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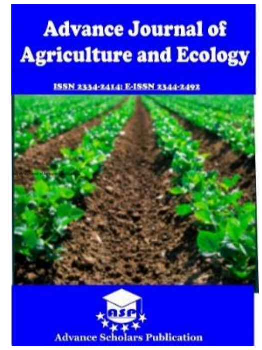

EVALUATION OF THE GLYCEMIC INDEX, PHYSICOCHEMICAL, AND SENSORY ATTRIBUTES OF PULPY JUICE BLENDS MADE FROM GUAVA (*PSIDIUM GUAJAVA*) AND WATERMELON (*CITRULLUS LANATUS*) FRUITS

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Keywords:
Fruits; pulpy juice blends; glycemic index; physicochemical properties; acceptability.

Abstract

Background: *The rising need for informed food choices emphasized the evaluation of the nutritional properties of new foods*

Objective: *The study evaluated the glycemic index, physicochemical, and sensory attributes of pulpy juice blends made from Guava and watermelon fruits.*

Methodology: The experimental study produced juices from fresh matured guava and watermelon fruits purchased from a Nigerian market, and introduced variety by blending the juices in ratios of 70:30, 50:50, and 30:70. The blends' physicochemical properties were determined with standard procedures. Thirty non-diabetic student (20 – 30 years) volunteers were purposively selected and used for glycemic response study and sensory evaluation with a 9-point hedonic scale. Data were analysed with IBM Statistical Product for Service Solution (version 21.0), and presented with descriptive statistics (Mean and Standard Deviation). The significance was judged at p<0.05.

Result: *The blends' physicochemical properties ranged from 4.5 to 4.75 pH, 0.17 to 0.20 titratable acidity, and 10.0 to 11.10 total soluble solids. Sample A (70% guava:30% watermelon) had 68mg/dl mean glycemic values at 0 minutes, 80mg/dl peak at 120mins. Sample B (50% guava:50% watermelon) had 66mg/dl at baseline, 82mg/dl peak at 30mins, and 74mg/dl at 120 mins. Sample C (30% guava:70% watermelon) had 73mg/dl at baseline, 82mg/dl peak at 30 to 90mins, and 75mg/dl at 120 mins. The samples' (A, B, C) glycemic index was 19, 26, and 21 respectively. The sensory scores ranges were 5.2 to 7.73 (appearance), 5.53 to 7.87 (taste), 5.87 to 7.53 (flavor), 5.73 to 7.33 (texture), and 5.93 to 8.40 (general acceptability).*

Conclusion: *The blends will contribute to varied healthy foods.*

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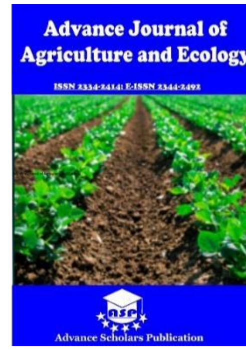

Introduction

Diet-related non-communicable diseases resulting from dietary and lifestyle practices are common in different populations. These diseases have consequences at local and international levels with unprecedented increases in the prevalence of diabetes mellitus, obesity, cardiovascular diseases, chronic respiratory diseases, and cancer [1]. In Nigeria, the rate is as much as 565 per 100,000 in males, and 546 per 100,000 in females causing up to 27% of deaths in 2019 [2]. Its effects on human productivity, development, and health are enormous with limited potential and high mortalities. The world's growing population, increase in the prevalence of NCDs, and advances in nutrition knowledge resulted in an upsurge in the demand for more and new foods. Both food manufacturers and consumers request foods with information to aid manufacturing and informed food choices. Researchers are joining nature in developing new foods from available foods [3,4]. The consumption of these foods will be based on their contribution to the needed health quest. Foods including fruits and juices with good nutritional attributes will be widely accepted as they can boost the immune system, prevent diseases, and improve overall health. Food quality is important in consumer health. The quality of a food added properties, applications as well as variety will determine its use by food industries and consumers. Glycemic index (GI), and physicochemical attributes will aid consumers concerned with their sugar levels to make proper food choices, and food manufacturers to know new foods suitable for specific products. The GI has been a method of ranking carbohydrates based on their immediate impact on blood glucose levels. It measures the food's ability to raise blood glucose concentration after a meal [5, 6]. The system classifies foods according to their blood glucose-raising potentials. Diabetics are constantly being challenged with food choices especially in Nigeria, they are always concerned with maintaining daily blood sugar levels. Many of them have limited food choices not necessarily due to poor economic power, but due to a paucity of available healthy foods of known nutritional benefits. Similarly, athletes involved in heavy physical activities who require blood sugar levels restoration after exercise need glycemic index data to make informed choices [7]. When GI is considered in meal preparation, it controls blood sugar in diabetics, athletes, and overweight/obese individuals. A low GI food has the potential to release glucose slowly and steadily leading to a better after-meal (postprandial) blood glucose level. High GI food presents a more rapid rise in blood glucose levels, suitable for energy recovery after exercise and for a person experiencing hypoglycemia [8]. In Africa, base meals contain mostly carbohydrates like bread, yam, corn, cassava,

