sig. value of 0.000, which is less than 0.001, indicating a very strong level of

significance). The Residual (or Error) Sum of Squares is 94.490 with 374 degrees of freedom, giving a Mean Square of 0.253. This suggests that the model is highly significant in explaining the variance in consumer purchase decisions, with the predictors. The F-statistic and its associated p-value indicate that the model is a good fit for the data, and the predictors collectively have a statistically significant effect on consumer purchase decisions.

The regression equation is constructed using the unstandardized coefficients (B) from the regression table. Here's how you can write the regression equation based on the given table:

Consumer Purchase Decisions=1.356+(0.111×price)+(0.123×quality) +(0.272×brand name)-(0.082×convenience)+(0.089×packaging)-(0.048×availability)+(0.097×nutritional value)-(0.037×recommendations for others)

Each variable (price, quality, brand name, etc.) is multiplied by its respective unstandardized coefficient and then added to the constant term, which is 1.356 in this case. The result of this equation would give you the predicted value of the dependent variable, Consumer Purchase Decisions, based on the values of the independent variables

Table 04: ANOVA

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	173.134	8	21.642	85.661	.000[b]
	Residual	94.490	374	.253		
	Total	267.624	382			

a. Dependent Variable: Consumer Purchase Decisions

b. Predictors: (Constant), recommendations for others, availability, packaging, nutritional value, brand name, convenience, price, quality

IV. CONCLUSION

The statistical analysis carried out in this study provides valuable insights into consumer purchasing behaviour concerning Freelan spicy products. The demographic breakdown revealed that the sample was predominantly female, with a wide distribution across various age groups, mainly concentrated in the 18-39 age range. The majority of participants were employed, with a significant portion falling within the middle-income brackets, suggesting that the economic status of most respondents was relatively stable. Ethnically, the Sinhala community was substantially overrepresented in the sample, which could influence the generalizability of the results to the broader population. As for the perception of Freelan products, most respondents considered the prices to be moderate to high, indicating a perception of reasonable value or premium pricing for these goods. A significant 95.05% of respondents are aware of Freelan products, with spices being the most recognized category. When it comes to consumption preferences, chilli pieces, curry powder and curry powder are the spices most commonly used in the kitchen. Freelan Outlets and Supermarkets emerge as the primary sources of consumer awareness, suggesting that physical stores play a crucial role in influencing purchasing decisions.

In terms of purchasing behaviour, consumers prioritize quality and Nutritional value equally when considering the labels of spicy products, with price, packaging and brand name also being an important factor. The reliability of the survey instrument was high, with a Cronbach's Alpha of .827, suggesting that the survey questions were consistent in measuring the intended constructs across 27 items. This level of reliability strengthens the confidence in the subsequent findings of the regression analysis. Hypothesis testing further supported these findings, confirming significant relationships between price, quality, brand name, packaging, recommendations from others, nutritional value, convenience, and availability with consumer purchase decisions. In conclusion, the study indicates that consumer purchase decisions for Freelan spicy products are primarily driven by brand name, product quality, and packaging. These factors are instrumental in shaping consumer behaviour, and any marketing strategies should focus on enhancing these product

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attributes. Additionally, while price and nutritional value are also important, they are less impactful compared to the brand-related factors. The study suggests that to capitalize on consumer behaviour, Freelan should continue to invest in brand equity and ensure high product quality and appealing packaging while considering the pricing strategy and nutritional aspects of their products

REFERENCES

Balasubramanian, S., Roselin, P., Singh, K.K., Zachariah, J. & Saxena, S.N. 2015, 'Postharvest processing and benefits of black pepper, coriander, cinnamon, fenugreek, and turmeric spices', Critical Reviews in Food Science and Nutrition, vol. 56, no. 10, pp. 1585–1607.

Frewer, L., & van Trijp, H. (2007). Understanding Consumers of Food Products. A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition. https://doi.org/10.1533/9781845692506

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Impact of Food-related Posts in Social Media on Eating Habits and Dietary Choices among the Undergraduates of Sri Lankan Universities

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Abstract

Compared to past decades, there is a notable rise in social media influencers and content creators who focus on food-related content. Simultaneously, the number of viewers who interact with food-related content also increases. Along with the rise of food-related content in social media, the prevalence of eating disorders and poor dietary choices also increased in young adults. Literature exhibits the gap in assessing the impact of FRPs (food-related posts) based on the Sri Lankan context. This study intends to analyze the frequency of exposure to FRPs and their effects on eating habits, food choices, and food cravings among university undergraduates in Sri Lanka. In this regard, an online survey based on the Google Forms platform was conducted to collect the relevant data. Correlation analysis and the χ^2(5% significance level) were chosen to evaluate the association between variables. Some 396 university undergraduates (female=68.9% & male=31.1%) between the age of 18-42 participated in the study. As per the results, the frequency of exposure to FRPs is notably high where the exposure to FRPs is associated with the number of social media accounts. Results indicate the popular site for watching FRPs is YouTube (63.13%) and the highly preferred contents were reviews on street food places, snacks and desserts, and food preparation videos. The study reports a significant effect due to FRPs on eating habits and food choices than food cravings from the analysis (p value<0.05). The impacts of FRPs might be positive and negative an equal ratio (73.7%) of participants' views.

Keywords: ***Food-related posts, social media, food habits, dietary choices, university undergraduates***

I. INTRODUCTION

By today, social media (SM) platforms have become an integral part of university students' lives and SMs have been imposing a multifaceted impact on students. Information retrieval via social networking sites is specifically linked to the needs of youth consumers for inclusion in the emerging trends of cultural and consumption culture, where technology is an agency to the emotions, cognition, and social patterns of Generation Y (Khalid, Jayasainan and Hassim, 2018). Social media usage in Sri Lanka has been significant over the last decades, representing 34.2% of social media users (from the population) and having the highest range of users aged 18 or above (47.0% of the users) (Kemp, 2024). Furthermore, Facebook has become the most popular social media platform, where YouTube and Instagram follow closely behind. In the above cluster of SM users, the 18-34 years age range corresponds to the largest portion who use SMs for more than 1 hour. Furthermore, 46% of users purchase products or services after seeing reviews or recommendations and 90% check online reviews before making a purchase (Digital Outlook Sri Lanka, 2024). This fact highlights the significant role SMs play in governing user decisions, particularly among young adults. Thus, there may be an influence of food-related posts on decision-making among SM users.

To this end, poor dietary choices and eating habits lead to an unhealthy life at an early age. Also, fast food consumption is a significant factor in obesity and causes non-communicable diseases, with a noticeable association between fast food intake and overweight problems among young adults in Sri Lanka (Nirmal and Padmasiri, 2022). The increasing prevalence of overweight and obesity could be mostly due to various behavioral and lifestyle factors, and that is a burden on the population. Overweight and obesity are recognized as the cause of many health-related complications. Unhealthy dietary practices such as high fat and salt intake lead to excess weight gain (Karthijekan and Angela, 2020). Moreover, food consumption behavior in young adults may be influenced by several factors such as

socioeconomic status, educational attainment, and home food availability (Ludwig-Borycz et al., 2023). Studies show a shift towards fast food consumption due to globalization, busy schedules, and the rise of fast-food outlets in Asian countries, leading to health concerns like obesity and non-communicable diseases (Ludwig-Borycz *et al*., 2023). Not only these, the food choice among the youth is highly influenced by their region, age, and gender (Soam *et* al., 2023). In contrast, the attitude of students toward SMIs (Social Media Influencers) does not affect their daily dietary choices, however, the subjective norms in the students' lives on SMIs make a difference in their eating habits (Ahmad and Bruno, 2021).

In reported studies, the impact of food-related posts on SM on eating habits and dietary choices was surveyed in other Asian countries (Alwafi *et al*., 2022; Tami and Alyousef, 2022; Salleh *et al*., 2021; Scheiber, Diehl, and Karmasin, 2023). In a Sri Lankan context, the published works focus on the impact of social media among Sri Lankan population on different aspects such as academic performance (Mufassirin *et al*., 2023; Chandrasiri and Samarasinghe, 2021, Suganya *et al.,* 2020; Shameera and Sabaretnam, 2019), emotional intelligence (Keara and De Zoysa, 2022), mental health (Weerasundera, 2014) and marketing (Dananjana, Yasara, and Abeysekera 2024). Thus, a notable gap in the literature has been identified regarding the specific impact of food-related posts on social media as well as among the young generation. Given these gaps, this study aims to examine the frequency of exposure to FRPs on SM platforms among Sri Lankan undergraduate students and to survey the influence of FRPs on SM on individuals' eating habits, food choices, and food cravings. This study is significant as the outcomes help reveal the current food practices of undergraduates, who will be the working force of the country very soon. Here, we have limited the scope of the study to undergraduates considering the convenience of conducting the research and analysis.

This article has been organized as follows. Firstly, in the methodology, we discuss the development of a detailed online questionnaire to evaluate the influence of food-related posts in SMs on the eating habits of (university) undergraduates. Next, the outcomes of the study will be presented and discussed, which also reveal possible correlations of variables such as the gender of participants with eating habits, dietary choices, and food cravings as influenced by food-related posts (FRPs). We also discuss the reliability of information shared via FRPs and the impact of FRPs based on the outcomes of the online questionnaire. The concluding remarks of the work are finally presented along with potential future works.

II. METHODOLOGY

*A. **Study design and sampling***

An anonymous online survey was conducted from May to June 2024, using a structured questionnaire to collect data from randomly selected undergraduate students (i.e. level-100, level-200, level-300, and level-400 students). The questionnaire was developed in the Google Forms platform and the respondents were invited via the link shared via social media platforms such as WhatsApp, Instagram, E-mail, and LinkedIn. The next section will outline the different sections included in the questionnaire.

*B. **Questionnaire***

The questionnaire was created based on a previously validated questionnaire (Alwafi et al., 2022) and modified based on the scope of this study. The questionnaire consists of three major parts as listed below:

1. *Part A:* This section collects socio-demographic details of the participants including their age (five age ranges: 18-22, 23-27, 28-32, 33-37, 38-42 and above), gender (male or female), and type of hometown (i.e. city, country) of the participant to enable a detailed analysis.

2. *Part B:* This section comprises social media (SM) posts-related questions including the types and number of SM accounts, frequency of check-in to SM, frequency of exposure to food-related posts on SM, the preferred SM sites to check food-related posts, and the preferred type of food-related contents that participants watch. A Likert scale was used appropriately to gather the responses.

3. *Part C*: This section includes questions related to eating habit changes including food habits, food choices, and food cravings, the reliability of the information given through food-related posts, and the impact of food-

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related posts based on participants' views. A Likert scale was used appropriately to gather responses.

