

Research Article

Whey Based Bulla Porridge Using Different Proportions of Acidic Whey and Water

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Abstract

Bulla porridge is a traditional food item often made from bulla paste, which is primarily obtained from fully matured Enset (*Ensete ventricosum*) plants. It is high in carbohydrates but low in protein. This study aimed to improve the nutritional value and sensory attributes of bulla porridge. 5 kg of bulla paste was collected from Gurage zone, Ezha woreda, Ethiopia. The experiment included seven treatments: T1 (100% water), T2 (85% Acidic Whey & 15% Water), T3 (70% Acidic Whey & 30% Water), T4 (55% Acidic Whey & 45% Water), T5 (40% Acidic Whey & 60% Water), T6 (25% Acidic Whey & 75% Water), and T7 (10% Acidic Whey & 90% Water). The moisture, ash, crude protein, calcium, iron, and zinc content of acidic whey blended bulla porridge ranged from 0.54% to 1.65%, 0.33% to 4.65%, 0.43% to 1.43%, 177.60 to 530.50, 9.37 to 24.51, and 0.69 to 2.34, respectively. The highest sensory attribute scores were 8.33 for appearance, 8.47 for color, 7.87 for taste, 8.07 for odor, 8.07 for texture, and 8.15 for overall acceptability. Bulla porridge with 70% acidic whey and 30% water showed a 16% increase in protein, 35% increase in calcium, and 7% increase in zinc. Bulla porridge made with acidic whey can be significantly improved in terms of protein content and sensory acceptability compared to the control.

Keywords

Bulla Paste, Bulla Porridge, Physicochemical, Sensory Attributes, Whey

1. Introduction

Nutritional security is a top priority globally. Proper formulation and use of agricultural products is essential to increase food diversity. Milk and its products, like whey, are rich in nutrients. Whey, particularly acid whey, contains proteins and minerals that can help combat protein malnutrition [2].

Enset is a key food source for approximately 20% of the Ethiopian population, which amounts to over 20 million people [18]. It is a dietary staple in the southern part of Ethiopia, providing carbohydrates, minerals, and fibers, alt-

hough it is low in protein content [14].

Bulla, one of the three main food products derived from Enset, is a water-insoluble starchy substance that can be extracted from Kocho through a process of squeezing and decanting the liquid stored in the pseudo stem. This is crucial for addressing food security challenges posed by the current population growth in Ethiopia [19]. Starchy foods prepared from enset were the primary source of calcium and an additional source of iron was reported [21]. Besides these, the mineral concentration of some of the elements (Ca, Fe and

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Zn) of bulla was reported by [31].

Currently, the application of whey for food formulation have given great attention [28]. Despite the lack of understanding of the essential nutrients present in whey, it is still considered as a waste product [12]. In the case of cheese production, ten parts of milk give nine parts of whey and one part of cheese [11]. The whey is a by-product of cheese making, contains up to 55% of milk nutrients and 20% of milk proteins [22, 23]. Acid whey, in particular, contains proteins, mineral salts, vitamins, and products of lactic acid fermentation [26]. Whey and its derivatives have been suggested as potential substitutes for main ingredients and can be incorporated in to different food products to increase the nutrient level of the food products in the literature was reported [30].

Regarding porridge is one of the most widely consumed foods in Ethiopia. Like other parts of Ethiopia, porridge is also a traditional food among the people of Guraga district. People in this district use bulla in place of other cereal crops. Hence, the porridge is made mostly from bulla paste instead of other cereal crops (rye, maize, barley, and wheat). Porridge may be served as a main meal (breakfast) or as a meal on special occasions (after birth or holiday). Most often, this food is given to special ceremonies, delivered mother, for caring the sick, aged and pregnant women. It is also used as a complementary food to feed children under the age of five years [32, 33].

For whey based bulla porridge study mixture design applied as a tool for determining the optimum formula by considering the quality of the characteristics of the food. This software provides us to improve the bulla porridge preparation in different proportion of whey.

There is limited research was conducted on the formulation of bulla with dairy processing products such as the whey in the literature. Therefore, the aim of this study was to enhance the nutritional content and sensory qualities of bulla porridge by using different ratios of acidic whey to water.

2. Material and Methods

2.1. Raw Materials

5 kg of bulla paste was obtained from Gurage Zone, Ezha district in Ethiopia. Milk was sourced from Holeta livestock farm and processed into acidic whey at the dairy processing laboratory at Holeta Agricultural Research Center as shown in Figure 1.



Figure 1. Raw material for the experiment.

2.2. Treatments

A total of seven treatments were prepared using 100 g of bulla paste for each. The preparation of bulla porridge was done by mixing the bulla paste with varying proportions of whey and water. The paste was then cooked until it reached the desired consistency and flavor, following the method described by [25]. Bulla porridges consisted of water, whey, and bulla paste as shown in Table 1.

