ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Comprehensive Analysis of a Whey-Mango Mixed Beverage: Physicochemical, Microbiological, and Sensory Evaluation throughout Storage

Kandi Sridhar

Department of Food Technology, Koneru Lakshmaiah Education Foundation Deemed to be University, Vaddeswaram 522502, Andhra Pradesh, India

Abstract:

In this study, three formulations were prepared with different whey and mango proportions (sample-1 = 60:20 mL, sample-2 = 65:15 mL, and sample-3 = 70:10 mL). Over a 25-day storage period, the prepared beverage samples exhibited significant changes in acidity (0.27 ± 0.02–0.64 ± 0.03%), TSS (17.15 ± 0.01–18.20 ± 0.01 °Brix), reducing sugars (3.01 ± 0.01–3.67 ± 0.01%), moisture (74.50 ± 0.02–87.02 ± 0.03%), protein (5.67 ± 0.02–7.58 ± 0.01%), fat (0.97 ± 0.01–1.39 ± 0.04%), and carbohydrate (18.01 ± 0.02–3.45 ± 0.02%). Sedimentation rate was negligible at 1%. The total plate count for the prepared samples ranged from 3.32 ± 0.08 to 3.49 ± 0.15 log CFU/mL, while yeast and mold counts varied between 0.48 ± 0.01 to 1.85 ± 0.11 Log CFU/mL. Coliform count was below the detection limit (<1). Overall sensory evaluation indicated that the whey beverage with higher mango juice content achieved an acceptable quality during processing. These findings suggest the potential of whey in developing beverages when combined with fruits and vegetables.

Keywords: whey; mango; physico-chemical properties; functional beverage; shelf-life

Introduction:

The food industry is currently searching for ingredients that can enhance both the functionality and nutrition of their products, aiming to create value-added food items [1]. With consumers becoming more informed about nutrition, health, and food quality, and the market becoming highly competitive[2], food manufacturers are exploring novel functional food options. Among these, dairy products account for over 40% of functional foods[3], and fermented beverages containing milk whey are leading examples of functional beverages[4]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Whey, a valuable by-product obtained during cheese production from milk protein precipitation[5], has garnered significant interest in recent years. Unfortunately, a considerable amount of global whey production[6], approximately 40%, goes to waste. Traditionally, whey has been disposed of in surface water or used as cattle feed, causing severe environmental pollution [7] and posing threats to aquatic life and human health. Meeting environmental regulations and the cost of transporting and disposing of whey have also presented challenges to cheese producers [8].

However, whey is a rich source of essential nutrients, such as calcium, magnesium, phosphorus, vitamins (riboflavin and thiamine) [9], and various proteins, accounting for 85-95% of milk volume and retaining up to 55% of its contents after processing. In light of the valuable nutrients in whey and the problem of waste [10], the food industry is actively developing innovative food combinations based on whey. This approach is not only a more logical and economical method than disposal but also presents an opportunity to address food security and environmental sustainability [11], considering the global food crisis and environmental concerns.

Numerous attempts have been made to incorporate whey into various dairy products, but there is still a vast potential to [12] explore its uses in the beverage industry. Several patents have been registered for preparing whey beverages by adding different ingredients, including various fruits like citrus, tropical fruits [13] (mango, banana, grapefruit, papaya, tangerine), and other fruits such as berries, apples, cherries, pear, apricot, and melon. Some researchers have also experimented with oats, vanilla, cocoa, rice, chocolate, mint [14], and other flavoring agents. However, these recipes may face challenges such as sedimentation due to a high volume of dry fruit matter and protein interactions [15], leading to suboptimal market performance. Additionally, certain fruits with strong acidity, bitterness, and astringency may not offer desirable taste and flavor [16].

Furthermore, some individuals may be allergic to whey protein[17], while others follow cholesterol-restricted diets or vegetarianism [18]. To address these issues and enhance the acceptance, nutrients, and sensory properties of whey-based beverages, combining fruits, vegetables, and whey could be a promising solution [19]. Mango and carrot stand out as suitable choices due to their low cost, nutrient content, and palatable flavor. Mango and carrot

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

also contain functional components like phenolic compounds [20], ascorbic acid, fiber, vitamins, minerals, alpha- and beta-carotene, lutein, and lycopene [21].

Researchers have recommended almond and green tea extract for their anti-allergic potential and flavor-enhancing properties [22]. Almonds provide essential fatty acids, vitamins, and minerals without cholesterol, while green tea extract may help in muscle preservation and fat burning [23]. Including citric acid in the recipe can enhance the shelf-life of the beverage, control microbial growth, and improve storage capabilities [24].

Previous studies have reported attempts to create whey-based beverages using only mango pulp or powder with varying concentrations of whey and mango [25]. However, finding the optimal recipe for mixing fruit concentrates and other ingredients with fresh whey remains a challenge [26]. This study aims to develop a whey-mango-based mixed beverage with different whey and mango concentrations, along with a constant amount of carrot, almond, green tea extract, sugar, and citric acid [27]. The physico-chemical, microbiological, and sensory characteristics of the prepared beverages will be evaluated both immediately after production and during a 25-day storage period in the refrigerator[28].

Materials and methods:

Chemicals:

All chemicals used in this study were of analytical grade and [29] procured from reputable suppliers, including Sigma-Aldrich (St. Louis, MI, USA) and Merck (Darmstadt, Germany)

Preparation of Milk Whey:

Raw milk was obtained from the local market of Sylhet city, Bangladesh. The whey was prepared with slight modifications based on the procedure described by Baljeet et al. [30]. The raw milk was heated to 82 ◦C while stirring continuously and then acidified by adding 2% citric acid at a rate of 2 g/kg of milk, resulting in the coagulation of milk proteins (casein). The coagulated mixture was filtered [31] using a muslin cloth to separate the whey from the coagulum. The pH of the collected whey was adjusted to pH 5.0 using 10% $NaHCO_3$ [32]. The obtained whey was then stored at 4 ± 1 ◦C in a refrigerator for further use [33].