C. *Statistical analysis*

The appropriate data were analyzed using Minitab-20 software. In the analysis, descriptive statistics were used to evaluate the continuous variables, and Chi-square testing was used for categorical variables at a 0.05 significance level.

III. RESULTS AND DISCUSSION

A. *Demographic information of the participants*

Out of 396 participants who responded to the questionnaire, a majority represents the 23-27 age range (i.e 81.1%), the 18-22 age group represents the second highest (i.e. 14.9%), and the 38-42 age group represents the lowest (i.e 0.5%), as depicted in Figure 01. There are 68.9% female participants and the highest number of participants are from the town area (i.e. 45.7%) while the lowest number of participants are from the city area (i.e. 23.5%).

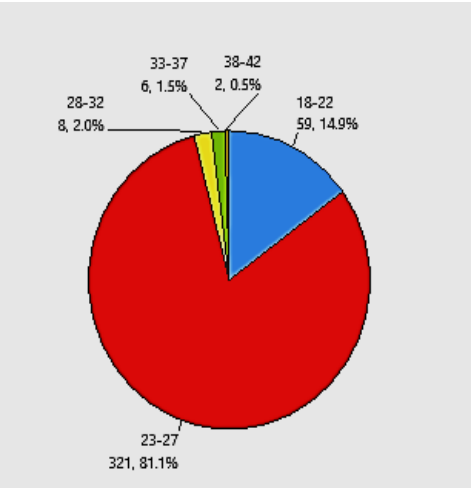

Figure 01: Age distribution of the respondents (18-22), (23-27), (28-32), (33-37), (38-42) represent the age intervals of each segments

B. *Frequency of exposure to social media sites and food-related posts*

According to Figure 02, 93.7% of participants have WhatsApp accounts, and 86.1% have YouTube accounts. Also, 66.7% and 60.4% of the tested population have Instagram and Facebook accounts, respectively. Furthermore, 89.4% of the participants have more than one SM account. Only a very few (< 1%) do not have any SM accounts in the given list.

Figure 03 shows that a majority (i.e. 30.3%) have three SM accounts, which is followed by participants who have four, five, two, and one accounts, respectively. One key reason for this observation could be the free access to these SM accounts. Thus, many undergraduates tend to have different SM accounts for different purposes such as information sharing, marketing their channels, and creating their public image in SM.

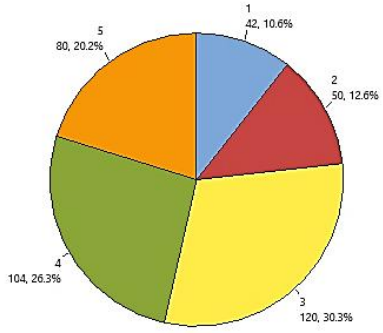

Figure 03: The frequency distribution of social media accounts owned by the participant based on the social media sites including YouTube, Facebook, Instagram, TikTok, and WhatsApp

Next, Figure 04 depicts the frequencies at which respondents use the SM. As per results, 49.0% of participants use SM more than five times per day while 30.8% of the population use SM platforms less than two times per day. To this end, a similar study conducted in Sri Lanka states that most undergraduates use SM for less than 2 hours daily while a notable group uses it for over 8 hours daily (Athukorala, 2021). It is clear that the SM usage has increased over three years (i.e. 2021 to 2024) such that more time is consumed for SM. The elevated use of artificial intelligence in SM platforms could be a reason behind this observation.

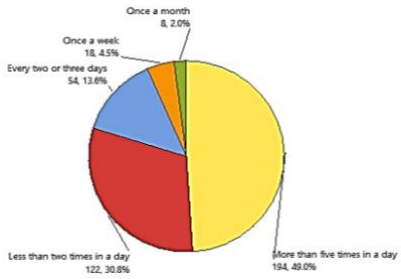

Figure 04: The distribution of frequency of exposure to social media among participants

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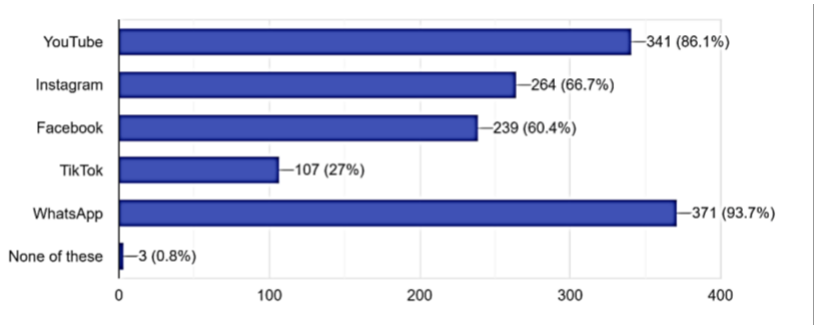

Figure 02: Distribution of the number of social media (SM) accounts participants currently have
Category 1,2,3,4,5 refers to the number of social media accounts participants own.

Figure 05 depicts the frequency of watching food-related posts (FRPs) on SM sites. As per the results, the frequency of watching FRPs on SM often is about 80% (i.e., the sum of percentages of extremely often, very often, and moderately often), and only 8.1% rarely use SM for FRPs. One key reason could be the lack of time that undergraduates have to visit the food shops to check them out due to their busy schedules. By today, most vendors tend to have publicity for their foods on SM, which can also be a reason for undergraduates to use SM to see the related posts.

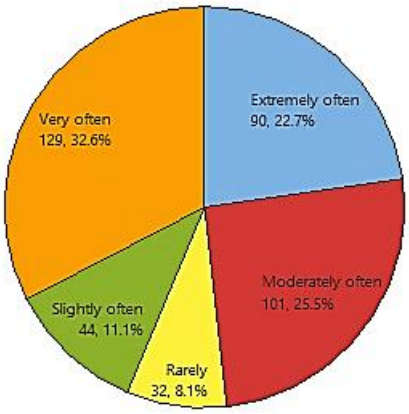

Figure 05: The frequency distribution of watching food-related posts on social media sites

Table 01 shows the relationship between the frequency of watching FRPs on SM and gender and the number of SM. Accordingly, the frequency of watching FRPs is significantly affected (p=0.000) by the number of SM accounts that participants have, while it is not affected by the frequency of engaging in SM (p=0.969). For this observation, one key reason could be the use of different SM platforms to distribute information on FRPs, for example, the same FRPs are shared through TikTok and YouTube shorts, etc.

Table 02 shows the frequency distribution for preferred SMs to watch food-related posts. The results indicate YouTube is largely preferred, while Instagram and Facebook have moderate preferences. On the contrary, a similar study conducted by examining nearly 10 million Instagram posts by 1.7 million users around the world shows that Instagram is highly utilized for food logging and research where the obsession with foods such as desserts, savories as well as healthy eating (Mejova, Abbar, and Haddadi, 2016). A key reason for the observed difference could be that the current study focuses only in Sri Lanka with a limited population. Another reason could be the introduction of YouTube shorts (a short-time video), introduced after 2016 to quickly deliver information.

Figure 06 depicts the likelihood distribution of food-related content participants watch. Results indicate that most of the contents are watched neutrally while contents on snacks and dessert reviews, street food place reviews, and food preparation and cooking videos are watched with great interest. The key reason could be the affordability of purchasing and the majority of participants are female in the study.

Table 01: The relationship between the frequency of watching FRPs on SM and gender, and the number of SM accounts at the significance level=0.05

Variable 01	Variable 02	Chi-square value	p-value	Relationship
Frequency of watching FRPs	Number of SM accounts	654.320	0.000	Dependent
Frequency of watching FRPs	Gender	1.458	0.834	Independent

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FRPs= food-related posts SM= social media

Table 02: The preference distribution for watching Food-related posts (FRPs) on different social media sites

Social media	Moderate to high prefer preference (%)	Neutral preference (%)	Low preference percentage (%)
YouTube	63.13	12.88	23.99
Instagram	43.18	15.91	40.91
Facebook	40.15	22.98	36.87
TikTok	34.34	11.87	53.78
WhatsApp	36.11	11.11	52.78

C. *Influence of FRPs on food habits, food choices, and food cravings.*

Table 03 shows the responses of participants on different statements on FRPs. As per the results, participants agree (i.e. sum of strongly agree and agree) with most of the statements, and the participants are neutral on the statement "The food hacks I have tried have never gone wrong ".

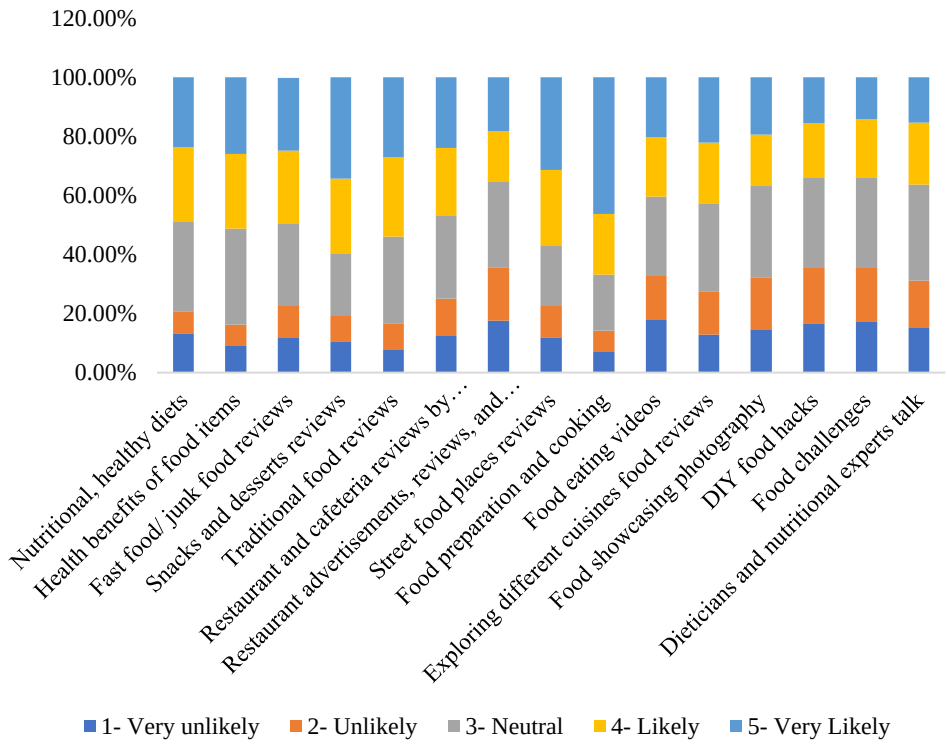

Figure 06: The likelihood percentages of different FRP contents according to the Likert scale 1-5