Table 1. Treatment combinations.

Treatments	Blending levels (%)	Bulla paste (g)
1	100% Water	100
2	85% Acidic Whey and 15% Water	100
3	70% Acidic Whey and 30% Water	100
4	55% Acidic Whey and 45% Water	100
5	40% Acidic Whey and 60% Water	100
6	25% Acidic Whey and 75% Water	100
7	10% Acidic Whey and 90% Water	100

2.3. Bulla Preparation

After obtaining the bulla pastes from the local market, they were placed in a plastic container and mixed well with water until completely dissolved. The mixture was then filtered using sieves to remove any extraneous materials (foreign matter). The bulla paste was collected from the plastic bucket and used for the experiment. Subsequently, the bulla paste dissolved in water was stored inside the bucket at room temperature for preservation. The water was changed every week to prolong the shelf life of the bulla paste until the end of the experiment, as shown in Figure 2.



Figure 1. Preparation process of bulla paste for the experiment.

2.4. Acidic Whey Preparation

Five liters of raw cow milk, collected from Holeta Agricultural Research Center dairy farm, were kept in a clean container for three days for spontaneous fermentation without the addition of any starter culture. The fermented and coagulated milk was then churned, and the butter was removed. After removing the butter, the remaining part was heated to 40-50 degrees Celsius until the cheese coagulated. Finally, the cottage cheese was separated from the whey by filtering it using muslin cloth. The filtered whey was then kept in a labeled clean container, as shown in **Figure 3**.



Figure 3. Prepared acidic whey taken from the experiment.

2.5. Porridge Preparation

Three hundred milliliters of distilled water with acidic whey were heated to 67 °C for 4 minutes. Then, 100 grams of the bulla paste mix were added and continuously stirred with a wooden ladle until the desired consistency was attained. This mixture was boiled at 80 °C for 13 minutes and allowed to cool to 40 °C before serving to the panelists. The porridge was prepared using the method with some modifications described by [20], as shown in **Figure 4**.



Figure 4. Prepared Porridge taken from the experiment.

2.6. Physicochemical Property Analysis

2.6.1. Determination of Moisture

A 3 g sample of bulla porridge was weighed into a heated and pre-weighed crucible. The moisture content was determined by oven drying at 105 °C for 3 hours. After drying, the crucibles containing the samples were removed, cooled in desiccators, and then re-weighed. The moisture content was calculated using the following formula [15].

$$\text{Moisture (\%)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

Where: W_1 = weight of crucible or empty dish (g); W_2 = weight of crucible + sample before drying (g); W_3 = weight of crucible + sample after drying (g).

2.6.2. PH and Titratable Acidity

The pH of the bulla porridge was measured using a glass electrode digital pH meter after calibration with standard buffer solutions of pH 4 and 7. 10 g of bulla paste was placed in a 100 ml beaker for analysis. The sample was then diluted in 90 ml of neutralized distilled water. 10 ml of the diluted sample was transferred to a pH reader, and 3 to 4 drops of 0.5% phenolphthalein indicator were added and dissolved using a magnetic stirrer. Each sample was titrated with 0.1 N NaOH until reaching an end point of 8.2 (confirmed with the pH meter or phenolphthalein indicator). The milliliters (ml) of NaOH used were recorded for each treatment, and the acidity was reported as ml of NaOH per 10 g of sample. Titratable acidity was determined using the titration method outlined in the standard procedure by Garner [5]. The titratable acidity was calculated using the following formula:

$$\% \text{ acidity} = \frac{(\text{mls NaOH used}) \times (0.1 \text{ N NaOH}) \times (\text{milliequivalent factor})}{\text{grams of sample}} \times 100$$

Where 0.064* = acid millequivalent factor

2.6.3. Determination of Ash Content

The total ash content was determined by using oven-dried samples at 65 °C overnight. The dried samples were placed in a desiccator and weighed using an analytical balance. Then, the dried samples were incinerated in a muffle furnace at 550 °C for 4 hours following the method described by [1].

The ash was cooled in a desiccator and reweighed using an analytical balance. The initial and final weights were recorded. The obtained ash weight was divided by the original sample weight, and the result was expressed as a percentage. The ash percentage was calculated using the following formula:

$$\text{Total ash (\%)} = \frac{(\text{Weight of residue g})}{(\text{weight of sample g})} \times 100$$