Preparation of mango juice:

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Fresh ripe mangoes (Mangifera indica L.) were purchased from the local market in Sylhet city, Bangladesh [34]. The mangoes were cleaned using hot water (55 ◦C) and then cut into small pieces after removing the peel and seeds [35]. The mango juice was extracted in an aseptic manner using a juice extractor (model TRK-74, Turbora, Thailand) [36]. The extracted juice was refined by passing it through a muslin cloth and then stored under refrigeration at 4 ± 1 ◦C for later use [37].

Preparation of Carrot Juice:

Mature carrots (Daucus carota subsp. Sativus) were procured from the local market in Sylhet city, Bangladesh [38]. The carrots were first rinsed with hot water (55 ◦C) and then washed with distilled water. The carrots were hand-peeled with a knife and cut into small pieces. The juice was extracted from the carrots using a juice extractor [39] (model: TRK-74, Turbora, Thailand) under aseptic conditions [40]. The extracted juice was strained through a muslin cloth to remove stone cells and coarse particles, leaving behind only fine particles with colloidal coherence. The carrot juice was stored at 4 ± 1 ◦C until further use [41].

Preparation of Green Tea Extract:

Green tea (Camellia sinensis) extract was prepared with slight modifications to the method described by Kawakastu et al. [42]. Refined green tea (Department of Food Engineering and Tea Technology, SUST, Bangladesh) was steeped and extracted using 10 g of green tea in 50 mL of hot water at 80–100 ◦C with moderate agitation (1500 rpm) in a 10 L container. The extract was then filtered through a no. 4 Whatman filter paper. After cooling the extract to 25 ◦C, it was used as a green tea extract for the experiment [43].

Preparation of Almond Extract:

Large quantities of almonds (Prunus dulcis) were obtained from the local market in Sylhet city, Bangladesh. The almond extract was prepared with slight modifications to the technique used by Erdogan and Aygun [44]. The almonds were sorted and soaked in distilled water for 24 hours. The peels were then removed from the almonds using a knife, and the almonds were crushed with a clean sterilized blender (model: Osterizer 857, Willamette Industries, Portland, Oregon, USA). The extract was filtered using a muslin cloth to remove any chaff, and then stored under refrigerated conditions for future use [45].

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Preparation of Whey-Mango-Based Mixed Beverage Modifications:

Three different beverages were prepared with varying proportions of whey and mango, denoted as sample-1 (60 mL whey, 20 mL mango), sample-2 (65 mL whey, 15 mL mango), and sample-3 (70 mL whey, 10 mL mango) [46]. Each sample included a constant amount of 10 mL carrot, 6 mL sugar, 1.5 mL almond, and 1.5 mL green tea extract (see Table 1)[47]. Whey was heated to 50 ◦C, and sugar was added to the mixture, which was then filtered through a muslin cloth after thorough mixing [48]. Subsequently, mango juice, carrot juice, green tea extract, almond extract, and 1% citric acid were added to the whey and homogenized [49]. The resulting beverages were filtered and transferred to sanitized glass bottles (250 mL) with 2.5 cm headspace, sealed with a crown cork for airtightness. The filled bottles were pasteurized at 85–90 ◦C for 10–15 min, cooled to room temperature, and stored in a refrigerator at 4 ± 1 ◦C for further [50].

Table 1. Formulation of whey-mango based mixed beverage.

Ingredients	Sample-1	Sample-2	Sample-3
Whey (mL)	60	65	70
Mango (mL)	20	15	10
Carrot (mL)	10	10	10
Sugar (mL)	6	6	6
Almond (mL)	1.5	1.5	1.5
Green tea extract (mL)	1.5	1.5	1.5
Citric acid (20%) (mL)	1	1	1

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Table 2. Physicochemical analysis of whey-mango based mixed beverage [1].