Table 03: Participants' responses to statements that measure the impact of FRPs on food habits

	Statements on food habits	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
1.	I have tried a nutritional diet plan promoted by social media	12.37% (47)	25.53% (97)	30.00% (114)	19.47% (74)	12.63% (48)
2.	I have added one or more nutritional foods to my daily diet	14.17% (54)	32.28% (123)	30.71% (117)	15.49% (59)	7.35% (28)
3.	I try novel junk food items on social media that are not in my usual eating habits	12.63% (49)	28.87% (112)	27.32% (106)	22.42% (87)	8.76% (34)
4.	Social media posts increased my fast-food consumption rate.	18.44% (71)	30.39% (117)	22.08% (85)	19.22% (74)	9.87% (38)

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5.	I have tried different cuisines from other countries.	13.51% (52)	25.97% (100)	23.12% (89)	21.56% (83)	15.84% (61)
6.	I have promoted many fast foods/junk foods/places with my friends and family members that I watched on social media.	15.89% (61)	24.47% (95)	22.40% (86)	23.44% (90)	13.54% (52)
7.	Social media posts increase my snacking habit.	20.05% (77)	28.91% (111)	22.66% (87)	18.49% (71)	9.90% (38)
8.	I have started preparing dishes that I watched on social media	28.42% (108)	32.89% (125)	21.32% (81)	11.32% (43)	6.05% (23)
9.	I have started having sugar-containing desserts or beverages as a habit after meals.	13.19% (50)	27.70% (105)	27.44% (104)	20.84% (79)	10.82% (41)
10.	The food hacks I have tried have never gone wrong.	12.06% (45)	19.84% (74)	34.85% (130)	21.45% (80)	11.80% (44)

Next, we present the response analysis of food choices. Table 04 exhibits the distribution of the responses to the statements on food choices. Accordingly, a similar agreeing pattern is observed in all statements except being neutral for the statement Social media posts help me find a nutritionally health FRPs= food-related posts SM= social media diet plan that fits me". This shows a current drawback (in Sri Lankan undergraduates) in choosing a healthy diet plan as proposed by FRPs.

Next, Table 05 shows the distribution of responses to statements on food cravings. As per the results, participants agree (i.e. sum of strongly agree and agree) with all statements.

Table 06 presents the correlation among different focused areas in FRPs with the above statements to further analyze any correlations. Here, statements 1-10, statements 11-17, and, 18-26 correspond to eating habits, dietary choices, and food cravings, respectively. As per results, significant correlations are observed between the frequency of watching FRPs and impacts on food habits (i.e. statements 1-10). In fact, the statements, the participants have started preparing their dishes (p= -0.013), increased their snacking habits (p= 0.013), tend to try different cuisines(p=0.017), and have added nutritional foods to their diet (p=-0.021) show strong associations while their fast-food consumption increased (p=-0.053) and they promoted food item/place (p=0.055) might be associated. In reported studies, SM influences eating habits among undergraduates in Malaysia (Ahmad and Bruno, 2021) and exposure to SM depicting unhealthy products, such as sugar, fast food, and snacks, is directly correlated with high consumption among the Saudi Arabian population (Alwafi *et al*., 2022).

Statements 11-17 also report strong and moderate correlations between the frequency of watching FRPs and the statements. Statements including street food places with affordable food items (p-= 0.002), SM posts help to find good restaurants with authentic dishes (p=0.008), SM helps to find a diet plan (p= -0.006) and the reviews are reliable for making choices (p= -0.033). it shows a significant association while the reviews on eateries and foods when visiting certain locations and before ordering (p= -0,.058) might be associated. To this end, in a recent cross-sectional study conducted in Saudi Arabia, state people are influenced by SM when making food-related decisions (Alwafi *et al*., 2022). Thus, the current study outcomes agree with this finding. However, another study conducted in Malaysia claims that the attitude of students towards SM influencers does not affect their daily dietary choices (Ahmad and Bruno, 2021).

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Table 04: Participants' responses to statements that measure the impact of FRPs on food choices

	Statements on food choices	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
1.	I searched for social media reviews on restaurants and street food places when I went to certain locations.	22.79% (85)	34.58% (129)	22.52% (84)	10.99% (41)	9.12% (34)
2.	I check social media reviews on food items before ordering them.	24.46% (91)	33.60% (125)	22.31% (83)	10.22% (38)	9.41% (35)
3.	Social media posts help to find good restaurants with luxury/ hospitality/buffet/authentic dishes.	25.40% (95)	42.78% (160)	19.52% (73)	8.02% (30)	4.28% (16)
4.	Social media posts help to try many food items at Street food places at affordable prices	27.88% (104)	37.00% (138)	21.18% (79)	8.85% (33)	5.09% (19)
5.	I search for the health benefits of natural foods before eating or buying them.	20.64% (77)	34.05% (127)	29.49% (110)	9.92% (37)	5.90% (22)
6.	I feel that the reviews are reliable for making choices most of the time	18.40% (69)	35.73% (134)	32.00% (120)	9.33% (35)	4.53% (17)
7.	Social media posts help me find a nutritionally healthy diet plan that fits me	16.89% (63)	27.88% (104)	34.85% (130)	12.60% (47)	7.77% (29)

Table 05: Participants' responses to statements that measure the impact of FRPs on food cravings

	Statements on food cravings	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
1.	Even though I do not feel hungry, I go to restaurants or street food places to satisfy my food cravings which I watch on social media	16.09% (60)	22.79% (85)	26.27% (98)	16.62% (62)	18.23% (68)
2.	I feel interested in preparing dishes at home from the recipe videos	29.87% (112)	35.73% (134)	20.27% (76)	8.27% (31)	5.87% (22)
3.	I feel a food craving for the foods that they are consuming in their posts.	19.29% (71)	34.24% (126)	29.08% (107)	10.33% (38)	7.07% (26)
4.	My cravings for sugary foods and spicy foods increased after watching social media posts	18.25% (69)	32.80% (124)	25.93% (98)	14.02% (53)	8.99% (34)
5.	I feel hungry after watching food-	24.73% (92)	31.72% (118)	23.92% (89)	11.83% (44)	7.80% (29)

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	consuming videos.					
6.	I forget that I am hungry when I am engaged with food-consuming contents	13.17% (49)	26.34% (98)	26.88% (100)	19.89% (74)	13.71% (51)
7.	I feel pressured to try certain foods or to visit specific eateries because they are popular with social media influencers and celebrities.	13.37% (50)	27.81% (104)	31.28% (117)	15.24% (57)	12.30% (46)
8.	Food-making videos make me feel satisfied like I have truly been involved.	25.60% (96)	32.27% (121)	28.27% (106)	8.00% (30)	5.87% (22)
9.	Food showcasing photographs and advertisements induces my cravings.	18.62% (70)	32.98% (124)	27.66% (104)	12.50% (47)	8.24% (31)

Next, considering statements 18-26, a strong correlation is observed between the frequency of watching FRPs and feeling hungry after watching food-consuming videos (p=0.021) while the association between statements 19,20 and 23 is not strong enough to prove. Past studies show that SM exposure increases anxiety and leads to emotional over-eating (Gao *et al*., 2022) and also the sight of food provokes various brain responses related to the preparation for food and the desire to eat. Also, food marketing may convincingly demonstrate that exposure to SM depicting unhealthy products, such as sugar, fast food, and, snacks, is directly correlated with high consumption among children and adults (Alwafi *et al*., 2022). The results along with the literature suggest that FRPs on SM may impact food cravings among the respondents but they are not strong enough to prove.

Table 06: The correlation analysis between statements and frequency of watching FRPs on social media at a confidence level of 0.05 FRPs= food-related posts (Statements 1-10: Eating habits, Statements 11-17: Dietary choices and Statements 18-26: Food cravings)

Focused area in FRP	**Variable 1: frequency of watching FRPs Variable 02**	**p-value**	**Relationship between variables 01 and 02**
Eating habits	Statement 01	-0.096	Independent
	Statement 02	-0.021	Dependent
	Statement 03	-0.101	Independent
	Statement 04	-0.053	Might be Dependent
	Statement 05	0.017	Dependent
	Statement 06	-0.055	Might be dependent
	Statement 07	0.013	Dependent
	Statement 08	-0.013	Dependent
	Statement 09	-0.089	Independent
	Statement 10	-0.069	Independent
Dietary choices	Statement 11	-0.076	Independent
	Statement 12	-0.058	Might be dependent
	Statement 13	-0.008	Dependent
	Statement 14	0.002	Dependent
	Statement 15	0.078	Independent

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	Statement 16	-0.033	Dependent
	Statement 17	-0.006	Dependent
Food cravings	Statement 18	-0.123	Independent
	Statement 19	-0.058	Might be dependent
	Statement 20	-0.054	Might be dependent
	Statement 21	-0.076	Independent
	Statement 22	0.021	Dependent
	Statement 23	-0.059	Might be dependent
	Statement 24	-0.074	Independent
	Statement 25	-0.081	Independent
	Statement 26	-0.125	Independent

D. ***Impact of food-related posts on social media***

Figure 07 shows the distribution of the frequencies that participants visit the restaurant or taste the food item they watched on SM. As per results, 80% of the population visits the restaurant or tastes the food at least once. Here, only 17% visit just once, and approximately a quarter of the population visits the restaurant more than 10 times. For the former observation, one key reason could be the food was not preferred by the consumers despite the marketing campaign signifying the ignited spark in consumers to visit the restaurant by the SM.

As per the results from Table 07, the participants who visited the restaurant or tasted the food that they checked on SM might have a significant association with gender (χ^2 =7.670 and p=0.053) at 0.05 significance level. However, considering the tested population, no correlation was found between the frequency of tried foods/visits to restaurants and the type of hometown or the frequency of watching FRPs on SM.

One key reason for the above observation could be the countrywide access to SM disregarding the type of hometown. Furthermore, the SM influencers can only make a one-time impact for the first-time visit or first-time tasting of the food as the frequency of tasting the foods is independent of the frequency of watching FRPs on SM. Furthermore, it seems further visits or tasting depend on other factors such as the quality of food, customer service, cleanliness of the place etc.

Next, Figure 08 describes the satisfaction level measure of their own experience they had on visiting the eateries or trying food which they choose from the information via SM posts. Apart from those who have not experienced it (14.4%), the majority of respondents (58.7%) are satisfied. To this end, Qualman (2014) argues "SM users at present trust peer recommendations more than search engines, and this fact is evident from the resonance of SM users with those who review their experiences in product consumption and services on their accounts, particularly on dining out and "cafe-hopping" as a social experience". The study also reveals the information shared about eateries and foods via SM can be mostly reliable.