2.6.4. Determination of Crude Protein Content

The total nitrogen content of 5 g porridge samples was determined using the Kjeldahl method as outlined in [1]. The bulla porridge was weighed and digested at 350 °C by adding 10 ml of sulfuric acid with a selenium mixture catalyst for 2 hours. Once a light green color appeared, the digest solution was cooled and transferred into a 100 ml volumetric flask, which was then filled to the mark with distilled water. A Micro Kjeldahl distillation apparatus was used to distill 25 ml of the prepared digest by adding 70 ml of 40% sodium hydroxide. The blue color changed to dark brown as the distillation continued. The released ammonia was condensed and collected in a receiver containing 30 ml of boric acid with indicator solution. The condensed ammonia was then back-titrated with 0.01 M HCl until a pink color endpoint was reached. The crude protein content of the porridge samples was calculated by multiplying the nitrogen content by a factor of 6.35.

$$\% \text{ Nitrogen by weight} = \frac{(R-B)N \times 14 \times 100}{1000} \times SW$$

$$\% \text{ Crude protein} = N \times 6.25$$

Where: *R*=Reading of the analysis; *B*= Blank used as a control; *SW*= Weight of the sample.

2.6.5. Mineral Analysis

To determine the levels of calcium, zinc, and iron in a sample of bulla porridge, 5 grams of the porridge were placed in a porcelain crucible that had been weighed beforehand. The porridge was then heated, and after cooling, 0.5 grams of white ash were weighed out. This ash was mixed with 2.5 ml of concentrated HCL and 2.5 ml of distilled water, and the resulting mixture was dissolved in a 25 ml calibrated flask. The digested sample was then filtered and transferred to a 100 ml volumetric flask. The solution was used to analyze the levels of calcium, zinc, and iron. Standard stock solutions of Fe, Zn, and Ca were prepared using AAS grade chemicals and appropriate dilutions. The concentrations of Ca, Zn, and Fe in the porridge were measured using an Atomic Absorption Spectrophotometer (Agilent AAS series 200, USA) following method [1].

$$\text{Conc. of minerals} \left(\frac{\text{mg}}{100\text{g}} \right) = \frac{\text{Conc. reading by AAS} \times DF}{10 \times SW}$$

Where: *DF*= Dilution factor, *SW*= Sample weight

2.7. Sensory Evaluation

The sensory attributes of the bulla porridge, such as general appearance, color, taste, odor, texture, and overall acceptability, were evaluated using a nine-point hedonic scale. The scale ranged from 9 (like extremely) to 1 (dislike extremely) for each attribute. Fifteen semi-trained panelists evaluated the sensory attributes following the method outlined by [29].

2.8. Statistical Analysis

The data on physicochemical and sensory attributes were analyzed using SAS (version 9.0) and the SPSS statistical package program (SPSS, Version 22 Inc., Chicago, IL, USA), respectively. Analysis of variance was conducted using one-way ANOVA at a 95% confidence interval. The experiment was designed in a completely randomized design (CRD) with replications.

3. Result and Discussion

3.1. The Physicochemical Properties of Porridge

Table 2 revealed that the results of the determination of the physicochemical properties of moisture, pH, acidity, ash, crude protein and fat values among the seven treatments. The present study shown that there were significant difference ($P < 0.05$) of moisture, acidity, ash, protein and fat except the pH respectively. In terms of moisture content, the overall mean of moisture of bulla porridge was 1.09. The maximum mean score of moisture was 1.65 ± 0.02 % for T1 (control) and the minimum mean score of moisture was (0.54 ± 0.03) % for T6 (25:75) respectively as presented in Table 2. This may be due to the nature of bulla to retain an adequate amount of water. Conversely, the percentage of moisture content is affected by increasing the proportion of whey in the porridge. The present finding in line with the work of [4] reported that the whey protein in the porridge could lower the moisture content due to the agglomeration process. With respect to acidity, the overall mean of acidity was 3.90. The maximum mean of acidity in two treatments were 6.59 ± 0.23 % and 6.59 ± 0.57 % for T2 and T3 and the minimum mean scores of acidity was (1.18 ± 0.23) % for T1 (Control) respectively as shown in Table 2. The value obtained for titratable acidity is generally above the standard, which is 0.7 % [10]. This may be due to the presence of organic acids, which increase acidity. Titratable acidity deals with the measurement of the total acid concentration contained within a food. Regarding the ash content, the overall mean of percentage of ash was 2.42. The maximum mean scores of total ash was 4.65 ± 0.14 % for T3 and the minimum ash content of porridge was 0.33 ± 0.02 % for T1 (control) (Table 2). The result of the

present finding similar with the work of [35] reported that the presence of whey improves the ash content of weaning foods. Ash content is a measure of the total amount of minerals within a food [9]. It may be due to addition of whey may have contributed to the increased total ash. In this study the presence of whey in the porridge was significantly improves the ash content of the porridge. In case of crude protein, the overall mean of protein was 0.89. The maximum mean score of protein was 1.43 ± 0.02 % for T3 and the minimum mean score of protein was 0.43 ± 0.01 % for T1 (control) respectively as shown in Table 2. The result of the present finding is similar with the work of [34] reported that adding whey or skimmed milk powder to fortified bended

foods improves the protein quality. This improvement may be attributed to the higher protein content of the whey. Moreover, the whey-incorporated bulla porridge had better protein content compared to the control. In terms of pH values, the overall mean of pH value of bulla porridge was 4.19. The maximum mean score of pH was 4.33 ± 0.01 for T5 (40:60) and the minimum mean score of pH was 4.07 ± 0.08 for T2 (85:15) respectively as presented in Table 2. The result of the present finding is consistent with the work of [6] who suggested that the minimal decrease in pH could be attributed to the buffering capacity of milk solids. In this study the presence of whey did not have a significant impact on the pH value of the bulla porridge.