Parameter	Storage (Days)	Sample-1	Sample-2	Sample-3
Acidity (%)	0	$0.41 \pm 0.03^{a\,A}$	$0.39 \pm 0.02^{bc\,A}$	$0.27 \pm 0.02^{c\,A}$
	5	$0.44 \pm 0.03^{a\,AB}$	$0.44 \pm 0.03^{bc\,AB}$	$0.29 \pm 0.02^{c\,AB}$
	10	$0.48 \pm 0.03^{a\,AB}$	$0.48 \pm 0.03^{bc\,BC}$	$0.32 \pm 0.02^{c\,AB}$
	15	$0.51 \pm 0.03^{a\,BC}$	$0.52 \pm 0.03^{bc\,C}$	$0.36 \pm 0.04^{c\,BC}$
	20	$0.58 \pm 0.03^{a\,CD}$	$0.55 \pm 0.04^{bc\,CD}$	$0.40 \pm 0.05^{c\,CD}$
	25	$0.64 \pm 0.03^{a\,D}$	$0.61 \pm 0.04^{bc\,D}$	$0.44 \pm 0.03^{c\,D}$
pH	0	$4.27 \pm 0.07^{a\,A}$	$4.44 \pm 0.02^{b\,A}$	$4.58 \pm 0.09^{c\,A}$
	5	$4.23 \pm 0.05^{a\,AB}$	$4.39 \pm 0.02^{b\,AB}$	$4.52 \pm 0.04^{c\,AB}$
	10	$4.17 \pm 0.03^{a\,AB}$	$4.35 \pm 0.04^{bc\,ABC}$	$4.43 \pm 0.02^{c\,BC}$
	15	$4.13 \pm 0.05^{a\,B}$	$4.28 \pm 0.03^{bc\,BCD}$	$4.36 \pm 0.06^{c\,CD}$
	20	$4.12 \pm 0.04^{a\,B}$	$4.26 \pm 0.05^{bc\,CD}$	$4.29 \pm 0.02^{c\,D}$
	25	$3.99 \pm 0.08^{a\,C}$	$4.21 \pm 0.04^{bc\,D}$	$4.28 \pm 0.03^{c\,D}$
TSS (°Brix)	0	$17.15 \pm 0.01^{a\,A}$	$17.50 \pm 0.01^{b\,A}$	$18.10 \pm 0.01^{c\,A}$
	5	$17.20 \pm 0.01^{a\,B}$	$17.60 \pm 0.01^{b\,B}$	$18.10 \pm 0.02^{c\,A}$
	10	$17.50 \pm 0.01^{a\,C}$	$17.80 \pm 0.01^{b\,C}$	$18.20 \pm 0.01^{c\,C}$
	15	$17.50 \pm 0.01^{a\,C}$	$17.80 \pm 0.01^{b\,C}$	$18.20 \pm 0.01^{c\,C}$
	20	$17.50 \pm 0.01^{a\,C}$	$17.80 \pm 0.02^{b\,C}$	$18.20 \pm 0.01^{c\,C}$
	25	$17.50 \pm 0.01^{a\,C}$	$17.80 \pm 0.02^{b\,C}$	$18.20 \pm 0.01^{c\,C}$
Reducing Sugars (%)	0	$3.32 \pm 0.02^{a\,A}$	$3.14 \pm 0.03^{b\,A}$	$3.01 \pm 0.01^{c\,A}$
	5	$3.45 \pm 0.02^{a\,B}$	$3.20 \pm 0.01^{b\,A}$	$3.12 \pm 0.04^{c\,B}$
	10	$3.52 \pm 0.01^{a\,C}$	$3.29 \pm 0.02^{b\,B}$	$3.19 \pm 0.06^{c\,C}$
	15	$3.59 \pm 0.04^{a\,D}$	$3.32 \pm 0.02^{b\,BC}$	$3.21 \pm 0.02^{c\,C}$
	20	$3.63 \pm 0.03^{a\,DE}$	$3.35 \pm 0.04^{b\,BC}$	$3.28 \pm 0.01^{c\,D}$
	25	$3.67 \pm 0.01^{a\,E}$	$3.38 \pm 0.03^{b\,C}$	$3.31 \pm 0.01^{c\,D}$
Ascorbic acid (mg/100 mL)	0	$9.92 \pm 0.01^{a\,A}$	$8.98 \pm 0.01^{b\,A}$	$7.76 \pm 0.01^{c\,A}$
	5	$8.89 \pm 0.01^{a\,B}$	$7.70 \pm 0.01^{b\,A}$	$6.73 \pm 0.01^{c\,B}$
	10	$8.04 \pm 0.01^{a\,C}$	$7.05 \pm 0.01^{b\,C}$	$6.38 \pm 0.01^{c\,C}$
	15	$7.80 \pm 0.01^{a\,D}$	$6.79 \pm 0.01^{b\,D}$	$5.95 \pm 0.01^{c\,D}$
	20	$7.18 \pm 0.01^{a\,E}$	$6.24 \pm 0.01^{b\,E}$	$4.89 \pm 0.01^{c\,E}$
	25	$6.26 \pm 0.01^{a\,F}$	$5.59 \pm 0.01^{b\,F}$	$4.01 \pm 0.01^{c\,F}$
Solid-not-fat (SNF) (%)	0	$5.78 \pm 0.01^{a\,A}$	$6.69 \pm 0.03^{b\,A}$	$8.23 \pm 0.01^{c\,A}$
	5	$5.75 \pm 0.01^{a\,A}$	$6.77 \pm 0.02^{b\,A}$	$8.20 \pm 0.01^{c\,A}$
	10	$5.67 \pm 0.01^{a\,B}$	$6.69 \pm 0.02^{b\,B}$	$7.98 \pm 0.03^{c\,B}$
	15	$5.59 \pm 0.01^{a\,C}$	$6.67 \pm 0.02^{b\,B}$	$7.83 \pm 0.02^{c\,C}$
	20	$5.48 \pm 0.01^{a\,D}$	$6.58 \pm 0.02^{b\,C}$	$7.75 \pm 0.05^{c\,D}$
	25	$5.20 \pm 0.01^{a\,E}$	$5.30 \pm 0.03^{b\,D}$	$5.60 \pm 0.02^{c\,E}$

[1] Results are expressed as mean values ± standard deviation ($n = 3$). Mean values followed by uppercase letters within column and lowercase letters within row indicates significant difference according to Tukey's multiple comparison test with a probability of 5% ($p < 0.05$).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Table 3. Physicochemical analysis of whey-mango based mixed beverage [1].