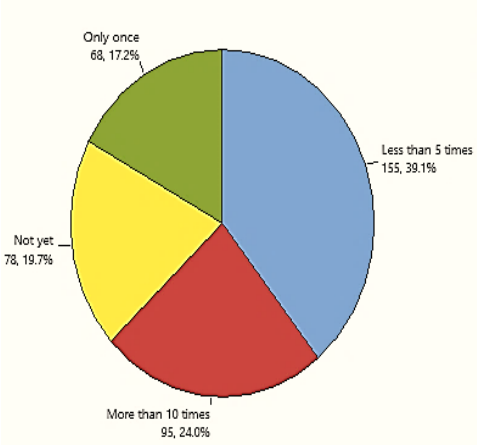

Figure 07: The distribution of frequency of times participants visited the restaurant or tasted the food items.

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Table 07: The relationship between the frequency of trial with food/ restaurants with Gender and type of hometown (i.e. city/village/town) at significance level= 0.05. FRPs= food-related posts SM= social media

Variable 1	Variable 2	Chi-square Value (x^2)	p-value	Conclusion
Frequency of tried foods/visits to restaurants	Gender	7.670	0.053	Might be dependent
	Type of hometown	3.085	0.798	Independent
	Frequency of watching FRPs on SM	6.120	0.910	Independent

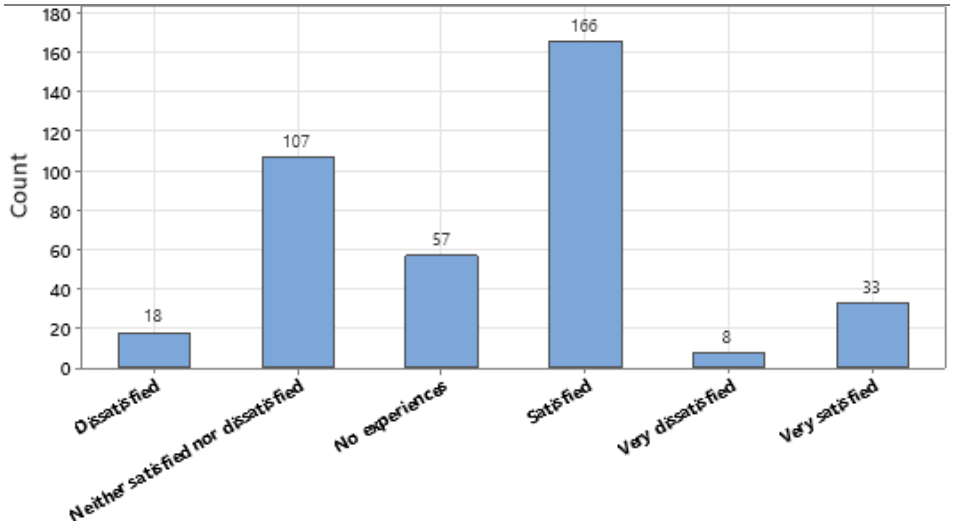

Figure 08. The frequency distribution in measuring the satisfaction level participants had with their own experience of trying foods or visiting eateries that are promoted by social media.

Past studies state that a significant positive correlation was found between the level of obesity rate and the mean percentage of followers of sugary drinks or fast-food brands on Instagram and Twitter (Gu *et al.*, 2021), and engagement with unhealthy food brands on SM is common among adolescents (Fleming-Milici and Harris, 2020). Accordingly, the level of agreement on the statement was assessed using 'Most of the foods promoted via SM platforms lead to an unhealthy lifestyle'.

Following the above agreement, Figure 09 shows the levels of agreement with the above statement. Based on results, 44.9% of respondents agree that they lead to unhealthy lifestyles while 41.7% say they are neutral. These findings agree with a recent study in Australia, which reports that SM engagement impacted negatively in body image and food choices in healthy young (Rounsefell et al., 2020).

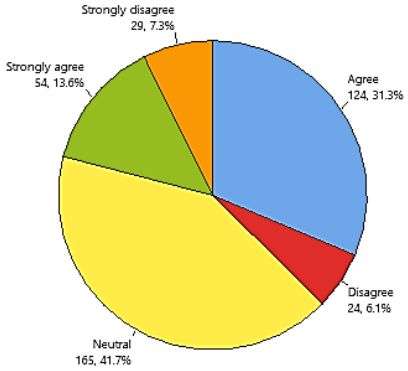

Figure 09: The frequency distribution regarding the level of agreement on the statement "Most of the foods promoted via social media platforms lead to an unhealthy lifestyle'

Figure 10 shows the distribution of responses obtained for overall impact due to food-related posts on SM on the undergraduates. As per results, the majority (i.e. 73.7%) agree that there could be positive impacts as well as negative impacts on an equal ratio from the perspective of the participants. Furthermore, only very few (2 %) are neutral or saying no impact, which implies that the

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undergraduates are well aware that SM has any sort of effect on FRPs.

IV.CONCLUSION

The reported study evaluates the impact of food-related posts on social media on eating habits and dietary choices among university undergraduates in Sri Lanka. The following can be concluded from the study outcomes.

- The time spent on social media in a day shows a rapid increase rate, particularly, the exposure to food-related posts on social media is also notably high among the undergraduates of Sri Lankan universities which strongly correlates with the number of social media accounts individuals have.
- YouTube is the most popular social media site for watching Food-related posts while Instagram and Facebook are moderately popular.
- The participants rather tend to watch food-related content like snack and dessert reviews, street food place reviews, and food preparation and cooking videos.
- The participants' agreement reveals that there are significant impacts on eating habits, food choices, and food cravings due to FRPs. However, correlation analysis results show significant effects due to FRPs on eating habits and food choices rather than food cravings.
- There is a correlation between gender and the frequency of tried foods/visited restaurants watched via FRPs by participants. Most undergraduates are aware that food related posts on social media have both positive and negative impacts on their lives, yet they agree that FRPs possibly lead to an unhealthy lifestyle.

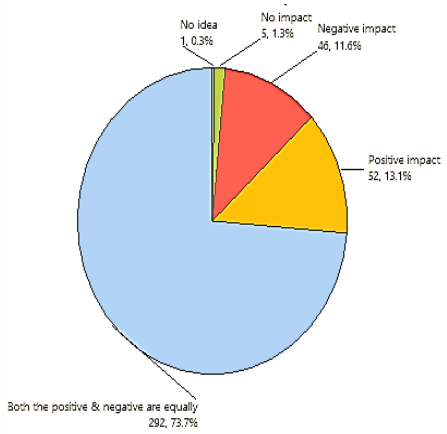

Figure 10: The distribution of the overall impact of FRPs on social media on the young generation

The findings of this study can lead to future research on the association between exposure to food-related posts and the present rise in health complications (i.e. obesity, non-communicable diseases, etc.) among young adults in Sri Lanka.

REFERENCES

Ahmad, S. A. and Bruno, D. E. (2021) 'Social media influencers and the dietary choices among university students', *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 6(10), pp. 543–557. https://doi.org/10.47405/mjssh.v6i10.1125

Alwafi, H. et al. (2022) 'The impact of social media influencers on food consumption in Saudi Arabia, a cross-sectional web-based survey', *Journal of Multidisciplinary Healthcare*, 15, pp. 2129–2139. https://doi.org/10.2147/jmdh.s384523.

Athukorala, A. W. V. (2021) 'Nature of social media usage by university students in Sri Lanka: A survey', *International Journal of Research and Innovation in Social Science*, 5(1), pp. 426–432. https://doi.org/10.47772/ijriss.2021.5130.

Chandrasiri, G. D. T. D. and Samarasinghe, S. M. (2021) 'Use of social media in student learning and its effect on academic performance', in *Future of Business and Finance*. Cham: Springer International Publishing, pp. 357–374.

Dananjana, W.I., Yasara, D.L.I. and Abeysekera, N. (2024) 'Impact of social media marketing on customer engagement in an apparel brand, Sri Lanka', *International Journal of Research and Scientific Innovation*, 11(4), pp. 968–987. https://doi.org/10.51244/ijrsi.2024.1104069.

Digital Outlook Sri Lanka (2024) *APIDM*. Asia Pacific Institute of Digital Marketing. Available at:

https://apidm.asia/resources/digital-outlook-2023/ [Accessed: 6 July 2024].

Fleming-Milici, F. and Harris, J. L. (2020) 'Adolescents' engagement with unhealthy food and beverage brands on social media', *Appetite*, 146, p. 104501. https://doi.org/10.1016/j.appet.2019.104501.

Gao, Y. et al. (2022) 'Social media exposure during COVID-19 lockdowns could lead to emotional overeating via anxiety: The moderating role of neuroticism', *Applied Psychology: Health and Well-Being*, 14(1), pp. 64–80. https://doi.org/10.1111/aphw.12291.

Gu, Y. et al. (2021) 'Associations between state-level obesity rates, engagement with food brands on social media, and hashtag usage', *International Journal of Environmental Research and Public Health*, 18(23), p. 12785. https://doi.org/10.3390/ijerph182312785.

Karthijekan, S. and Angela, J. (2020) 'Nutritional status and dietary practices among university students in Sri Lanka', *International Journal of Scientific and Research Publications (IJSRP)*, 10(10), pp. 359–365. https://doi.org/10.29322/ijsrp.10.10.2020.p10648.

Kemp, S. (2024) *Digital 2024: Sri Lanka*. Data Reportal – Global Digital Insights. Available at: https://datareportal.com/reports/digital-2024-sri-lanka [Accessed: 8 June 2024].

Khalid, N. L., Jayasainan, S. Y. and Hassim, N. (2018) 'Social media influencers: Shaping consumption culture among Malaysian youth', *SHS Web of Conferences*, 53, p. 02008. https://doi.org/10.1051/shsconf/20185302008

Ludwig-Borycz, E. et al. (2023) 'Personal, behavioral and socio-environmental correlates of emerging adults' sustainable food consumption in a cross-sectional analysis', *Public Health Nutrition*, 26(6), pp. 1306–1316. https://doi.org/10.1017/s1368980023000654.

Mejova, Y., Abbar, S. and Haddadi, H. (2016) 'Fetishizing food in the digital age: #foodporn around the world', *arXiv [cs.SI]*. Available at: http://arxiv.org/abs/1603.00229.

Mufassirin, M. M. M. et al. (2023) 'Impact of social media usage on students' academic performance before and during the COVID-19 pandemic in Sri Lanka', *Global Knowledge Memory and Communication*. https://doi.org/10.1108/gkmc-01-2023-0028.

Nirmal, G. G. R. and Padmasiri, M. K. D. (2022) 'Health behavior and academic performance of Sri Lankan undergraduates', *International Journal of Human Resource Studies*, 12(2), p. 90. https://doi.org/10.5296/ijhrs.v12i2.19696.