Table 2. Mean of proximate composition of bulla porridge.

Trt	MC (%)	pH (%)	TA (%)	Ash (%)	CP (%)
1	1.65 ± 0.02^a	4.24 ± 0.19^{ab}	1.18 ± 0.23^e	0.42 ± 0.02^e	0.43 ± 0.01^g
2	1.43 ± 0.02^b	4.07 ± 0.08^b	6.59 ± 0.23^a	4.54 ± 0.16^a	1.38 ± 0.01^b
3	1.10 ± 0.01^c	4.16 ± 0.09^{ab}	6.59 ± 0.57^a	4.65 ± 0.14^a	1.43 ± 0.02^a
4	1.09 ± 0.04^d	4.27 ± 0.03^{ab}	4.37 ± 0.22^b	2.49 ± 0.15^b	1.02 ± 0.01^c
5	0.97 ± 0.03^e	4.33 ± 0.01^a	3.59 ± 0.63^{bc}	1.30 ± 0.13^d	0.70 ± 0.03^d
6	0.87 ± 0.03^f	4.20 ± 0.06^{ab}	2.74 ± 0.46^{cd}	1.99 ± 0.13^c	0.57 ± 0.03^e
7	0.54 ± 0.03^g	4.09 ± 0.01^b	2.28 ± 0.62^d	1.52 ± 0.13^d	0.50 ± 0.01^f
p	<0.05	0.097	<0.05	<0.05	<0.05

Each value is expressed as mean \pm standard deviation (n=2). Means followed by different letters within column are significantly different at (p<0.05) according to Duncan's Multiple Range Test.; Trt = Treatments MC= Moisture content, TA= Titratable acidity, CP= Crude protein.

3.2. Mineral Composition of Whey Based Bulla Porridge

Figures 5, 6 and 7 revealed that the determination of minerals of whey incorporated bulla porridge were significant difference (P<0.05) of calcium, iron and zinc respectively. With respect to calcium is one of the most significant minerals in the bulla products. It is necessary for bone strength, for the maintenance of the water electrolyte homeostasis, acid-base balance and for muscle and nerve excitation [21]. The overall mean of calcium in whey incorporated bulla porridge was 344.48. The highest mean score of calcium was 530.50 ± 0.71 mg/100 g for T3 (70:30) and the lowest mean score of calcium was 177.60 ± 0.42 mg/100 g respectively as shown in Figure 5. The result of the present finding is similar with the work of [7] which stated that the major ingredient of whey is lactose, with a positive effect on mineral absorption, especially calcium. This may be due to the whey acting as a source of calcium. Even though the availability of calcium in the porridge was

the minimum concentration in the control, the whey may have contributed to increasing the calcium content in the other treatments. In case of iron is important mineral for the production of red blood cell in the body. It is necessary for improve hemoglobin in our body. Considering the availability of iron in the bulla product is satisfactory. The overall mean of iron in the whey incorporated bulla porridge was 14.19. The highest mean score of iron was 24.51 ± 0.01 mg/100 g for T2 (85:15) and the lowest mean score of iron was 9.37 ± 0.02 mg/100 g for T4 (55:45) respectively as shown in Figure 6. The present finding in agreement with the work of [3] reported that whey lactoferrin regulates iron absorption. This may be attributed to the high iron content in whey, particularly lactoferrin, which is an iron-binding glycoprotein in whey. With respect to zinc is important for boosting immunity, regulates blood pressure, nerve and reproductive functions and acts as a cofactor for various enzymes. The overall mean of zinc in whey formulated bulla porridge was 1.11. The highest mean score of zinc was 2.34 ± 0.02 mg/100 g for T2 (85:15) and 0.70 ± 0.01 mg/100 g for T5 (40:60) respectively as shown in Figure 7.

The result of the present finding in agreement with the work of [16], suggesting that whey lactose binds zinc ions in trace amounts. The high zinc content may be due to the presence of lactose, which promotes the absorption of zinc.