Parameter	Storage (Days)	Sample-1	Sample-2	Sample-3
Moisture (%)	0	$74.50 \pm 0.02^{a\,A}$	$78.59 \pm 0.06^{b\,A}$	$83.09 \pm 0.04^{c\,A}$
	5	$75.00 \pm 0.01^{a\,B}$	$79.01 \pm 0.04^{b\,B}$	$84.02 \pm 0.03^{c\,B}$
	10	$75.86 \pm 0.03^{a\,C}$	$79.88 \pm 0.02^{b\,C}$	$85.47 \pm 0.04^{c\,C}$
	15	$78.04 \pm 0.01^{a\,D}$	$81.09 \pm 0.05^{b\,D}$	$86.66 \pm 0.01^{c\,D}$
	20	$78.83 \pm 0.02^{a\,E}$	$81.79 \pm 0.01^{b\,E}$	$86.91 \pm 0.02^{c\,E}$
	25	$79.91 \pm 0.02^{a\,F}$	$82.08 \pm 0.05^{b\,F}$	$87.02 \pm 0.03^{c\,F}$
Protein (%)	0	$5.67 \pm 0.02^{a\,A}$	$7.36 \pm 0.01^{b\,A}$	$7.66 \pm 0.01^{c\,A}$
	5	$5.65 \pm 0.01^{a\,AB}$	$7.36 \pm 0.01^{b\,A}$	$7.62 \pm 0.01^{c\,B}$
	10	$5.65 \pm 0.01^{a\,AB}$	$7.33 \pm 0.01^{b\,AB}$	$7.62 \pm 0.02^{c\,B}$
	15	$5.63 \pm 0.02^{a\,BC}$	$7.34 \pm 0.01^{b\,AB}$	$7.62 \pm 0.01^{c\,B}$
	20	$5.60 \pm 0.01^{a\,CD}$	$7.32 \pm 0.01^{b\,BC}$	$7.60 \pm 0.01^{c\,BC}$
	25	$5.57 \pm 0.02^{a\,D}$	$7.29 \pm 0.02^{b\,C}$	$7.58 \pm 0.01^{c\,C}$
Fat (%)	0	$0.97 \pm 0.01^{a\,A}$	$1.30 \pm 0.01^{b\,A}$	$1.57 \pm 0.01^{c\,A}$
	5	$0.96 \pm 0.03^{a\,A}$	$1.29 \pm 0.04^{b\,A}$	$1.57 \pm 0.03^{c\,A}$
	10	$0.96 \pm 0.02^{a\,A}$	$1.27 \pm 0.04^{b\,A}$	$1.56 \pm 0.02^{c\,A}$
	15	$0.95 \pm 0.01^{a\,AB}$	$1.27 \pm 0.05^{b\,A}$	$1.53 \pm 0.02^{c\,AB}$
	20	$0.89 \pm 0.02^{a\,BC}$	$1.19 \pm 0.02^{b\,B}$	$1.48 \pm 0.03^{c\,B}$
	25	$0.83 \pm 0.01^{a\,C}$	$1.14 \pm 0.02^{b\,B}$	$1.39 \pm 0.04^{c\,C}$
Carbohydrate (%)	0	$18.01 \pm 0.02^{a\,A}$	$11.67 \pm 0.01^{b\,A}$	$6.98 \pm 0.02^{c\,A}$
	5	$17.91 \pm 0.02^{a\,B}$	$11.27 \pm 0.01^{b\,B}$	$6.47 \pm 0.02^{c\,B}$
	10	$17.01 \pm 0.06^{a\,C}$	$11.19 \pm 0.02^{b\,C}$	$6.09 \pm 0.02^{c\,C}$
	15	$14.07 \pm 0.02^{a\,D}$	$8.98 \pm 0.06^{b\,D}$	$4.07 \pm 0.04^{c\,D}$
	20	$12.96 \pm 0.02^{a\,E}$	$8.91 \pm 0.03^{b\,E}$	$3.98 \pm 0.02^{c\,E}$
	25	$12.87 \pm 0.01^{a\,F}$	$8.79 \pm 0.02^{b\,F}$	$3.45 \pm 0.02^{c\,F}$
Ash (%)	0	$0.84 \pm 0.01^{a\,A}$	$0.75 \pm 0.01^{b\,A}$	$0.67 \pm 0.02^{c\,A}$
	5	$0.84 \pm 0.01^{a\,A}$	$0.72 \pm 0.01^{b\,AB}$	$0.64 \pm 0.02^{c\,AB}$
	10	$0.83 \pm 0.04^{a\,A}$	$0.71 \pm 0.03^{b\,AB}$	$0.60 \pm 0.03^{c\,BC}$
	15	$0.79 \pm 0.02^{a\,AB}$	$0.71 \pm 0.04^{b\,AB}$	$0.60 \pm 0.02^{c\,BC}$
	20	$0.79 \pm 0.03^{a\,AB}$	$0.70 \pm 0.03^{b\,AB}$	$0.59 \pm 0.01^{c\,BC}$
	25	$0.77 \pm 0.02^{a\,B}$	$0.68 \pm 0.01^{b\,B}$	$0.56 \pm 0.02^{c\,C}$

[1] Results are expressed as mean values ± standard deviation ($n = 3$). Mean values followed by uppercase letters within column and lowercase letters within row indicates significant difference according to Tukey's multiple comparison test with a probability of 5% ($p < 0.05$).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