Qualman, E. (2010) *Social media revolution video (refreshed)*. *Socialnomics*. Available at: https://socialnomics.net/2010/05/05/social-media-revolution-video-2-refresh/ [Accessed: 1 July 2024].

Rounsefell, K. et al. (2020) 'Social media, body image and food choices in healthy young adults: A mixed methods systematic review', *Nutrition & Dietetics: The Journal of the Dietitians Association of Australia*, 77(1), pp. 19–40. https://doi.org/10.1111/1747-0080.12581.

Salleh, M. M. et al. (2021) 'Social medias' influences on food popularity amongst Malaysian university students', *International Journal of Academic Research in Business and Social Sciences*, 11(13). https://doi.org/10.6007/ijarbss/v11-i13/8540.

Scheiber, R., Diehl, S. and Karmasin, M. (2023) 'Analysing the effects of social media influencers' food-related posts on healthy eating intentions, orthorectic eating tendencies, product attitudes, and purchase intentions', *MedienJournal*, 46(3), pp. 47–64. https://doi.org/10.24989/medienjournal.v46i3.2193.

Shameera, A. and Sabaretnam, W. (2019) *Impact of social media use on academic performance among university students: Special reference with South Eastern University of Sri Lanka*. Oluvil: South Eastern University of Sri Lanka. Available at: http://ir.lib.seu.ac.lk/handle/123456789/4275

Soam, S. K. et al. (2023) 'Factors influencing dietary patterns among the youth from higher educational institutions in India', *Frontiers in Nutrition*, 10. https://doi.org/10.3389/fnut.2023.1134455.

Suganya, D. F. J., Kengatharan, L. and Yogendrarajah, R. (2020) 'Use of social media and academic performance of students: Evidence from undergraduate students in University of Jaffna, Sri Lanka', *Journal of Business Studies*, 7(2), pp. 62–76. https://doi.org/10.4038/jbs.v7i2.61.

Tami, S. and Alyousef, A. (2022) 'The effect of food advertisements on social media on the dietary behaviors of the community of King Faisal University in Saudi Arabia', *Current Developments in Nutrition*, 6, p. 866. https://doi.org/10.1093/cdn/nzac065.050.

Weerasundera, R. (2014) "The impact of social media in Sri Lanka: issues and challenges in mental health," *Sri Lanka journal of psychiatry*, 5(1), p. 1. Available at: https://doi.org/10.4038/sljpsyc.v5i1.7049.

Development of a Seaweed-based Vegan Burger Patty Rich in Protein

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Abstract

Seaweed is a versatile plant used globally for food and non-food applications, valued for its nutritional and medicinal benefits. In Sri Lanka, seaweed is abundant yet underutilized due to limited awareness. This study developed a vegetarian burger patty incorporating seaweed to address micronutrient deficiencies. Ulva fasciata (green algae) and Sargassum sp. (brown algae) were selected for their high nutrient value. Fresh seaweed was sorted, soaked in a 4% brine solution, rinsed, washed, blanched, dried, ground, and sieved into powder. Steam blanching was selected to preserve seaweed's nutritional and sensory qualities, enhancing the protein and mineral content of burger patties. The proximate composition (dry basis) of Ulva fasciata includes 24.07%±0.02 protein, 0.81%±0.00 fat, 42.14%±0.01 carbohydrates, 11.59%±0.06 ash, 21.37%± 0.02 fiber, whereas Sargassum sp. contains 13.92%±0.03 protein, 0.79%±0.00 fat, 49.89%±0.01 carbohydrates, 26.97%±0.04 ash, 7.98%±0.00 fiber, highlighting significant nutrient content, with Ulva fasciata showing higher protein, fiber values. Burger patties with varying Ulva fasciata content (50%,55%,60%,65%) were prepared with tomato, onion, garlic, corn flour, and spices. Sensory evaluation by a trained panel using a 7-point hedonic scale assessed color, appearance, odor, texture, taste, aftertaste, mouthfeel, and overall acceptability. Proximate analysis of the seaweed-based burger patty revealed a moisture content of 32.45±0.013%, fat content of 10.86±0.042%, protein content of 11.99±0.17%, carbohydrate content of 30.50±0.14%, ash content of 4.79±0.01%, and fibre content of 8.94±0.03%. Elemental analysis showed reduced heavy metals like Pb and As in burger patties compared to raw Ulva fasciata.

Keywords: Seaweed, Ulva fasciata, Sargassum sp., Burger patty, Blanching, Vegetarian, Proximate composition

I. INTRODUCTION

The global population is projected to reach approximately 9 billion by 2050 and could level off at 10 to 11 billion by the next century (Prager, 2016). This surge necessitates sustainable food alternatives, positioning seaweed-based products as a viable solution due to their nutrient-rich profile and sustainable cultivation, which doesn't require fresh water, chemical fertilizers, or land (Premarathna et al., 2020; Gomez-Zavaglia et al., 2019). Seaweeds, primarily used in Asia, have applications in food, industry, and agriculture (Mahadevan, 2015). In countries like Japan, Korea, and China, seaweed cultivation is a significant industry, whereas in Sri Lanka, it remains underutilized (Wickramasinghe et al., 2020). Seaweeds, classified as algae, are categorized into brown (phaeophyta), red (rhodophyta), green (chlorophyta), and blue-green (cyanophyta) (Emrkb and Rmsm, 2015). They are recognized for their high levels of protein, carbohydrates, minerals, vitamins, and trace elements like iodine (Jayakody et al., 2019). Historically, seaweed has been a part of diets in Japan since the fourth century and in China since the sixth century, used for its nutritional and medicinal properties (Baweja et al., 2016). Currently, China, Japan, and Korea are the largest consumers, but global demand is increasing, prompting the development of cultivation industries that now meet over 90% of market needs (Quitral et al., 2021; Puminat, 2019).

In Sri Lanka, the need for more awareness about seaweed's benefits has hindered its utilization. This study focuses on developing a high-protein, non-meat seaweed burger patty to cater to the growing demand for vegan products, particularly in Western countries and among populations reducing meat consumption (Premarathna et al., 2019). The research examines the nutritional and sensory properties of seaweed-based patties, emphasizing their potential to provide a balanced diet with high protein and fibre content, thus addressing the nutritional deficiencies of conventional burger patties.

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II. LITERATURE REVIEW

2.1 Seaweed as a Nutritional and Functional Food Source

Seaweed, a marine macroalgae, has been utilized for centuries in various cultures for its nutritional and medicinal benefits. Seaweeds are rich in essential nutrients, including proteins, vitamins, minerals, dietary fibres, and bioactive compounds, which confer multiple health benefits. The nutritional profile of seaweeds varies significantly across species, making them a valuable addition to the human diet (Dhargalkar & Pereira, 2005).

2.1.1 Nutritional Benefits

Seaweeds are a potent source of essential micronutrients such as iodine, iron, calcium, magnesium, and vitamins A, B, C, and E. Iodine, in particular, is crucial for thyroid function and is abundant in seaweeds like kelp. The protein content in seaweeds, though varying among species, provides essential amino acids, making it a beneficial supplement for vegetarian and vegan diets (MacArtain et al., 2007). The high fibre content in seaweed aids in digestive health and contributes to a feeling of fullness, which can help in weight management (Jiménez-Escrig & Sánchez-Muniz, 2000).

2.1.2 Medicinal Properties

Seaweeds possess various bioactive compounds, including polysaccharides, polyphenols, and carotenoids, which exhibit antioxidant, anti-inflammatory, antiviral, and anticancer properties. These compounds can help reduce the risk of chronic diseases such as cardiovascular diseases, diabetes, and cancer (Gupta & Abu-Ghannam, 2011). The polysaccharides in seaweed, such as alginate, carrageenan, and agar, have been shown to enhance immune function and promote gut health by acting as prebiotics (Zaporozhets et al., 2014).

2.1.3 Seaweed in Food Products

The incorporation of seaweed into food products has gained traction due to its health benefits and functional properties. Seaweeds are used as gelling, thickening, and stabilizing agents in various food formulations. Their unique umami flavour also enhances the taste profile of many dishes. Recent studies have explored the use of seaweed in bakery products, snacks, beverages, and meat alternatives (Sappati et al., 2019).

2.1.4 Seaweed in Meat Alternatives

The rising demand for plant-based meat alternatives has led to the exploration of seaweed as a key ingredient due to its high nutrient density and functional properties. Seaweed-based meat analogues have been developed to mimic the texture and flavour of conventional meat products while providing added health benefits. The addition of seaweed can enhance the nutritional profile of these products, offering a rich source of vitamins, minerals, and antioxidants (Mouritsen et al., 2019).

2.2 Challenges and Opportunities

Despite its benefits, seaweed still needs to be utilized in many parts of the world due to limited consumer awareness and acceptance. The unique taste and texture of seaweed can be a barrier to its incorporation into mainstream diets. However, with increasing interest in sustainable and health-promoting foods, there is significant potential for the growth of seaweed-based products. Research and development efforts are focused on improving the sensory qualities of seaweed products and educating consumers about their benefits (Fleurence, 2016).

2.3 Seaweed in Sri Lanka

Sri Lanka has a rich diversity of seaweed species, particularly along its coastline. The potential for utilizing these resources to address nutritional deficiencies and promote health is significant. Local seaweed species, such as Ulva fasciata and Sargassum sp., are abundant and can be sustainably harvested year-round. Developing value-added seaweed products, such as the vegan seaweed burger patty, can help promote the consumption of seaweed and improve public health outcomes in Sri Lanka (Mendis & Kim, 2011).

III. MATERIALS AND METHODS

3.1 Sample Collection

Seaweed Ulva fasciata and Sargassum sp. were collected from the southern coast of Sri Lanka, specifically Thalpawatta Thalangama Matara. Samples were washed, rinsed with seawater, and stored in plastic bags. Upon arrival at the laboratory, they were further washed with distilled

water, frozen, and dried at 60°C for 8 hours before being ground and stored at 4°C.

3.2 Processing of Seaweeds

The fresh, undamaged seaweeds were sorted and soaked in a 4% brine solution before being rinsed. Blanching methods, including hot water and steam blanching, were compared through sensory evaluation of appearance, odour, taste, and overall acceptability by a trained panel.

3.3 Chroma meter Values

Measured L*, a*, b* color values using a Lovibond LC 100 chroma meter (n=15).

3.4 Development of Burger Patty with Ulva Fasciata

Ingredients: Seaweeds, corn starch, carrot, tomato, spice mix powder, olive oil, onion, and salt.
Method: Ingredients were mixed, cooked, and deep-fried. The sensory evaluation identified the best formula.