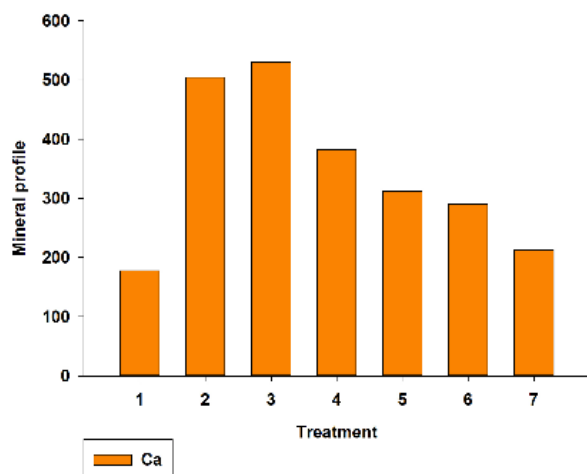


Figure 5. Calcium profile of bulla por-ridge.

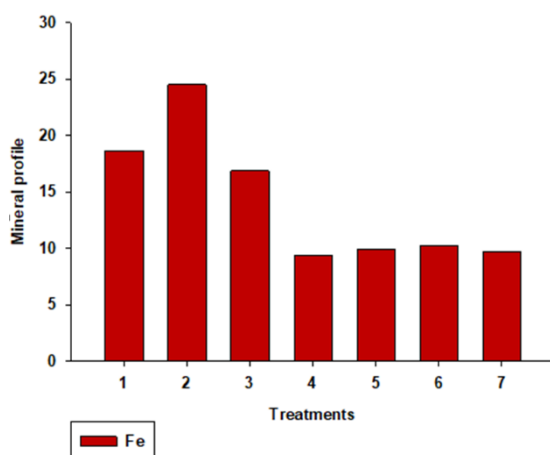


Figure 6. Iron profile of bulla porridge.

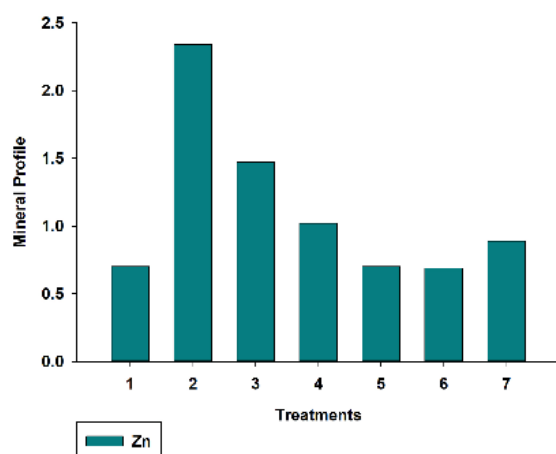


Figure 7. Zinc profile of bulla porridge.

3.3. Sensory Evaluation

Table 3 revealed that the determination of sensory evaluation among the seven treatments with the choice of panelists. In this study there were significant difference ($P < 0.05$) of general appearance, color and overall acceptance except taste, odor and texture with nine point hedonic scale. In case of general appearance the overall mean of general appearance of whey incorporated bulla porridge was 7.68. The highest mean score of appearance in porridge was 8.33 ± 0.89 for T3 (70:30) and the lowest mean score of appearance in porridge was 6.93 ± 1.44 for T1 (control) as presented in Table 3. The result of the present finding in line with the work of [24] reported that whey increases appearance due to its lactose content of the whey. In case of color, the overall mean of porridge incorporated whey was 7.81. The highest mean score of color in porridge was 8.47 ± 0.63 for T3 (70:30) and the lowest mean score of color in porridge without whey was 7.13 ± 1.41 for T1 (control) respectively as shown in Table 3. The result of the present finding is similar with the work of [17], who suggested that casein and rennet casein improved color and sensory scores in tapioca and sorghum flour-based snack food. This may be due to the presence of lactose in the whey. In the present study, the score for color increased significantly with the increase in the level of whey. The color of the bulla porridge improved from less white to deep white as the level of whey increased. Consequently, an increase in the proportion of whey led to good acceptance due to the amplification of the white color of the porridge. With respect to overall acceptability is based on multiple organoleptic quality parameters, including appearance, color, odor, taste, and texture. It represents the cumulative perception and acceptance by the panelists. The overall mean of overall acceptance in porridge incorporated whey was 7.73. The highest mean of overall in porridge with whey was (8.15 ± 0.82) for T3 (70:30) and the lowest mean score in porridge incorporated whey was (7.15 ± 1.01) for T1 (Control) respectively as shown in Table 3. The result of the present finding in agreement with the work of [27], which found whey protein isolate to increase the overall acceptability of sorghum, corn, and defatted soy flour-based extruded products. This may be due to the presence of whey protein increases the acceptance of the porridge. Moreover, it observed that the highest whey incorporation generally improved the acceptance of the porridge. Furthermore, it indicated that bulla porridge cooked with a 70% whey ratio is more acceptable than the rest of the treatments. The taste of whey incorporated porridge was no statistically significant difference ($P > 0.05$) across the treatments. In case of taste, treatment 3 exhibited the highest taste value in porridge of incorporated whey with a mean of (7.87 ± 1.13) as compared with treatment 1 (control) that displayed the lowest taste score with a mean of (6.60 ± 1.68) respectively as shown in Table 3. The present finding is aligned with the work of [13], who suggested that lactose may be used in bakery products to enhance the color or taste of food.