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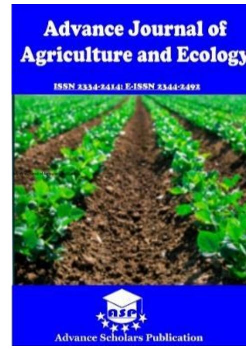

plantain, rice, milk, and fruits depending on the region. The Nigerian diet has a low protein, high carbohydrate (basically refined cereals, roots, and tubers), high fiber, and moderate fat and oil [9]. These foods could either increase or decrease blood sugar levels. In diabetes management, the dietary regimen is usually strict on carbohydrates, and intake of carbohydrate foods, and high GI foods is restricted for uncontrolled or insulin-dependent diabetes [10]. Although fruits are sweet to taste, they usually have low GI [11]. Fruits are generally eaten raw/ or in their natural form. Evidence has shown that the micronutrients and fibers in fruits can lower the incidence of cardiovascular diseases and obesity [12]. As rich sources of vitamin C, dietary fiber, minerals (potassium, iron, magnesium copper), and vitamins (B6 and K), fruits can prevent chronic diseases [13]. For good nutritional status, and to ensure adequacy of diets, fruits should be consumed daily and in moderation. Widespread misconception prevents the generality of diabetics from consuming fruits. This myth specifies that diabetics should not consume fruits as they increase blood sugar levels. Regrettably, fruits are very rich in vitamins, minerals, antioxidants, phytochemicals, and fiber [14]. Daily moderate fruit consumption has already been advocated [15]. It has been noted that restrictions on foods with high GI will eliminate foods with valuable vitamins and minerals and do not necessarily improve glycemic control [16]. Evidence has also shown that plain sugar and complex carbohydrates (baked potatoes) can significantly increase blood sugar levels [17]. Carbohydrate food can also raise blood glucose significantly. Most fruits are poor carbohydrate sources [18] Fruits like Watermelon originated in Africa, it grows wild in most areas, especially in South Africa where it has been cultivated for ages. Guava was adopted from Mexico/Central America into tropical Africa [19]. They are now cultivated in many areas. In Nigeria, many diabetics have huge challenges in dietary management, partly due to the application of GI to mix foods/fruits. The GI of fruits is believed to differ due to different digestion and absorption rates in the gastrointestinal tract (GIT). Low-GI starchy fruits are digested and absorbed more slowly than high-GI fruits [20]. The GI of fruits also varies daily depending on the blood glucose levels, and the insulin resistance. The lack of research/data on the nutritional properties of mixed fruits made it pertinent to investigate the glycemic response, index, physicochemical, and sensory properties of pulpy juice blends made from guava and watermelon fruits.

Methodology

Study design: The study employed experimental and clinical methods.

Study area: The study was conducted in the Diet therapy laboratory of the Department of Human Nutrition and Dietetics, College of Applied Food Sciences and Tourism Michael Okpara University of Agriculture Umudike Abia State Nigeria. Abia State is located in the South-Eastern part of Nigeria. It occupies an area of

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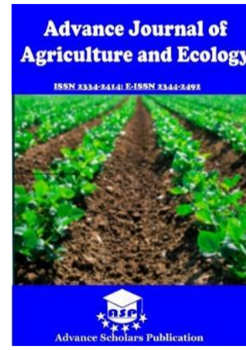

5,834 square kilometers east of Nigeria. Its capital Umuahia, houses the Institution where the study was conducted.