3.5 Proximate Analysis of Fresh Seaweeds

The analyses followed AOAC (2012) and SLS 824 (2018): moisture content was determined using the oven drying method and rapid moisture analyzer; ash content with a muffle furnace; crude fat via a Soxtherm apparatus; crude fibre with a Fibertc hot extractor; protein by the Kjeldahl method using a UDK139 distillation unit; and carbohydrate content calculated by difference (Igbabul et al., 2014).

3.5 Proximate Composition Analysis of Burger Patty

Table 01 : Methods used for Proximate Composition Analysis of Burger Patty

Component	Method
Moisture Content	Oven Drying Method and Rapid Moisture Analyzer
Protein Content	Kjeldahl Method with UDK139 Distillation Unit
Fat Content	AOAC (2012) official method
Fiber Content	AOAC (2012) official method
Ash Content	AOAC (2012) official method
Carbohydrate Content	method described in literature Igbabul B et al., 2014

3.6 Sensory Evaluation

Appearance, colour, odour, texture, and overall acceptability were assessed using a seven-point hedonic scale. The results were analyzed using the Kruskal-Wallis Test in MINITAB.

3.7 Determination of Heavy Metal Content

The analysis was performed using ICP-MS following the protocols outlined in AOAC 2015.01, AOAC 2011.4, and AOAC 99.10.

3.8 Analysis of Shelf Life

Microbiological studies were conducted according to SLS 1463:2013 (ISO 7218:2007). Yeast and mould counts were performed per SLS 516 PART 2/SECTION 1:2013 (ISO 21527-1:2008), and the total plate count was conducted as per SLS 516 PART 1/SECTION 1:2013 (ISO 4833-1:2013).

IV. RESULTS AND DISCUSSION

Figure 02 - Fresh seaweeds (*Ulva fasciata*)

Figure 03 - Fresh seaweeds (*Sargassum* sp.)

Figure 04 - Dried seaweed samples

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4.1 Selecting the best pretreatment method

Steam blanching was selected based on physical conditions and organoleptic properties, over hot water blanching despite taking more time, as it better preserves the texture, color, and nutrients of seaweed. As a pre-treatment, blanching not only enhances shelf life but also helps remove fishy odors, improving overall product quality. A sensory evaluation was conducted by assessing key attributes such as appearance, odor, taste intensity, and overall acceptability using a seven-point hedonic scale, with participation from aseven-member trained industrial panel.

4.2 Proximate Analysis

The proximate composition of *Ulva fasciata* and *Sargassum* sp. was analyzed, revealing significant differences in moisture, protein, fat, carbohydrate, ash, and fibre content.

Table 02 : Results of proximate composition of dry powdered *Ulva fasciata* and *Sargassum* sp.

Composition Dry Basis (%)	*Ulva fasciata*	*Sargassum* sp.
Moisture	85.72±0.00	84.82±0.00
Protein	24.07±0.02	13.92±0.03
Fat	0.81±0.00	0.79±0.00
Carbohydrate	42.14±0.01	49.89±0.01
Ash	11.59±0.06	26.97±0.04
Fibre	21.37±0.02	7.98±0.00

4.3 Proximate Composition Analysis of Seaweed-Based Burger Patty

Table 03: Proximate Composition of Seaweed-Based Burger Patty

Composition /Dry Basis (%)	Percentage ± SD
Moisture	32.45±0.013
Protein	11.99±0.17
Fat	10.86±0.04
Carbohydrate	30.50±0.14
Ash	4.79±0.01
Fibre	8.94±0.03

4.4 Sensory Evaluation of the Burger Patty

The sensory evaluation assessed consumer preference across four burger formulations with varying seaweed content. Kruskal-Wallis Test showed significant differences in attributes like appearance, colour, odour, texture, and overall acceptance. The most preferred sample contained 55% seaweed, 18% corn starch, 15% carrot, 10% tomato, 2% spice mix, 0.5% olive oil, and 0.5% salt.

4.5. Determination of Heavy Metal Content

Heavy metal content in raw materials and the final product was within permissible limits, ensuring safety

Table 04 : Heavy Metal Content in Seaweed and Final Product

Element (ppm)	Powder Product	Final Product	Permissible Value
Pb	0.08	0.08	6.0
Cd	0.092	<0.05	0.2
As	1.21	0.15	1.4
Hg	<0.05	<0.05	0.5

The low levels of heavy metals confirm the relative safety of the macro-algae from the southern coast of Sri Lanka, supporting their use in food products.

V. CONCLUSION

This study successfully demonstrated the nutritional potential of incorporating *Ulva fasciata* and *Sargassum* sp. into vegetarian burger patties. Both seaweed varieties were found to be rich in essential nutrients such as protein, minerals, and carbohydrates, while being low in fat. Notably, the high fiber content in these seaweeds contributes to various health benefits. The results indicated that *Ulva fasciata* is particularly suitable for developing burger patties, offering a high-protein and fiber-rich alternative for vegetarian diets. The processed seaweed patties showed enhanced nutritional profiles, making them a valuable addition to the food industry, especially in addressing nutritional deficiencies. This study found that steam blanching, compared to hot water blanching, is the superior method for preserving the nutritional content and sensory properties of seaweed-based products. Additionally, the reduction in heavy metal content through processing further supports the safety and efficacy of using seaweed as a food ingredient. The findings of this study highlight the potential for seaweed-based products to contribute to sustainable and health-promoting food options, aligning with the growing demand for plant-based alternatives. This study revealed that *Ulva fasciata* (green algae) and *Sargassum* sp. (brown algae) are nutritionally rich in protein, minerals, and carbohydrates, while being low in fat. Both varieties contain high amounts of fiber, which, though indigestible by human enzymes, offers several health benefits. The essential and trace element content, as well as heavy metal levels in seaweed, vary depending on species and location, and are altered by processing steps in product

development. *Ulva fasciata* has been successfully used to develop a fiber-rich vegetarian burger patty, which can be commercialized. Given the increasing global acceptance of seaweed as a vital nutrient source, it may address deficiencies in protein, carbohydrates, and minerals. The findings of this study conclude that seaweeds are a potential health food and can serve as valuable ingredients in the food industry due to their high nutritional and commercial value. Enhancing product quality and expanding the range of seaweed-based products will further boost their appeal.

REFERENCES

Abdul Khalil, H. P. S. et al. (2018) 'A review of extractions of seaweed hydrocolloids: Properties and applications', Express Polymer Letters, 12(4), pp.296–317.doi:10.3144/expresspolymlett.2018.27.

Bangmei, X. and Abbott, I. A. (1987) 'Edible seaweeds of China and their place in the Chinese diet', Economic Botany, 41(3), pp. 341–353. doi: 10.1007/BF02859049.Baweja, P. et al. (2016) Biology of Seaweeds, Seaweed in Health and Disease Prevention. Elsevier Inc. doi: 10.1016/B978-0-12-802772-1.00003-8.

Fleurence, J. (2004) 'Seaweed proteins', Proteins in Food Processing, (April 2004), pp. 197–213. doi: 10.1533/9781855738379.1.197.

García-Poza, S. et al. (2020) The evolution road of seaweed aquaculture: Cultivation technologies and the industry 4.0, International Journal of Environmental Research and Public Health. Doi: 10.3390/ijerph17186528.

Godlewska, K. et al. (2016) 'Plant Growth Biostimulants Based on Different Methods of Seaweed Extraction with Water', BioMed Research International, 2016. doi: 10.1155/2016/5973760.

Gomez-Zavaglia, A. et al. (2019) 'The potential of seaweeds as a source of functional ingredients of prebiotic and antioxidant value', Antioxidants, 8(9). doi: 10.3390/antiox8090406.

Gunathilaka, T. L. et al. (2020) 'Antidiabetic Potential of Marine Brown Algae - A Mini Review', Journal of Diabetes Research, 2020. doi: 10.1155/2020/1230218.

Hafting, J.T. et al. (2012) 'On-land cultivation of functional seaweed products for human usage', Journal of Applied Phycology, 24(3), pp. 385–392. doi: 10.1007/s10811-011-9720-1.

Jayakody, M., Vanniarachchy, M.P. and Wijesekara, I. (2019) 'Composition analysis of selected Sri Lankan seaweeds', Journal of Tropical Forestry and Environment, 9(2), pp. 93–100. doi: 10.31357/jtfe.v9i2.4471.

Jayasinghe, G., Jinadasa, B. and Chinthaka, S.D.M. (2018) 'Nutritional composition and heavy metal content of five tropical seaweeds', Open Science Journal of Analytical Chemistry, 3(2), pp. 17–22.

Khan, W. et al. (2009) 'Seaweed extracts as biostimulants of plant growth and development', Journal of Plant Growth Regulation, 28(4), pp. 386–399. doi: 10.1007/s00344-009-9103-x.

Makawita, G.I.P.S. et al. (2020) 'Analysis of metals and metalloids present in Sri Lankan dried seaweeds and assessing the possibility of health impact to general consumption patterns', Aquatic Living Resources, 33, doi: 10.1051/alr/2020017.

Ogundele, K.O., Adeyemi, S.B. and Animasaun, M.A. (2014) 'Influence of drying methods on the proximate and phytochemical composition of Moringa oleifera Lam', Global Journal of Medical Plant Research, 2(1), pp. 1–5.

Premarathna, A.D. et al. (2020) 'Preliminary screening of the aqueous extracts of twenty-three different seaweed species in Sri Lanka with in-vitro and in-vivo assays', Heliyon, 6(6), p. e03918. doi: 10.1016/j.heliyon.2020.e03918.

Quitral, V. et al. (2021) 'Seaweeds in bakery and farinaceous foods: A mini-review', International Journal of Gastronomy and Food Science, p. 100403. doi: 10.1016/j.ijgfs.2021.100403.

Radulovich, R. et al. (2015) 'Tropical seaweeds for human food, their cultivation and its effect on biodiversity enrichment', Aquaculture, 436, pp. 40–46. doi: 10.1016/j.aquaculture.2014.10.032.

Salehi, B. et al. (2019) 'Current trends on seaweeds: Looking at chemical composition, phytopharmacology, and cosmetic applications', Molecules,24(22).doi:10.3390/molecules24224182.

Sánchez-García, F. et al. (2021) 'Freshness quality and shelf life evaluation of the seaweed Ulva rigida through physical, chemical, microbiological, and sensory methods', Foods, 10(1). doi: 10.3390/foods10010181.

Stegenga, H. (2011) 'Sri Lankan seaweeds: methodologies and field guide to the dominant species', Botanica Marina, 54(1), pp. 301–110. doi: 10.1515/bot.2011.004.

T., R., A., M.S. and Joseph, J. (2019) 'Screening of phytochemical, antioxidant activity and anti- bacterial activity of marine seaweeds', International Journal of Pharmacy and Pharmaceutical Sciences, 11(1), p. 61.