This may be due to the lactose content in the whey. In the present study, the taste of bulla porridge improved with an increasing level of whey percentage. This may be due to the absence of lactose in the bulla paste. Based on odor, the majority of the treatments were rated as moderately satisfactory as mentioned in Table 3. The overall mean of odor in whey supplemented porridge was (7.83). The highest mean of odor in porridge incorporated whey was 8.07 ± 0.79 for T3 (70:30 ratio) and the lowest mean score of odor in porridge incor-

porated whey was 8.07 ± 0.88 for T2 (85:15 ratio) respectively as presented in Table 3. Regarding texture, treatment 4 (55:45) demonstrated the highest texture value in porridge with a mean score of (8.07 ± 0.79) and T7 (10:90) displayed the lowest texture value in porridge incorporated whey with a mean score of (7.40 ± 1.12). The present finding in agreement with the work of [8] reported that whey protein characteristics providing textural benefits that enhance gel properties.

Table 3. The sensory attributes of bulla porridge.

Trt	G. Appearance	Color	Taste	Odor	Texture	Overall
1	6.93+1.44 ^c	7.13+1.41 ^b	6.60+1.68 ^b	7.93+0.70 ^a	7.83+1.09 ^a	7.15+1.01 ^b
2	8.07+0.88 ^{ab}	8.20+0.64 ^a	7.73+1.17 ^a	8.07+0.88 ^a	8.00+0.93 ^a	8.01+0.69 ^a
3	8.33+0.89 ^a	8.47+0.63 ^a	7.87+1.13 ^a	8.07+0.96 ^a	7.87+1.06 ^a	8.15+0.82 ^a
4	8.20+1.15 ^a	7.53+1.51 ^a	7.67+1.29 ^a	7.73+1.53 ^a	8.07+0.79 ^a	8.02+1.01 ^a
5	7.73+1.22 ^{abc}	7.20+1.61 ^{ab}	7.67+1.11 ^a	7.87+0.92 ^a	7.80+0.94 ^a	7.77+0.96 ^{ab}
6	7.33+1.59 ^{abc}	7.53+1.51 ^{ab}	7.87+1.41 ^a	7.73+1.33 ^a	7.93+1.53 ^a	7.62+1.28 ^{ab}
7	7.13+1.68 ^{bc}	7.20+1.61 ^b	7.80+1.01 ^a	7.40+1.12 ^a	7.53+1.19 ^a	7.38+1.07 ^{ab}
P	0.02	0.01	0.10	0.67	0.89	0.04

Mean \pm standard deviation followed with the same letter within a column are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. T1 (100% water), T2 (85% Whey & 15% 0.51 Water), T3 (70% Whey & 30% Water), T4 (55% Whey & 45% Water), T5 (40% Whey & 60% Water), T6 (25% Whey & 75% Water), T7 (10% Whey & 90% Water).

4. Conclusion

The results of the present study revealed that consumers preferred porridge prepared by adding acidic whey compared to porridge prepared using only water in terms of both physicochemical composition and sensory attributes. Although all the treatments had acceptable sensory scores, the addition of whey further improved overall acceptability. The addition of acidic whey also improved the nutritional profile of bulla porridge. Porridge prepared using acidic whey can be used as an alternative nutritious food. Demonstrating the preparation process and informing consumers of the nutritional benefits of this product is encouraged. Enhancing traditional foods with protein-rich ingredients can greatly improve the nutritional value for pregnant women and children.

Abbreviations

AAS	Atomic Absorption Spectrophotometer
AOAC	American of Analytical Chemistry
NaOH	Sodium Hydroxide
CRD	Completed Randomized Design

ANOVA	Analysis of Statistics
SAS	Software of Statistical Analysis
SPSS	Social Science Statistical Package
HCL	Hydrochloric Acid
pH	Concentration of Hydrogen Ion
CP	Crude Protein
CF	Crude Fat

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Author Contributions

Nesru Zeynu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision,

Validation, Visualization, Writing – original draft, Writing – review & editing

Yadesa Abeshu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Visualization, Writing – review & editing

Biadge Kefale: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Validation, Visualization