Source, and Identification of Materials: Guava, watermelon, and Glucose D were purchased from Ndioro Market, a local market in Ikwuano Local Government Area Abia State. E.N., a crop scientist in the Institution's Crop and Soil Science department, identified the fruits.

Preparation of Samples: Fresh whole guavas and watermelon fruits were washed properly with tap water. The watermelon was peeled to remove the hardback. The fruits were cut open, deseed, and chopped into small cubes. Four hundred (400) milliliters of clean tap water were added to 1200g of each chopped fruit and milled for 8 minutes using an electric food blender (Panasonic MXGX1021) into a pulpy juice as described [21]. The pulpy juices were properly labeled as G for guava and W for watermelon, and measured into 3 clean food bowls in the ratios of G70:W30; G50:W50; and G30:W70. Each sample was thoroughly mixed with the blender for 3 minutes. The blends were poured into clean sterile juice bottles and refrigerated until use.

Physicochemical Analysis of the pulpy juice blends made from guava and watermelon: Physicochemical properties like pH, total titratable acidity, and total soluble solute of the juice blends were determined.

Determination of the pH: The pH of the samples was determined in triplicate using a pH meter (Conon model 520) at 27^{o}C as described [22]. Ten (10) milliliters (ml) of the test samples were individually pipetted into a clean dry beaker and placed in a pH meter for 10 minutes, the ready sign allows for standardization with a freshly prepared buffer solution. The electrode was then immersed in the sample solution and stirred a little to stabilize. The reading appeared on the monitor and was recorded.

Determination of total acidity: The acidity of the samples was determined as described [23]. Ten (10) ml of the extract was pipetted into a 25 ml conical flask, to which 3 drops of phenolphthalein indicator was added, and the content was titrated with 0.1N sodium hydroxide against a white background. The titration was done to the first appearance of the faint pink color and the reading was noted and recorded. The values obtained was calculated using the formula TTA = N x T x equivalent weight / V_1 x 10 where N = normality of the titrant (0.1N NaOH), T = titre value, V_1 = volume of the sample, 10 = constant

Determination of total acidity: This was determined as described [23]. Two (2) ml of each test sample were measured with a previously weighed evaporation dish. The dish and the content were placed in a Carbolyte moisture extraction oven at 105^{o}C. The samples were evaporated individually to dryness, dried to a constant weight, and allowed to cool in a desiccator and reweighed. The differences in the initial and final weights were determined and expressed as a percentage of the sample using the formula: Total soluble solute %TSS = (W_2 – W_1)

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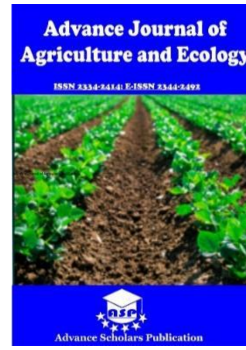

x 100 where W_1 = weight of empty dish, W_2 – = weight of empty dish + sample

Ethical Approval and Informed Consent: A concise study proposal was presented to the Research Project Board of Human Nutrition and Dietetics Department of the College of Applied Food Sciences and Tourism of Michael Okpara University of Agriculture Umudike. Ethical approval was given after due consideration (HND/DAB/2016/02/067). The detailed principle and procedure of the study and the participatory duty (to have early dinner before 8.00 pm, no alcohol or smoke, and no other food for breakfast on the study day) of the subjects were explained to the subjects, and their oral consent was obtained.

Selection of subjects for Glycemic, and sensory evaluations:

Thirty (30) student volunteers from the College of Applied Food Sciences and Tourism Michael Okpara University of Agriculture Umudike were selected from the student population using multi-stage sampling methods. The first stage involved the purposive selection of 30 students. The inclusion criteria included those aged 20 to 30 years, with blood glucose below or equal to 100mg/dl (non-diabetic), while all diabetic volunteers were excluded. The second stage randomized the students into 2 groups (1 and 2) of 15 subjects each. Group 1 was used for the glycemic response study, while Group 2 formed the panelists for the sensory evaluation.