Determination of Quality Characteristics of 'Nimba Arishta': A Comparative Analysis of Sri Lankan Brands

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Abstract

Ayurveda is an ancient system of medicine that has been used for thousands of years. It comprises a variety of medicines, including fermented forms such as Arishta (fermented decoctions). The therapeutic use of Arishta is determined by the properties of its ingredients and the method of preparation. Because of the differences in the ingredients used and the manufacturing process applied by different manufacturers, the physicochemical characteristics are susceptible to various changes. In the present study, different brands of Nimba Arishta, mainly made from Azadirachta indica (A, B, C, D, E and F) available in the market were thoroughly evaluated for their physicochemical parameters to establish an accepted procedure for standardisation of these Ayurvedic formulations. The physicochemical parameters such as pH, brix, refractive index, specific gravity, total dissolved solids, total ash content, acid insoluble ash and water soluble ash contents were evaluated. The results of the study were found within these ranges; pH 3.01(D) - 3.64(A), refractive index 1.3725 (A) - 1.4019(C), specific gravity 1.0684(A)- 1.0864(F), brix 25.06(A) - 41.00(C), total dissolved solids (g/mL) 0.1993(A) - 0.4107(C), total ash content (w/w%) 0.0971(D) – 0.1070(A), water soluble ash content (w/w%)(0.004(B) - 0.0899(F), acid insoluble ash content (w/w%) 0.0131(D) - F-0.0571(F). The results showed that the formulation of different brands of Nimba Arishta varies, highlighting the need for standardisation of Arishta.

Keywords: Arishta, Standardization, Nimba arishta, Physicochemical

I. INTRODUCTION

With the known negative impacts of synthetic products, there is a rising shift toward using herbal treatments for disease management. (Luqman et al., 2014). Ayurveda has a rich and ancient tradition of utilizing polyherbal drugs and formulations to address various health conditions. (Nandre et al., 2012). Ayurvedic practitioners have been utilizing fermentation techniques for centuries to enhance the effectiveness of medicines. Arishta are self-fermented ayurvedic medicines prepared by blending a decoction of various parts of different plants with sugar and bee honey. In most Arishta preparations, dried flowers of *Woodfordia fruticosa* L. Kurz (Lythraceae) known as 'malitha mal' in Sinhala are added as the fermentation initiator, in combined with dried plant parts collectively referred to as the 'Kalka'. Differences in preparation methods and ingredients for the same Arishtas result in variations in the quality parameters of the final product. Due to the differing production processes employed by various manufacturers, the organoleptic and physicochemical characteristics can show inconsistencies in quality parameters. Since plant materials are used, the content of the extracted ingredients may be varied depending on the identity, purity, quality and maturity level of the plant materials, their source of origin and on the fermentation process. If commercially available Nimba Arishtas differ considerably with regard to their physical and chemical composition, there's a problem with these products about their quality, safety and efficacy in providing expected outcomes. In Sri Lanka, all commercially available Arishtas are marketed under the traditional names listed in the Ayurvedic Pharmacopoeia. The presence of identical names for preparations from different manufacturing companies might lead to the assumption of uniformity among the products.

To enhance the therapeutic effectiveness of Ayurvedic herbs, it is crucial to ensure they comply with modern standards for identity, purity, safety, drug content, and both physical and biological properties. This can be accomplished through the use of scientific methods to evaluate

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and improve the quality of these herbs. (Patwardhan, 2005; Kulkarni et al., 2012a). In the absence of a well-established system for standardization and monitoring in the country, questions often arise regarding the quality, safety, and efficacy of these medicines.

In Ayurveda pharmacopoeia in Sri Lanka (1976), 32 Arishtas are described. Nimba Arishta is one such Arishta utilized in Sri Lanka to treat rashes and gout, purify the blood, and act as an anthelmintic. To investigate those variations, same type of Arishta, 'Nimba Arishta' produced from different manufacturers in Sri Lanka are analysed and compared by this study.

II. METHODOLOGY

Collection of samples - Sealed bottles of Nimba Arishta were randomly collected from six different manufacturers from the districts of Colombo and Kandy and they were kept at room temperature. Those samples were identified as A, B, C, D, E and F. Following analyses on the physicochemical properties of the samples were performed.

A. Determination of pH

pH was measured using the method described in The Ayurvedic Pharmacopoeia of India -2.4.24. A digital pH meter was calibrated using standard buffer solutions. The Arishta sample was thoroughly mixed to ensure homogeneity, and the pH value was measured with the calibrated pH meter (bench 700 series). The determination was performed at a temperature of 23°C.

B. Determination of Brix

The brix value (total soluble solids) of samples were measured using digital Abbe refractometer (Biobase BK-R2S).

C. Determination of refractive index

The Abbe refractometer (Biobase BK-R2S) was used to measure the refractive index at 23 ◦C according to the method outlined in Indian Pharmacopoeia-2018: 2.4.27.

D. Determination of specific gravity

Specific gravity was measured using the method described in Ayurvedic Pharmacopoeia of India - 2018 : 3.8. A thoroughly cleaned and dried calibrated pycnometer was selected. The temperature of the substance to be examined was adjusted to about 20◦C and the pycnometer was filled with it. The temperature of the filled pycnometer was adjusted to 25◦C. Any excess of the substance was removed and weighed. The tare weight of the pycnometer was subtracted from the filled weight of the pycnometer. The specific gravity was determined by dividing weight of the liquid contained in the pycnometer by the weight of water contained, both determined at 25◦C.

E. Determination of Total Dissolved Solids (TDS)

The method is given in the Indian Pharmacopoeia-2018 : 2.6.5

Method:

Empty weights of cleaned tared dishes were weighed and an accurate quantity of the arishta sample was measured, placed in a tared dish, evaporated at a low temperature as possible until the solvent is removed and heated on a water-bath until the residue is apparently dry. The dishes were transferred to an oven and dried to constant weight at 105°C. Again, the weight after drying (W2) was recorded and the percentage of solid content was calculated based on the following formula:

Total dissolved solids (w/v %) = (W3 – W1) / V x 100%

W1- weight of empty dish, W3- weight of residue, V – volume of the sample

F. Determination of total ash content

Ash contents of the Arishta samples were determined by wet ashing method - gravimetric principal, specified in Ayurvedic Pharmacopoeia of India – 2.2.3.

Method: Arishta sample (10.000 g. n=3) was accurately weighed into a previously cleaned and dried porcelain crucible, then heated over a water bath until all liquid had evaporated. The crucible was subsequently transferred to the muffle furnace set at 450 °C and incinerated until it was free of Black carbon particles, resulting in light grey ash. Afterward, the crucible was taken out of the furnace and allowed to cool in a desiccator. The weight of the crucible was recorded soon after it reached room temperature. The ashing, cooling and weighing processes were repeated until no further weight loss was observed. Ash content of the Arishta sample was calculated using the following equation.

Calculation:

Ash content (%) = $(W_1-W_2) / W_o$ x 100%

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Where, W_1- Weight of the crucible with residue after drying, W_2- Weight of the empty crucible, W_o- Weight of the sample.

G. Determination of Acid-Insoluble Ash

The method described in Ayurvedic Pharmacopoeia of India – 2.2.4 was followed.
The ash obtained was boiled for 5 minutes with 25.00 mL of dilute hydrochloric acid; the insoluble matter was collected on ashless filter paper, washed with hot water and ignited to a constant weight. The crucibles were then cooled in a desiccator and weighed. The percentage of acid insoluble ash was calculated.

H. Determination of Water-Soluble Ash

The method described in Ayurvedic Pharmacopoeia of India – 2.2.5 was followed. The ash obtained in Section 3.4.2.6 was boiled with 25.00 mL of water for 5 minutes. The resulting insoluble matter was filtered using an ashless filter paper, thoroughly washed with hot water, and then ignited for 15 minutes at a temperature not exceeding 450°C. The weight of the insoluble residue was subtracted from the total weight of the ash to determine the water-soluble ash. The percentage of water-soluble ash was then calculated accordingly.

III. RESULTS AND DISCUSSION

A. *Statistical analysis:*

The results are expressed as the mean ± standard deviation (SD) from three independent experiments. Statistical analysis was performed using one-way analysis of variance (ANOVA), followed by Tukey's test, with a significance level of $p < 0.05$. All analyses were conducted using Minitab software. (version- Minitab® 19.2020.1).

B. *Physicochemical properties of Nimba Arishta samples*

Results of all the physicochemical properties were statistically analyzed using one way ANOVA with 95% confidence level (α=0.05).

Two hypotheses were used for each parameter.

H_0 – All means are equal.

H_1 – Not all means are equal.

Decision rule: if p value < α, reject H_0

Data represented as mean values ± S.D. (n=3) Means that do not share a letter are significantly different.
According to the results of one-way ANOVA (Table 01), it can be concluded that there are significant differences among different brands of Nimba Arishta in terms of the pH value except the brands B, C, E and F. The observed pH values are found within the range of 3.01 and 3.64 which are acidic values. The acidic pH can help create an environment conducive to the growth of desired microorganisms and inhibit the growth of undesirable ones, thus helping to extend the shelf life of the Arishta. According to Chinky et al., 2021 this acidic pH range is an indicative of low bacterial count, while neutral or alkaline pH levels may suggest a higher level of contamination in the herbal preparation. The pH of Nimba Arishtas in a previous study ranged from 3.2 to 3.6 (Kroes et al., 1989), which slightly changes to the pH range observed in the present results.
These statistical findings suggest that there are variations in the brix values among the different Arishta brands, indicating differences in their composition or manufacturing processes. Only brands D and F are statistically similar in terms of brix and refractive index, while all the other brands are significantly different from each other. However, one common component of Arishta is sugar, which contributes to sweetness and acts as a source of fermentable carbohydrates for the fermentation process. It's important to note that the specific composition and concentration of soluble solids in Arishta can differ based on the individual recipe and the desired therapeutic effects. The concentration of soluble solids, including sugars, in Arishta can vary depending on factors such as the amount of sweetener added and the duration of fermentation. Those samples with higher brix values were found to contain lesser ethanol content due to the incomplete fermentation.
The refractive index can be influenced by the composition and concentration of solutes present in the sample. Here, the refractive index value is found within a narrow range of 1.37 and 1.40. The Tukey pairwise comparisons further elucidate the specific differences between the brands. Sample C exhibits a significantly higher refractive index compared to all other brands, indicating that it likely contains a different concentration of solutes or unique chemical components affecting its optical properties. In certain cases, the refractive index can be used as an indicator of quality or adulteration in beverages. Deviations from

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expected refractive index values may indicate the presence of contaminants, dilution, or improper manufacturing processes. The refractive index can serve as a quality control parameter for consistency in the production of Arishtas. Establishing a reference range of refractive index values for a specific decoction formulation can help identify any deviations or variations in subsequent batches, indicating potential issues in the fermentation process or ingredient quality.