Data Availability Statement

Data will be available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] AOAC, Official Methods of Analysis, Association of Official Analytical Chemists, 18th Edition. Washington, DC, USA, 114-222, 2005.
- [2] A. Kimhi, “Socio-economic determinants of health and physical fitness in Southern Ethiopia”, *Economics and Human Biology*, 1(1), 55-75, 2003.
[https://doi.org/10.1016/S1570-677X\(02\)00007-2](https://doi.org/10.1016/S1570-677X(02)00007-2)
- [3] C. Sill, R. Biehl, B. Hoffmann, A. Radulescu, MS. Appavou, B. Farago, R. Merkel, and D. Richter, Structure and domain dynamics of human lactoferrin solution and the influence of Fe (III)-ion ligand binding, *BMC Biophys.*, 97, 2016.
<https://doi.org/10.1186/s13628-016-0032-3>
- [4] CS. Luciano Bruno, ZV. Fernanda, AF. Jaime, Physico-Chemical Properties of Milk Whey Protein Agglomerates for Use in Oral Nutritional Therapy. *Food and Nutrition Sciences*, 4, 69-78, 2013.
<https://doi.org/10.4236/fns.2013.49A2010>
- [5] DC. Garner, P. Crisosto, G. Wiley and Crisosto, Measurement of pH and titratable acidity. Available by Kearney Agricultural Center files/Guidelines/quality, 2005.
[http://www.uckac.edu/postharv/PDF%](http://www.uckac.edu/postharv/PDF%20files/Guidelines/quality)
- [6] D. Errak and O. Tulay, Effects of various whey proteins on the physicochemical and textural properties of set type nonfat yoghurt. *Journal of Dairy Technology*, 67, 495-503, 2014.
<https://doi.org/10.1111/1471-0307.12142>
- [7] EV. Lifrah, JA. Hourigan, RW. J. Sleight, New Wheys for Lactose. *Food Australia*, 52: 120-125, 2000.
- [8] F. Alavi, Z. Emam-Djomeh, MS. Yarmand, M. Salami, S. Momen and AA. Moosavi-Movahedi, Cold gelation of curcumin loaded whey protein aggregates mixed with k-carrageenan: Impact of gel microstructure on the gastrointestinal fate of curcumin. *Food Hydrocolloids*, 85, 267-280, 2018.
<https://doi.org/10.1016/j.foodhyd.2018.07.012>
- [9] FAOSTAT, <http://faostat.fao.org/site/567/DesktopDefault.aspx?lang=en>, 2011.
- [10] FDA, Milk and cream products and yogurt products. Food and Drug Administration Federal Register, 74: 2448, 2009.
<https://doi.org/10.12691/ajfn-6-4-4>
- [11] G. Bylund, Dairy Processing Hand book. Tetra Pak Processing Systems, 2003.
- [12] G. Gupta, D. Prakash, AP. Garg and S. Gupta, Whey proteins: A novel source of bioceuticals. *Middle-East J. Sci. Res.*, 12: 365-375, 2012.
<https://doi.org/10.5829/idosi.mejsr.2012.12.3.64227>
- [13] G. Schaafsma, Lactose and lactose derivatives as bioactive ingredients in human nutrition. *International Dairy Journal*, 18, 458-465, 2008.
- [14] G. Yemata, *Ensete ventricosum*: A Multipurpose Crop against Hunger in Ethiopia. *The scientific world journal*, 643184, 2020.
<https://doi.org/10.1155/2020/6431849>
- [15] IA. Hassan, JM. Basahi, IM. Ismail, and TM. Habeebullah, Spatial Distribution and Temporal Variation in Ambient Ozone and Its Associated NOx in the Atmosphere of Jeddah City, Saudi Arabia. *Aerosol Air Qual. Res.* 13: 1712-1722, 2013. <https://doi.org/10.4209/aaqr.2013.01.0007>
- [16] JG. Zadow, Lactose Hydrolysis: In: Whey and Lactose Processing. Elsevier Applied Science, London, and New York, 157-194, 367-408, 1992.
- [17] JR. Patel, AA. Patel, and AK., Singh, Production of a protein-rich extruded snack base using tapioca starch, sorghum flour and casein. *Journal Food Science Technology*, 53, 71- 87, 2016. <https://doi.org/10.1007/s13197-015-2012-z>
- [18] JS. Borrell, MK. Biswas, M. Goodwin, G. Blomme, T. Schwarzacher, PJS. Heslop-Harrison, P. Wilkin, Enset in Ethiopia: A poorly characterized but resilient starch staple. *Annals of Botany*, 123, 747-766, 2018.
<https://doi.org/10.1093/aob/mcy214>
- [19] JS. Borrell, M. Goodwin, G. Blomme, K. Jacobsen, AM. Wendawek, D. Gashu, E. Lulekal, Z. Asfaw, S. Demissew and P. Wilkin, Enset-based agricultural systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative. *Plants, People, Planet*, 2(3), 212-228., 2020.
<https://doi.org/10.1002/pp3.10084>
- [20] LV. Rowe, OA. Ogden, FM. Pike, Steele, and ML. Dunn, “Effect of end-user preparation methods on the vitamin content of fortified humanitarian food-aid commodities”, *Journal of Food Composition and Analysis*, 22(1), 33-37, 2009.
<https://doi.org/10.1016/j.jfca.2008.09.004>
- [21] M. Atlabachew, and BS. Chandravanshi, Levels of major, minor and trace elements in commercially available enset (*Ensete ventricosum* (Welw.), Cheesman) food products (Kocho and Bulla) in Ethiopia. *Journal of Food Composition and Analysis*, 21(7), 545-552, 2008.
<https://doi.org/10.1016/j.jfca.2008.05.001>