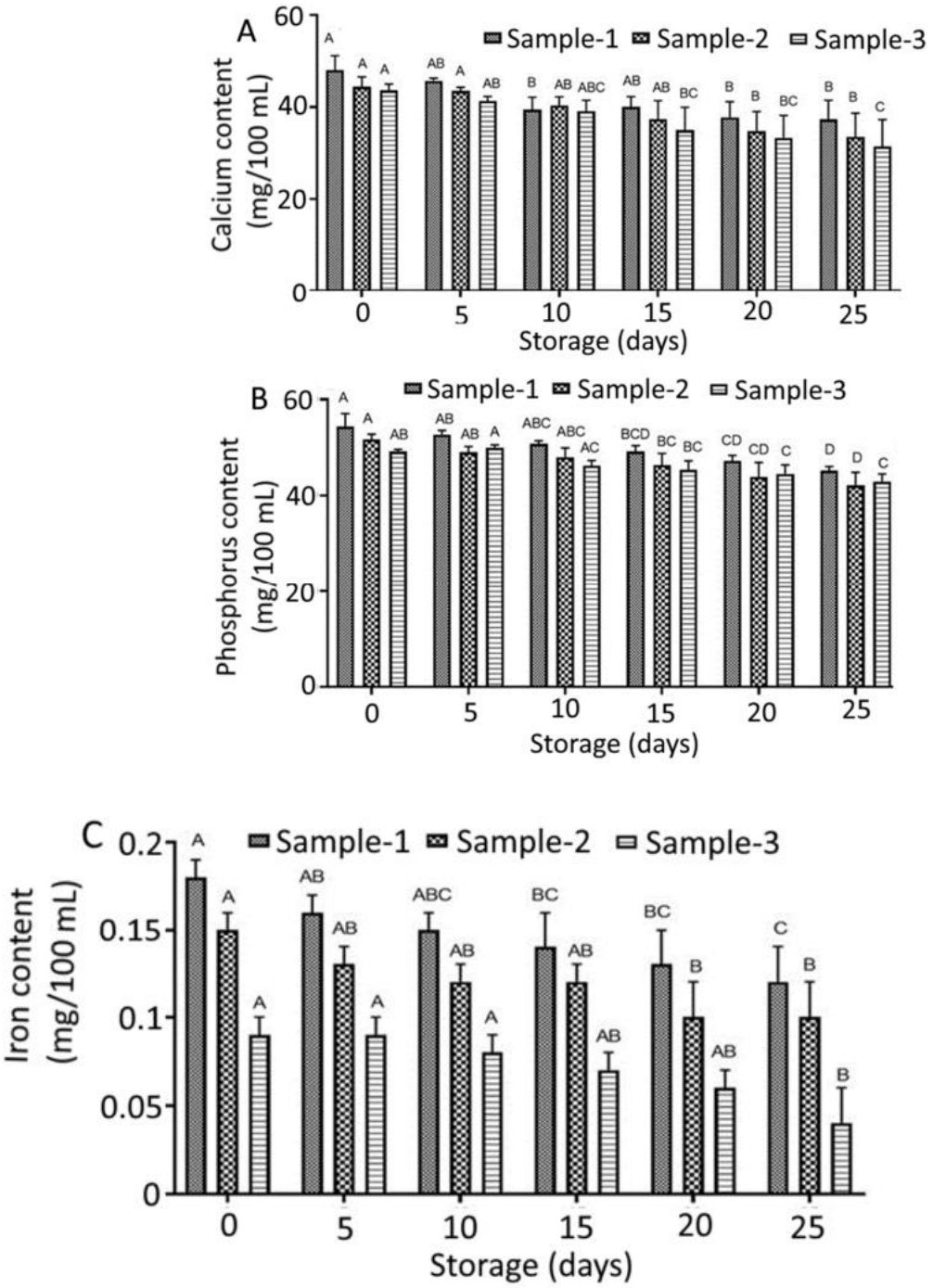

Figure 1. Minerals profile of whey-based mixed beverages: (**A**) calcium content; (**B**) phosphorus content; and (**C**) iron content. All the values are expressed as mean ± standard deviation of three replicates. Different uppercase letters above the same pattern bars indicate significant differences according to Tukey's multiple comparison test ($p < 0.05$).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Table 4. Microbiological analysis of whey-mango based mixed beverages during storage [1].

Parameter	Storage (Days)	Sample-1	Sample-2	Sample-3
TPC (log CFU/mL)	0	$3.32 \pm 0.08^{a\ A}$	$3.33 \pm 0.08^{a\ A}$	$3.34 \pm 0.10^{a\ A}$
	5	$3.34 \pm 0.05^{a\ AB}$	$3.35 \pm 0.05^{a\ AB}$	$3.37 \pm 0.05^{a\ AB}$
	10	$3.37 \pm 0.08^{a\ B}$	$3.38 \pm 0.09^{a\ B}$	$3.39 \pm 0.10^{a\ B}$
	15	$3.40 \pm 0.06^{a\ C}$	$3.42 \pm 0.07^{a\ C}$	$3.43 \pm 0.04^{b\ C}$
	20	$3.43 \pm 0.07^{a\ CD}$	$3.45 \pm 0.08^{a\ CD}$	$3.46 \pm 0.05^{a\ C}$
	25	$3.45 \pm 0.09^{a\ D}$	$3.47 \pm 0.07^{a\ D}$	$3.49 \pm 0.15^{a\ D}$
Yeast and mold (log CFU/mL)	0	$0.48 \pm 0.01^{a\ A}$	$0.60 \pm 0.02^{a\ A}$	$0.60 \pm 0.03^{a\ A}$
	5	$1.00 \pm 0.03^{a\ AB}$	$1.15 \pm 0.05^{a\ AB}$	$1.20 \pm 0.04^{a\ AB}$
	10	$1.26 \pm 0.05^{a\ AB}$	$1.36 \pm 0.08^{a\ B}$	$1.48 \pm 0.09^{a\ BC}$
	15	$1.38 \pm 0.06^{a\ BC}$	$1.48 \pm 0.08^{a\ BC}$	$1.57 \pm 0.09^{a\ CD}$
	20	$1.58 \pm 0.08^{a\ CD}$	$1.63 \pm 0.06^{a\ CD}$	$1.72 \pm 0.11^{b\ DE}$
	25	$1.71 \pm 0.10^{a\ D}$	$1.78 \pm 0.12^{a\ D}$	$1.85 \pm 0.11^{b\ E}$
Coliform (log CFU/mL)	0	0	0	0
	5	<1 **	<1 **	<1 **
	10	<1 **	<1 **	<1 **
	15	<1 **	<1 **	<1 **
	20	<1 **	<1 **	<1 **
	25	<1 **	<1 **	<1 **

[1] Results are expressed as mean values ± standard deviation ($n = 3$). Mean values followed by uppercase letters within column and lowercase letters within row indicates significant difference according to Tukey's multiple comparison test with a probability of 5% ($p < 0.05$). ** below the detection limit of the method.