Glycemic response study: A laboratory scientist from the Institution's medical center was deployed to assist in the 2-day glycemic response watch. On day 1 after an early dinner and overnight fast, by 8.00 am, the fasting blood sugar levels of the 15 subjects in Group 1 were obtained with an ACCU-CHECK glucometer with a measuring range of 10 – 600mg/dl. The glucose test strip was inserted into the glucometer. The tip of each subject's thumb was cleaned with a cotton wool swap and the lancet was used to puncture the fingertip to obtain a drop of blood. The device was turned on and the blood was applied on the middle of the strip when a dropping sign was shown on the glucometer. The device measured and showed the blood glucose levels of the subjects which were then recorded and categorized as described [24, 25] classification (Normal = < 100mg/dl, pre-diabetes = >100 and <126 mg/dl, diabetes = >126 mg/dl). After this process, the subjects were fed 50g glucose D. The timing of the response watch commenced, their blood samples were collected every 30 minutes for 2 hours of consumption, and the readings were recorded. The subjects were given a good breakfast and allowed to go. On day 2, the Group was further randomized into three groups (A, B, and C) of 5 subjects each. Their fasting blood glucose level was obtained by 8.00 am and the measured proportions of the different test samples containing 50g carbohydrate were fed to the groups. The glycemic response timing commenced, and their blood samples were taken at an interval of 30 minutes for 2 hours, and

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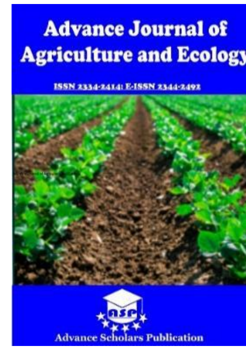

recorded. Quality breakfast was served as an incentive.

Determination of glycemic index of the pulpy blends: The glycemic index of Glucose D and the test blends was calculated using the formula IAUs/IAUC X 100% [26], where IAUC is the incremental area under the curve, which refers to the area below the curve and above the fasting level, with the area beneath the fasting ignored. This was calculated for each test sample in every subject separately (as the sum of the surface triangle and the trapezoids of the blood glucose curve and the horizontal baseline running in parallel to the x-axis from the beginning of the B-glucose curve at time 0 to the point at time 120 minutes) to reflect the total rise in blood glucose concentration after consumption of the test samples. Similarly, the incremental area under the curve for the test control (50g of glucose) IAUCS was obtained. The GI for each test sample was calculated by dividing the IAUCS for the test blends by the IAUC for the standard food and multiplying by 100.

Sensory evaluation: The pulpy blends were subjected to organoleptic evaluations for appearance, taste, flavor, and consistency with the 15 panelists in group 2 using a 9-point hedonic scale as described [27]. Nine (9) represented the highest score of liked extremely, 8 liked very much, 7 liked moderately, 6 liked slightly, 5 neither liked nor disliked, 4 disliked slightly, 3 disliked moderately, 2 disliked very much, and 1 the lowest of disliked extremely. Each panelist was provided with a cup of drinking water to rinse the mouth after each tasting to avoid bias. The general acceptability and the mean scores for the sensory attributes were obtained and recorded.

Statistical Analysis: Data obtained from the study was analyzed using IBM Statistical Product for Service Solution (SPSS). Results were presented as mean and standard deviation, Analysis of variance (ANOVA) was used to compare the means, differences were determined with Duncan's Multiple Range Test, and significance was accepted at $p<0.05$.

Results

Table 1 shows the physicochemical properties of guava and watermelon pulpy juice blends. Samples G30%: W70% had the highest pH (4.75) value, while samples G70%: W30%, and G50%: W50% have pH values of 4.50 and 4.60 respectively. All the test samples (G70: W30, G50%: W50%, G30: W70) had low titratable acidity 0.204%, 0.189%, and 0.172% respectively. Sample G70%: W30% had 11.10^{o} total soluble solute, significantly higher at $p<0.05$ than the other juice blends.