The analysis of specific gravity among different brands of Nimba Arishta revealed significant differences in the means of specific gravity values. This implies that the specific gravity, which is a measure of the density of the liquid, varies significantly across the different brands.

Higher specific gravity values may indicate a higher concentration of dissolved substances or herbal extracts in the fermented decoction.

Table 01: Results of analyzed tests

Sample	pH	Brix%	Refractive index	Specific gravity	Total Dissolved Solids (g/mL)	Total ash content (w/w%)	Acid insoluble ash content (w/w%)	Water soluble ash content (w/w%)
A	3.64 ± 0.04^{a}	25.06 ± 0.15^{d}	1.3725 ± 0.0005^{e}	1.0684 ± 0.0004^{f}	0.1993 ± 0.0012^{e}	0.1070 ± 0.0014 ^{d}	0.0399 ± 0.0013 ^{a}	0.0580 ± 0.0113 ^{a,b}
B	3.11 ± 0.01^{b}	29.23 ± 0.25^{b}	1.3798 ± 0.0002^{c}	1.0965 ± 0.0005^{c}	0.2522 ± 0.0050^{c}	0.3378 ± 0.0455 ^{c}	0.0135 ± 0.0050 ^{a}	0.0040 ± 0.0028 ^{c}
C	3.10 ± 0.03^{b}	41.00 ± 0.50^{a}	1.4019 ± 0.0001^{a}	1.1632 ± 0.0005^{a}	0.4107 ± 0.0023 ^{a}	0.2709 ± 0.0005 ^{c}	0.0481 ± 0.0099 ^{a}	0.0878 ± 0.0108 ^{a}
D	3.01 ± 0.01^{c}	27.40 ± 0.40^{c}	1.3769 ± 0.0003^{d}	1.0894 ± 0.0004^{d}	0.2534 ± 0.0030 ^{c}	0.0971 ± 0.0045 ^{d}	0.0131 ± 0.0041 ^{a}	0.0444 ± 0.0076 ^{b}
E	3.14 ± 0.04^{b}	30.10 ± 0.10^{b}	1.3814 ± 0.0004^{b}	1.1048 ± 0.0007^{b}	0.2806 ± 0.0013 ^{b}	1.5548 ± 0.0011 ^{a}	0.0406 ± 0.0288 ^{a}	0.0280 ± 0.0113 ^{b,c}
F	3.07 ± 0.03^{b,c}	27.5 ± 0.50^{c}	1.3767 ± 0.0003^{d}	1.0864 ± 0.0004e	0.2387 ± 0.0042 ^{d}	0.9607 ± 0.0010 ^{b}	0.0571 ± 0.0306 ^{a}	0.0899 ± 0.0127 ^{a}

Sample C exhibits a significantly higher specific gravity compared to all other brands. This suggests that the specific gravity of Arishtas is influenced by factors such as the selection and proportions of herbs used, the fermentation process, and the manufacturing techniques employed by different brands.

The variations in TDS content suggest differences in the composition and processing methods among the brands. Additionally, water-soluble components like herbal extracts or secondary metabolites derived from the herbs used in the formulation such as organic acids, amino acids, soluble pectins, etc. may also contribute to the overall dissolved solids content of Arishta. Only brands D and B are statistically similar in terms of TDS, while all the other brands are significantly different from each other. Elevated levels of TDS may suggest the presence of contaminants such as minerals, salts, heavy metals, organic compounds, or other dissolved substances. Controlling and maintaining appropriate TDS levels can help enhance the sensory qualities and consumer acceptance of beverages.

High TDS levels can impact the solubility and precipitation of certain components, leading to sedimentation or changes in appearance over time. Monitoring and controlling TDS levels help

maintain the desired product stability and extend the shelf life of the beverage.

The significance of the total ash (%) parameter in the analysis of Arishta, lies in its ability to provide information about the mineral content of the product. Total ash refers to the inorganic residue left behind after the complete combustion of organic matter. Thus, the ash content serves as a

criterion for assessing the identity and purity of crude drugs.

The brands do not vary in terms of their acid insoluble ash content. The presence of only a little amount of acid insoluble ash in these Arishta samples indicates the absence of impurities resembling silica in the drug. Low acid insoluble ash content in all samples indicates high purity of the drugs with lesser contaminations during the manufacturing process.

The water-soluble ash content of a herbal drug is an indicator of the amount of inorganic substances present in the drug that are soluble in water. It provides information about the level of mineral matter present in the herbal drug. Thus, the water-soluble ash content helps assess the quality of the herbal drug by measuring the amount of these water-soluble inorganic content.

In this study, the determination of the acid value in Nimba Arishta was challenging due to the lack of standardized methods specifically tailored for Arishta formulations. A titrimetric method was described in literature in determining the acid value of sevaral Arishta types, adopted from the Indian and Ayurvedic Pharmacopoeias for crude drugs, which use acetic acid in the calculation to quantify the acid value. However, the applicability of these methods to Nimba Arishta is questionable as the main primary acids present in this Arishta, which could be identified through HPLC analysis may differ from acetic acid.

IV. CONCLUSION

The present investigation evaluated six different brands of ayurvedic commercial preparations of Nimba Arishta. Comparative studies on samples of various brands were done based on their physicochemical parameters.

The investigation showed that organoleptic and various physicochemical parameters such as pH, brix, specific gravity, refractive index, total ash, water soluble ash, total dissolved solid, etc. were found to be different in leading brands of Nimba Arishta. The study revealed that it may be due to the variations in the formulation or in the production process. But from a similar field study, it has been found that the standard method described in the ayurvedic pharmacopoeia for the preparation of Arishta was generally used throughout the country and no alternative method was identified for use. (Menike, 1995).

It can be concluded that the observed variations in the standardization parameters for evaluating commercially available polyherbal formulations may be attributed to several factors, such as the different ingredients used, sources of herbs or plants used, and their quantities. This study was done with the aim to understand the variations of these ayurvedic formulations to standardize them. The data evolved in this study will be highly valuable for routine quality control of Nimba Arishta. By implementing and embracing standardization and quality control mechanisms, the effectiveness and acceptance of these medications can be further enhanced.

Additionally, ensuring the quality and safety measures of these medicines can contribute to their increased efficacy and popularity.

REFERENCES

Indian Pharmacopoeia. Ministry of Health and Family Welfare, Govt. of India, Indian Pharmacopoeia Com-mission, Ghaziabad, 2007; Vol. 1 & 2:141, 163, 165, 1101.

Kroes, B. H., van den Berg, A. J. J., Abeysekera, A. M., de Silva, K. T. D., & Labadie, R. P. (1993). Fermentation in traditional medicine: the impact of Woodfordia fruticosa flowers on the immunomodulatory activity, and the alcohol and sugar contents of Nimba Arishta. Journal of Ethnopharmacology, 40(2). doi:10.1016/0378-8741(93)90056-B

Kroes, B. H., Van Den Berg, A. J. J., Labadie, R. P., Abeysekera, A. M., & De Silva, K. T. D. (1993). Impact of the preparation process on immunomodulatory activities of the ayurvedic drug Nimba Arishta. Phytotherapy Research, 7(1). doi: 10.1002/ptr.2650070110

Kroes, B. H., Van Den Berg, E. J. J., Heystra, E. A., De Silva, K. T. D., & Labadie, R. P. (1990). Fermentation in traditional medicine: The impact of Woodfordia fruticosa flowers on the immunomodulatory activity, and the alcohol and sugar contents of Nimba Arishta. Planta Medica, 56(6). doi: 10.1055/s-2006-961331

Kroes, B., van den Berg, A., de Silva, K., & Labadie, R. (1989). Investigations on Nimba Arishta, an Ayurvedic Drug Obtained by Fermentation with Immuno-Modulating Properties. Planta Medica, 55(07). doi: 10.1055/s-2006-962237

Kulkarni, O., Mukherjee, S., Giramkar, S., Ligade, G., Narkhede, A., Takle, S., Patil, S., & Jagtap, S. (2012a). Effect of pre-sterilization on physicochemical parameters and in vitro free radical scavenging potential of SaraswatArishta. Journal of Pharmacy Research, 5(5), 2657–2663. Available at: https://www.researchgate.net/publication/233861622

Kulkarni, O., Mukherjee, S., Giramkar, S., Ligade, G., Narkhede, A., Takle, S., Patil, S., & Jagtap, S. (2012b). Valorizing Waste from Sugarcane and associated industries via innovations in pretreatment, biotransformation and process intensification View project Effect of pre-sterilization on physicochemical parameters and in vitro free radical scavenging potential of SaraswatArishta. Journal of Pharmacy Research, 5(5), 2657–2663. Available at: https://www.researchgate.net/publication/233861622

Kumar, D., Rahal, A., & Malik, J. K. (2016). Neem Extract. Nutraceuticals: Efficacy, Safety and Toxicity (pp. 585–597). Elsevier Inc. doi:10.1016/B978-0-12-802147-7.00043-7

Kumar, T., Larokar, Y. K., Jain, V., & Kumar Larokar, Y. (2013). Standardization of different marketed brands of AshokArishta: An Ayurvedic formulation. Journal of Scientific and Innovative Research, 2(6), 993–998. Available at: www.jsirjournal.com

Luqman, S., Rizvi, S. I., Beer, A. M., Khare, S. K., & Atukeren, P. (2014). Efficacy of herbal drugs in human diseases and disorders. Evidence-Based Complementary and Alternative Medicine, 2014. doi:10.1155/2014/273676

Mani Adhikari Bal Mukunda Regmi, S., & Mani Adhikari, S. (2008). Status of ayurvedic medicines available in the markets of nepal study team report prepared by.

Menike, A., (1995). Study of the chemistry and technology of ayurvedic preparations. PhD thesis, University of Sri Jayewardenepura.

Nandre, B. N., Bakliwal, S. R., Rane, B. R., & Pawar, S. P. (2012). Traditional Fermented Formulations-Asava and Arishta. In International Journal of Pharmaceutical & Biological Archives. 3(6). www.ijpba.info

Patwardhan, B. (2005). Ethnopharmacology and drug discovery. Journal of Ethnopharmacology. 100(1–2), pp. 50–52. Elsevier Ireland Ltd. doi:10.1016/j.jep.2005.06.006

The British Pharmacopoeia. The Department of Health Social Services and Public Safety,
Great Britain, 2003; 4: A- 238.

ABBREVIATIONS

Total Dissolved Solids (TDS)