S

Table 5. Sensory analysis of whey-mango based mixed beverage during storage [1].

Sample	Storage (Days)	Color	Flavor	Taste	Appearance	Overall Acceptability
Sample-1	0	8.24 ± 0.03^{A}	7.28 ± 0.03^{A}	6.88 ± 0.03^{A}	5.25 ± 0.03^{B}	6.87 ± 0.04^{A}
	5	7.79 ± 0.06^{B}	7.16 ± 0.04^{B}	6.39 ± 0.03^{C}	4.85 ± 0.02^{D}	6.76 ± 0.17^{B}
	10	7.42 ± 0.02^{C}	6.92 ± 0.03^{D}	6.09 ± 0.03^{F}	4.21 ± 0.02^{F}	6.18 ± 0.02^{D}
	15	6.24 ± 0.01^{E}	6.18 ± 0.05^{G}	5.71 ± 0.04^{H}	4.09 ± 0.03^{G}	5.53 ± 0.05^{F}
	20	4.24 ± 0.03^{F}	3.99 ± 0.02^{J}	4.09 ± 0.06^{K}	3.48 ± 0.07^{L}	3.88 ± 0.10^{I}
	25	2.89 ± 0.02^{I}	2.17 ± 0.05^{I}	3.10 ± 0.03^{N}	3.09 ± 0.03^{J}	2.83 ± 0.02^{K}
Sample-2	0	8.29 ± 0.03^{A}	7.28 ± 0.04^{A}	6.71 ± 0.03^{B}	5.36 ± 0.03^{A}	6.87 ± 0.06^{A}
	5	7.83 ± 0.09^{B}	7.14 ± 0.06^{B}	6.20 ± 0.02^{E}	5.09 ± 0.03^{C}	6.60 ± 0.03^{C}
	10	7.31 ± 0.08^{D}	6.85 ± 0.04^{E}	5.73 ± 0.04^{H}	4.88 ± 0.02^{D}	6.20 ± 0.03^{D}
	15	6.22 ± 0.04^{E}	6.18 ± 0.05^{G}	5.20 ± 0.08^{I}	4.26 ± 0.03^{F}	5.41 ± 0.07^{G}
	20	4.13 ± 0.06^{G}	3.78 ± 0.09^{K}	3.91 ± 0.06^{L}	3.69 ± 0.02^{H}	3.86 ± 0.06^{I}
	25	2.99 ± 0.02^{H}	2.11 ± 0.05^{I}	3.07 ± 0.04^{N}	3.02 ± 0.05^{K}	2.81 ± 0.02^{K}
Sample-3	0	8.23 ± 0.05^{A}	7.25 ± 0.04^{A}	6.31 ± 0.02^{D}	5.21 ± 0.02^{B}	6.73 ± 0.04^{B}
	5	7.79 ± 0.02^{B}	6.99 ± 0.02^{C}	6.24 ± 0.03^{E}	5.13 ± 0.07^{C}	6.55 ± 0.04^{C}
	10	7.33 ± 0.02^{D}	6.45 ± 0.01^{F}	5.88 ± 0.01^{G}	4.58 ± 0.03^{E}	6.05 ± 0.03^{E}
	15	6.20 ± 0.02^{E}	5.77 ± 0.02^{H}	4.99 ± 0.02^{J}	4.08 ± 0.03^{G}	5.25 ± 0.03^{H}
	20	4.30 ± 0.01^{F}	4.12 ± 0.01^{I}	3.26 ± 0.03^{M}	3.13 ± 0.02^{J}	3.67 ± 0.05^{J}
	25	2.83 ± 0.02^{I}	2.18 ± 0.03^{L}	3.10 ± 0.03^{N}	2.85 ± 0.02^{L}	2.75 ± 0.03^{K}

[1] Results are expressed as mean values ± standard error ($n = 30$). Mean values followed by uppercase letters within column indicates significant difference according to Tukey's multiple comparison test with a probability of 5% ($p < 0.05$).

Sensory evaluation:

The sensory evaluation results for all samples after 25 days are presented in Table 5. Initially, the sample [51] with a whey to mango juice ratio of 60:20 and 65:15 received the highest sensory score for overall acceptability, with a score of 6.87 [52]. However, these scores gradually decreased during the storage period, reaching 2.83 and 2.81, respectively [53], on the

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

25th day of storage. The sample with the highest proportion of whey obtained similar scores in terms of color and flavor compared to other samples, but there were noticeable differences in taste, appearance, and overall acceptability [54]. The decline in overall acceptability scores over the storage period may be attributed to the beverages' color changes, increased acidity[55], and alterations in taste and flavor. Regardless of the treatment and storage duration, all samples experienced a reduction in their sensory scores as the storage period progressed.

Conclusion:

In conclusion, this study demonstrates that whey combined with fruits and vegetables holds great potential for developing healthy whey-based beverages with favorable sensory attributes. The whey-mango-based mixed beverages showed satisfactory microbiological safety during storage for up to 15 days under refrigerated conditions (4 ± 1 ◦C). Considering the functional properties derived from the bioactive constituents present in both fruit and whey, these whey-mango-based mixed beverages could be an appealing product in the ever-expanding beverage market.

To utilize whey-mango-based mixed beverages at a commercial scale, further investigations are recommended. These include studying the beverage's shelf life, enhancing quality through the incorporation of stabilizers and employing opaque packaging, optimizing the production process conditions, and conducting clinical trials to ensure safety and verify the beverage's functional benefits for human health.