Table 1 Physicochemical properties of pulpy juice blends made from Guava and watermelon fruits

	Samples of pulpy juice blends made from Guava and watermelon fruits

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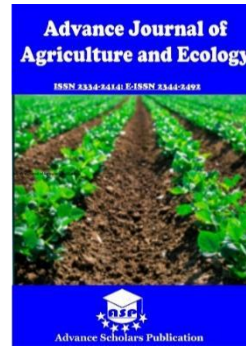

Physicochemical variables	G70%: W30%	G50%: W50%	G30%: W70%
Ph	4.50 ± 0.00b	4.60 ± 0.00b	4.75 ± 0.01 a
TTA (titratable acids)	0.204 ± 0.00a	0.189 ± 0.04ab	0.172 ± 0.01b
TSS (Total soluble solute)° Brix	11.10 ± 0.14a	10.50 ± 0.00 b	10.00 ± 0.00c

Values are means ± SD of duplicate analysis; means with different superscripts down the row are significantly different (P<0.05). G70%: W30% = 70% Guava, 30% Watermelon; G50%: W50% = 50% Guava, 50% Watermelon; G30%: W70%= 30% Guava, 70% Watermelon.

Table 2 shows the mean and standard deviations of the glycemic response of groups fed the pulpy juice blends. Glucose D served as the control for the test samples. It had 67mg/dl at baseline, peaked at 120mg/dl at 60 mins, and 87mg/dl at 120 mins. Sample G30%: W70% had a higher glycemic response (73mg/dl) at 0 minutes than the other samples. At 30 minutes, all the test samples had a lower glycemic response (77 - 82mg/dl) than glucose D (111mg/dl), the control. This trend remained the same even at 120 minutes. The peak response of sample G70%: W30% was 80mg/dl at 120 minutes while samples G50%: W50%, G30%: W70%, and Glucose D peaked at 82mg/dl at 30 minutes, 82mg/dl at 30 to 90 minutes and 120mg/dl at 60 minutes respectively.

Table 2 Mean and standard deviations of glycemic response of groups fed guava and watermelon pulpy juice blends

Samples	0 minutes	30 minutes	60 minutes	90 minutes	120 minutes
G70%: W30%	68^{b} ± 5.4	77^{b} ± 6.1	69^{c} ± 4.3	75^{c} ± 3.7	80^{a} ± 5.3
G50%: W50%	66^{ab} ± 7.8	82^{b} ± 5.3	80^{a} ± 5.4	76^{c} ± 6.8	74^{b} ± 4.5
G30%: W70%	73^{a} ± 8.6	82^{b} ± 5.7	82^{b} ± 3.8	82^{b} ± 3.8	75^{b} ± 6.2
Glucose D	67^{b} ± 9.2	111^{a} ± 17.2	120^{a} ± 25.6	107^{a} ± 19.6	87^{a} ± 11.8

Values are mean ± Standard deviation (SD) based on 4 determinations. Mean with different superscripts down the column are significantly different at P ≤ 0.05. Glucose D = Control, G70%: W30% = 70% Guava, 30% Watermelon; G50%: W50% = 50% Guava, 50% Watermelon; G30%: W70%= 30% Guava, 70% Watermelon.

Table 3 presents the glycemic index of the test samples as derived with Wolever [1990] formula as 19, 26, and 21 for samples G70%: W30%, G50%: W50%, and G30%: W70% respectively.

Table 3 Glycemic index of Guava and watermelon pulpy juice blends

Samples	IAUC	Glycemic index
G70%: W30%	780.00	19.00

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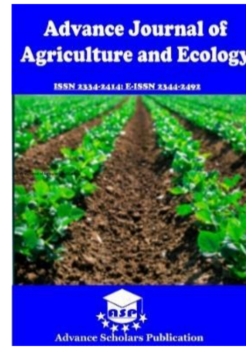

G50%: W50%	1080.00	26
G30%: W70%	855.00	21.00
Glucose D	4110.0	100.0

Key: IAUC = Incremental area under the curve; Glucose D = Control, G70%: W30% = 70% Guava, 30% Watermelon; G50%: W50% = 50% Guava, 50% Watermelon; G30%: W70% = 30% Guava, 70% Watermelon.