- [22] M. Becerra, ME. Cerdan, MI. Gonzalez-Siso, Biobutanol from cheese whey. *Microbial Cell Factories*, 14(1), 27-41, 2015. <https://doi.org/10.1186/s12934-015-0200-1>
- [23] ME. Bertrand and SL. Turgeon, Improved gelling properties of whey protein isolate by addition of xanthan gum. *Food Hydrocolloid* 21(2): 159-166, 2007.
- [24] ME. Norhaizan and AW. Nor Faizadatul, Determination of Phytate, Iron, Zinc, Calcium Contents and Their Molar Ratios in Commonly Consumed Raw and Prepared Food in Malaysia. *Malaysia Journal Nutrition*, 15(2): 213 – 222, 2009. <https://www.researchgate.net/publication/225300331>
- [25] MT. Yirmaga, Improving the Indigenous Processing of *Kocho*, an Ethiopian Traditional Fermented Food. *J Nutr. Food Sci* 3: 182., 2013. <https://doi.org/10.4172/2155-9600.1000182>
- [26] M. Sady, G. Jaworska, T. Grega, E. Bernas and J. Domagal, Application of Acid Whey in Orange Drink Production. *Food Technol. Biotechnol*, 51(2), 266–277, 2013.
- [27] NL. Devi, S. Shobha, X. Tang, SA. Shaur, Development of protein-rich sorghum-based expanded snacks using extrusion technology. *Int. J. Food Prop.*, 16, 263– 227, 2013. <https://doi.org/10.1080/10942912.2011.551865>
- [28] RM. Silviya, KD Bhumika, SC Parmar and KD. Aparnathi, Whey and its Utilization. *Int. J. Curr. Microbiol. App. Sci.* 5(8): 134-155, 2016. <https://doi.org/10.20546/ijcmas.2016.508.016>
- [29] Stone and Sidel. 2004: Sensory evaluation practices. Academic press, Florida (2004). <https://doi.org/10.1016/B978-012672690-9/50005-6>
- [30] VG. Chandrajith and GA. Karunasena, Applications of Whey as A Valuable Ingredient in Food Industry. *Dairy and Vet Sci J*, 6(5): 555698, 2018. <https://doi.org/10.19080/JDVS.2018.06.555698>
- [31] Y. Abebe, A. Bogale, KM. Hambidge, BJ. Stoecker, K. Bailey, & RS. Gibson, Phytate, zinc, iron and calcium content of selected raw and prepared foods consumed in rural Sidama, Southern Ethiopia, and implications for bioavailability. *Journal of Food Composition and Analysis*, 20(3–4), 161–168, 2007. <https://doi.org/10.1016/j.jfca.2006.09.003>
- [32] FA. Getaneh, SF. Forsido, BT. Yetenayet, AA. Addisu, AT. Minbale, A. Endale Traditional Food Processing Practices Of Oats (*Avena Sativa*) And Its Contribution To Food Security In Gozamin District Of Northwest Ethiopia. *Afr. J. Food Agric. Nutr. Dev.*, 21(5), 18083-18100, 2021. <https://doi.org/10.18697/ajfand.100.19810>
- [33] O. Ekpa, N. Palacios-Rojas, G. Kruseman, V. Fogliano, AR. Linnemann, Sub-Saharan African Maize-Based Foods - Processing Practices, Challenges and Opportunities. *Food Reviews International*, 35(7), 609–639, 2019. <https://doi.org/10.1080/87559129.2019.1588290>
- [34] H., Camilla, S. A. Gregers, J., Stine, M., Christian (2008). The Use of Whey or Skimmed Milk Powder in Fortified Blended Foods for Vulnerable Groups. *Journal of Nutrition* 138(1): 145S-161S. <https://doi.org/10.1093/jn/138.1.145S>
- [35] H., Mahadevaiah, M., Jayaprakasha and K. B. Suresha (2018). Optimization of (Ragi) finger millet and whey protein concentrate level in weaning food. *THE ASIAN JOURNAL OF ANIMAL SCIENCE*, 13(1) | 31-36. <https://doi.org/10.15740/HAS/TAJAS/13.1/31-36>