References:

1. Turkmen, N.; Akal, C.; Özer, B. Probiotic dairy-based beverages: A review. J. Funct. Foods 2019, 53, 62–75. [CrossRef]

2. Alves, A.T.; Spadoti, L.M.; Zacarchenco, P.B.; Trento, F.K.H.S. Probiotic functional carbonated whey beverages: Development and quality evaluation. Beverages 2018, 4, 49. [CrossRef]

3. León-López, A.; Pérez-Marroquin, X.A.; Campos-Lozada, G.; Campos-Montiel, R.G.; Aguirre-Álvarez, G. Characterization of whey-based fermented beverages supplemented with hydrolyzed collagen: Antioxidant activity and bioavailability. Foods 2020, 9, 1106. [CrossRef] [PubMed]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

4. Begum, T.; Islam, M.; Siddiki, M.S.R.; Habib, R.; Harun-ur-Rashid, M. Preparation of fermented beverage from whey-based watermelon (Citrullus lanatus) juice. Asian J. Dairy Food Res. 2019, 38, 301–306. [CrossRef]

5. Yadav, J.S.S.; Yan, S.; Pilli, S.; Kumar, L.; Tyagi, R.D.; Surampalli, R.Y. Cheese whey: A potential resource to transform into bioprotein, functional/nutritional proteins and bioactive peptides. Biotechnol. Adv. 2015, 33, 756–774. [CrossRef]

6. Pescuma, M.; Hébert, E.M.; Mozzi, F.; deValdez, G.F. Whey fermentation by thermophilic lactic acid bacteria: Evolution of carbohydrates and protein content. Food Microbiol. 2008, 25, 442–451. [CrossRef] [PubMed]

7. Vivas, Y.A.; Morales, A.J.; Otálvaro, Á.M. Utilization of whey in the development of a refreshing beverage with naturalantioxidants. Aliment. Hoy. 2017, 24, 185–199.

8. Navas, J.S.R. Industrial use of whey by fermentation processes. Public. Investig. 2012, 6, 69–83.

9. Chatterjee, G.; DeNeve, J.; Dutta, A.; Das, S. Formulation and statistical evaluation of a ready-to-drink whey based orange beverage and its storage stability. Rev. Mex. Ing. Qum. 2015, 14, 253–264.

10. Djuri´c, M.; Cari´c, M.; Milanovi´c, S.; Teki´c, M.; Pani´c, M. Development of whey-based beverages. Eur. Food Res. Technol. 2004, 219, 321–328. [CrossRef]

11. Jeli˘ci´c, I.; Božani´c, R.; Tratnik, L. Whey-based beverages-a new generation of dairy products. Mljekarstvo 2008, 58, 257–274.

12. Koffi, E.; Shewfelt, R.; Wicker, L. Storage stability and sensory analysis of UHT-processed whey-banana beverages. J. Food Qual. 2005, 28, 386–401. [CrossRef]

13. Bhardwaj, R.L.; Pandey, S. Juice blends—A way of utilization of under-utilized fruits, vegetables, and spices: A review. Crit. Rev. Food Sci. Nutr. 2011, 51, 563–570. [CrossRef] [PubMed]

14. Martins, E.M.F.; Ramos, A.M.; Vanzela, E.S.L.; Stringheta, P.C.; de Oliveira Pinto, C.L.; Martins, J.M. Products of vegetable origin: A new alternative for the consumption of probiotic bacteria. Food Res. Int. 2013, 51, 764–770. [CrossRef]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

16. Briviba, K.; Gräf, V.; Walz, E.; Guamis, B.; Butz, P. Ultra high pressure homogenization of almond milk: Physico-chemical and physiological effects. Food Chem. 2016, 192, 82–89. [CrossRef]

17. Maeda-Yamamoto, M.; Tachibana, H. Anti-allergic action of o-methylated EGCG in green tea cultivar Benifuuki. J. Food Drug Anal. 2012, 20, 313–317. [CrossRef]

18. Hodgson, A.B.; Randell, R.K.; Jeukendrup, A.E. The effect of green tea extract on fat oxidation at rest and during exercise: Evidence of efficacy and proposed mechanisms. Adv. Nutr. 2013, 4, 129–140. [CrossRef]

19. Hasan, M.M.; Kabir, M.S. Study on Shelf life of non-preservative containing mango drinks produced in Dhaka, Bangladesh. Stamford J. Microbiol. 2014, 4, 24–27. [CrossRef]

20. Pandey, S.; Ojha, P. Preparation and quality evaluation of mango based whey beverage. J. Food Sci. Technol. Nepal 2020, 12, 59–61. [CrossRef]

21. Alane, D.; Raut, N.; Kamble, D.B.; Bhotmange, M. Studies on preparation and storage stability of whey based mango herbal beverage. Int. J Chem. Stud. 2017, 5, 237–241.

22. Chavan, R.; Nalawade, T.; Kumar, A. Studies on the development of whey based mango beverage. Food Dairy Technol. 2015, 3, 1–6.

24. Mathur, B.; Hashizume, K.; Musumi, S.; Nakazawa, Y.; Watanabe, T. Traditional cheese “paneer” in India and Soy bean food “tofu” in Japan. Jpn. J. Dairy Food Sci. 1986, 35, 137–141.

25. Kawakatsu, T.; Kobayashi, T.; Sano, Y.; Nakajima, M. Clarification of green tea extract by microfiltration and ultrafiltration. Biosci. Biotechnol. Biochem. 1995, 59, 1016–1020. [CrossRef]

26. Erdogan, V.; Aygun, A. Fatty acid composition and physical properties of Turkish tree hazel nuts. Chem. Nat. Compd. 2005, 41, 378–381. [CrossRef]

27. Ranganna, S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products; Tata McGraw-Hill Education: Columbus, OH, USA, 1986; pp. 1–1112.