Table 4 shows the mean scores for sensory evaluation of Guava and watermelon pulpy juice blends with a 9-point hedonic scale. Sample G70%: W30% was relatively, neither liked nor disliked by the panelists as its appearance, taste, flavor, texture, and general acceptability scores ranged from 5.2 to 5.93. Samples G50%: W50% scored highest in general acceptability (8.40), and appearance (7.73), while G30%: W70% had a higher taste score (7.87). The flavor and texture of the latter blends were not significantly different at $p < 0.05$

Table 4: The mean scores of the sensory evaluation of Guava and watermelon pulpy juice blends.

Samples	Appearance	Taste	Flavor	Texture	General acceptability
G70%: W30%	$5.2^{b} \pm 1.32$	$5.53^{b} \pm 1.19$	$5.87^{b} \pm 0.03$	$5.73^{b} \pm 1.58$	$5.93^{c} \pm 1.03$
G50%: W50%	$7.73^{a} \pm 0.59$	$7.67^{a} \pm 0.72$	$7.53^{a} \pm 0.74$	$7.33^{a} \pm 0.62$	$8.40^{a} \pm 0.63$
G30%: W70%	$7.47^{a} \pm 1.13$	$7.87^{a} \pm 0.99$	$7.53^{a} \pm 0.64$	$7.33^{a} \pm 0.82$	$7.87^{b} \pm 0.83$

Values are mean ± Standard deviation (SD). Mean with different superscripts down the column are significantly different at $P \leq 0.05$. G70%: W30% = 70% Guava, 30% Watermelon; G50%: W50% = 50% Guava, 50% Watermelon; G30%: W70% = 30% Guava, 70% Watermelon.

Discussion

The study measured the pH, the total titratable acidity, and total soluble solute of guava and watermelon pulpy juice blends. The samples' pH range of 4.50 to 4.75 indicated an acidic medium. The acidity increases as the guava content of the juices increases. These ranges were more than 3.97 reported for Pineapple juice [28], and comparable to 4.7 for Ehuru-spiced watermelon juice [29]. The differences observed could be attributed to the basic ingredients of the juices. The lower pH values were related to their content of organic acids. Low pH fruits are rich in organic acids [30]. As a measure of the active acidity of food, pH has important implications for food quality. The low pH of the test samples indicated an appreciable shelf-life as most bacteria cannot proliferate in an acidic medium. An acidic

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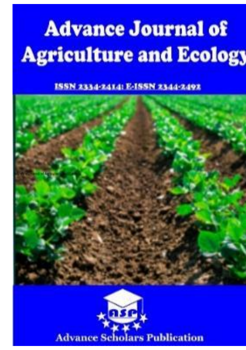

medium can be stored without rapid deterioration [31]. The titratable acidity (TTA) which is the measure of the free acids circulating in the juice were 0.204%, 0.189%, and 0.172% for samples G70%: W30%, G50%: W50%, G30%: W70% respectively. These values were higher than 0.127% reported for orange juice, and 0.1% for Ehuru-spiced watermelon juice [29]; but lower than 0.36 to 0.80% apple/pear juices [32]. The TTA is a better predictor of acid impact on flavor than the pH, it is also an indicator of maturity and sourness; a factor for consideration in consumer protection. The total soluble solute (TSS) often referred to as brix, the measure of the sugary level of the juice, was highest in sample G70%: W30% 11.10^{o} Brix followed by 10.50^{o} Brix in G50%: W50%, and 10.0^{o} Brix in G30%: W70%. These values were comparable to 11.95^{o} Brix reported for orange juice [28], but higher than 7.6^{o} Brix in Ehuru-spiced watermelon juice [29].

The glycemic response ranges (66mg/dl to 73mg/dl) of the test samples at 0 minutes were in line with the report that the glycemic response of all samples used at fasting blood sugar will not be significantly different due to biological invariability [33]. The control sample glucose D, had higher glucose response than all the test samples throughout the 2-hour response study. This underscored the fact that the specific type and amounts of sugars in a food impact the GI of the food [34]. Foods formulated with high amounts of glucose will have higher GI than those with fructose. Sample G70%: W30% had its peak sugar level (80mg/dl) at 120 minutes, while samples G50%: W50%, and G30%: W70% had their peaks (82mg/dl) at 30 minutes, and 30 to 90 minutes of feeding suggesting that these samples may trigger digestion of carbohydrates. This observation further emphasized that the type and amounts of sugars in a food sample will impact the GI of the food [34]. The low GI of the test samples (19, 26. And 21), and the gradual release of glucose as observed in the study samples suggested low carbohydrate contents of the test samples. It has been reported that the amount of carbohydrates in a food will either trigger or reduce the GI of the fruit. The low GI of the test samples was an indication of low glycemic load. it may also indicate greater extraction from the liver and periphery of the products of digestion [35]. Factors like fat, protein, dietary fiber, cooking/processing (degree of starch gelatinization, particle size, food form, and cellular structure), antinutrients, organic acids, nature of starch (amylose, amylopectin, starch-nutrient interaction, resistant starch), nature of the monosaccharides (glucose, fructose, galactose), and the way fruits are combined can reduce the GI of foods. The low GI of the pulpy juice blends will benefit active individuals involved in physical exercises like athletes and those consumers concerned with blood glucose management. Evidence suggests that a low-glycemic index meal consumed before an event is associated with a slower increase in insulin, and improved exercise performance due to sustained blood glucose during the last stages

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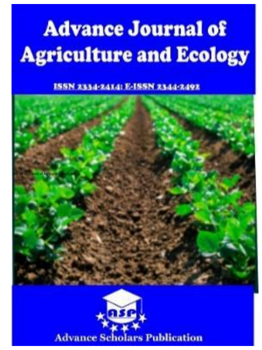

of exercise [35]. It has also been documented that low GI fruit intake will lower HbA_{1c}, blood pressure, and CHD risk in type 2 diabetics [36]. The blending of the pulpy juices will provide a mixed-fruit appeal. The preference of sample G50%: W50% in terms of color could be attributed to the combination of the carotenoids and green chlorophyll color of watermelon and guava respectively which gave the blends a bright color. These color combinations suggest that the blends could contribute to the intake of carotenoids (carotenes, xanthophyll), chlorophyll, and isothiocyanates and improve food quality. The high score of Guava 50%: and Watermelon 50% in general acceptability indicates consumer acceptance.

Conclusion: Whole fruits can be combined to provide variety, mixed appeal, and improve nutrient intake. Data on the glycemic response, glycemic index, physicochemical, and sensory properties of the pulpy juice blends made from guava and watermelon is a working tool for consumers interested in the nutrition information of new foods for good health, and food manufacturers for new product development. The blended pulpy juices provided a mixed-fruit appeal and will improve fruit consumption. The juice blends offered a rich combination of carotenoids, chlorophyll and isothiocyanates necessary for good health. The low glycemic juice blends will allow diabetics to enjoy the enormous nutrients and phytochemicals available in fruits. It will also introduce variety to available fruit juices and inform consumers' decisions on food quality. The data on physicochemical attributed will also offer manufacturers, an insight into the useability of fruit blends, and quality standards for consumer health benefits.

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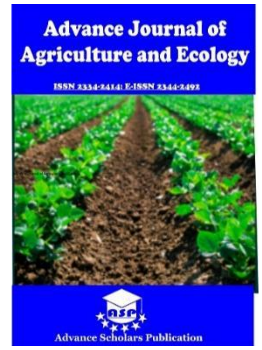

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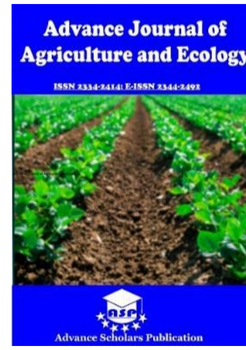

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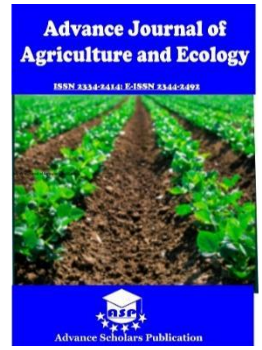

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