28. Association of Official Analytical Chemists (AOAC). Official Methods of Analysis, 21st ed.; AOAC: Washington, DC, USA, 2019; pp. 1–3172.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

29. Pyne, G.T. The determination of milk-proteins by formaldehyde titration. Biochem. J. 1932, 26, 1006. [CrossRef]

30. Alam, M.R.; Habib, M.A.; Chowdhury, P.; Shill, L.C.; AlMamun, M.A. Determination of ascorbic acid concentration in commercially available fruit drinks in Bangladesh. Asian Food Sci. J. 2019, 3, 1–6. [CrossRef]

31. Lane, J.H.; Eynon, L. Determination of Reducing Sugars by Fehling's Solution with Methylene Blue Indicator; N. Rodger: London, UK, 1934; pp. 1–8.

32. Patel, K.J.; Boghra, V.R. Modifications in Richmond formula for calculating solids-not-fat/total solids percent in cows' milk in Gujarat state. Asian J. Dairy Food Res. 2018, 37, 278–282. [CrossRef] 33. Association of Official Analytical Chemists (AOAC). Official Methods of Analysis, 18th ed.; AOAC: Washington, DC, USA, 2005; pp. 1–26.

34. Gad, A.S.; Emam, W.H.; Mohamed, G.F.; Sayd, A.F. Utilization whey in production of functional healthy beverage "whey-mango beverages". Amer. J. Food Technol. 2013, 8, 133–148. [CrossRef]

35. Seibel, W. Approved Methods of the American Association of Cereal Chemists, 8th ed.; Standardmethoden der Amerikanischen Gesellschaft für Getreidechemiker, 8. Ausgabe; Committee American Association of Cereal Chemists, Inc.: St. Paul, MN, USA, 1989; Volume 41, p. 443.

36. Vanderzant, C.; Splittstoesser, D.F. Compendium of Methods for the Microbiological Examination of Foods, 3rd ed.; American Public Health Association: Washington, DC, USA, 1992; pp. 423–431.

37. Nicolas, L.; Marquilly, C.; O'Mahony, M. The 9-point hedonic scale: Are words and numbers compatible? Food Qual. Prefer. 2010, 21, 1008–1015. [CrossRef]

38. Jooyandeh, H. Manufacturing of a novel naturally carbonated fruit beverage. J. Appl. Environ. Biol. Sci. 2015, 4, 47–53.

39. Mishra, L.K.; Sangma, D. Quality attributes, phytochemical profile and storage stability studies of functional ready to serve (RTS) drink made from blend of aloe vera, sweet lime, amla and ginger. J. Food Sci. Technol. 2017, 54, 761–769. [CrossRef] [PubMed]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

40. Etzel, M.R. Manufacture and use of dairy protein fractions. J. Nutr. 2004, 134, 996–1002. [CrossRef]

41. Beecher, J.W.; Drake, M.A.; Luck, P.J.; Foegeding, E.A. Factors regulating astringency of whey protein beverages. J. Dairy Sci. 2008, 91, 2553–2560. [CrossRef]

42. Kalra, S.K.; Tandon, D.K.; Garg, N.; Singh, B.P. Quality evaluation of some market drinks. Indian Food Pack. 1991, 45, 40–53.

43. Yadav, R.B.; Yadav, B.S.; Kalia, N. Development and storage studies on whey-based banana herbal (Mentha arvensis) beverage. Am. J. food Technol. 2010, 5, 121–129. [CrossRef]

44. Sakhale, B.K.; Pawar, V.N.; Ranveer, R.C. Studies on the development and storage of whey based RTS beverage from mango Cv. Kesar. J. Food Process. Technol. 2012, 3, 1–4.

45. Divya, D.; Kumari, A. Effect of different temperatures, timings and storage periods on the physico-chemical and nutritional characteristics of whey-guava beverage. World J. Dairy Food Sci. 2009, 4, 118–122.

46. Saravana, K.R.; Manimegalai, G. Studies on storage stability of whey-based papaya juice blended RTS beverage. J. Food Sci. Technol. 2005, 42, 185–188.

47. Barwal, V.S.; Singh, T.K.; Alkesh, A. Studies on processing and development of ready-to-serve drink from bittergourd fruit. J. Food Sci. Technol. 2005, 42, 217–220.

48. Sirohi, D.; Patel, S.; Choudhary, P.L.; Sahu, C. Studies on preparation and storage of whey-based mango herbal pudina (Mentha arvensis) beverage. J. Food Sci. Technol. 2005, 42, 157–161.

49. Sharma, R.; Choudhary, R.; Thakur, N.S.; Thakur, A. Development and quality of apple-whey based herbal functional ready-toserve beverage. J. Appl. Nat. Sci. 2019, 11, 291–298. [CrossRef]

50. Panghal, A.; Kumar, V.; Dhull, S.B.; Gat, Y.; Chhikara, N. Utilization of dairy industry waste-whey in formulation of papaya RTS beverage. Curr. Res. Nutr. Food Sci. J. 2017, 5, 168–174. [CrossRef]

51. Jakhar, M. Development of whey with apple juice and appraisal of their nutritional qualities. Asian J. Dairy Food Res. 2019, 38, 163–166. [CrossRef]

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

52. Ilamaran, M.; Amutha, S. Effect of total soluble solids and CO2 pressure on physico-chemical and sensory qualities of carbonated banana and sapota beverages. J. Food Sci. Technol. 2007, 44, 178–182.

53. Jain, S.K.; Khurdiya, D.S. Vitamin C enrichment of fruit juice based ready-to-serve beverages through blending of Indian gooseberry (Emblica officinalis Gaertn.) juice. Plant Foods Hum. Nutr. 2004, 59, 63–66. [CrossRef]