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Analysis of Nutritional Composition and Sensory Evaluation of Sorghum Tacos Incorporated with Cassava

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Abstract

The Nahuatl term 'tlahco' means "half or in the middle," which refers to the way tacos aremade. The taco is a delicious and historic component of Mexico's cultural and culinary variety. Sorghum is a tropical grass that is usually grown in semi-arid climates. Sorghum is a good source of phenolic compounds, including phenolic acids, flavonoids, and condensed tannins. Cassava usage in taco shells as a binding agent to reduce breakage. The developed gluten-free sorghum tacos incorporated with cassava are very rich in protein and calcium (31.2g/100g and 34.9g/100g). It can be recommended for celiac patients.

***Key words*:** Sorghum, Cassava, Tacos, Gluten free

Tacos are becoming an essential source of nourishment for the majority of the people. Tacos are typically produced from corn and cooked in an alkaline environment (nixtamalization). After wheat, rice, maize, and barley, sorghum (*Sorghum bicolor* (L.) Moench) is the world's fifth most important crop. It's widely grown in Asia, Africa, and other semi-arid areas. Sorghum comes in a variety of types, each of which is used for a different purpose. Sorghum is drought-tolerant, it can be used as a partial or total substitute for corn in the preparation of tortillas in areas with minimal rainfall. Maicillos are the name for these sorghums. These maicillos have boosted their yield potential, and resilience to diseases and pests, and decreased their height through introgression utilizing external genetic elements. They are also tannin-free, which prevents nutritional value loss [9].

Need and significance of the study

Sorghum contains various phenolic and antioxidant compounds that could have health benefits, making the grain suitable for developing functional foods and other applications.It makes it an exceptional snack or it can also be eaten as a healthy wholesome breakfast. Sorghum is a gluten-free grain that is tolerated by celiac disease patients and offers gluten-free food industry potential.so there is a significant opportunity to develop innovative products using sorghum flour [9].

There is no previous scientific research on sorghum flour and cassava usage in taco shells.Hence, this study aims to provide nutritionally enriched simple ready-to-eat food that can be consumed even by low-income people too. Using cassava as a binding agent to reduce the breakage. When compared to a gluten-free wrap already on the market, the sorghum flour and cassava taco shell made in this study scored significantly higher in all attributes, including overall acceptability.

Objectives of the study

To formulate sorghum millet tacos based as gluten-free food and analyze in triplicate value for its physical properties, nutrient composition, storage stability, microbial analysis, sensory evaluation, and cost calculation of the tacos.

MATERIALS AND METHODS

This research design's framework aids in the easy comprehension of the study work's processing and analysis. This study is set up as an experiment. The research design is depicted inpictorial form in the diagram below:

The methodology referring to the study entitled "Analysis of nutritional composition and sensory evaluation of sorghum tacos incorporated with cassava" is discussed under the following phase.

Selection and procurement of raw materials

The raw materials like Sorghum, Cassava flour, Oil, Salt were procured from the local market of Chennai, Tamil

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Nadu, India. The (Table 1) depicts the various proportions taken for the control group and sample group. The control sample consists solely of 100 g of sorghum flour with no oil or salt added. Sample S1, S2, and S3 progressively reduce the amount of sorghum flour while increasing the cassava flour content. Additionally, each of these samples includes a constant amount of oil (2 ml) and salt (2 g), which are absent in the control sample.

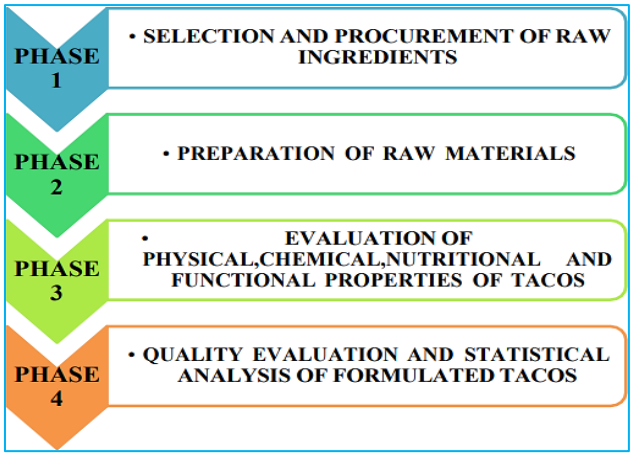

Fig 2 Phases of the study

Fig 3 Preparation of sorghum flour

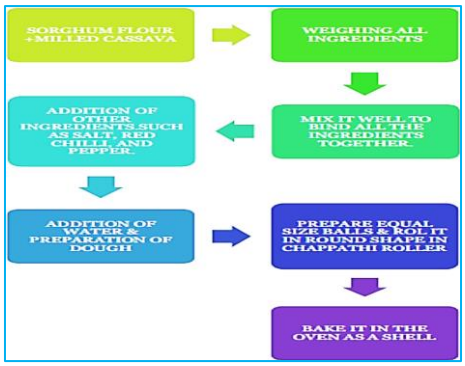

Fig 4 Formulation and standardization of Tacos

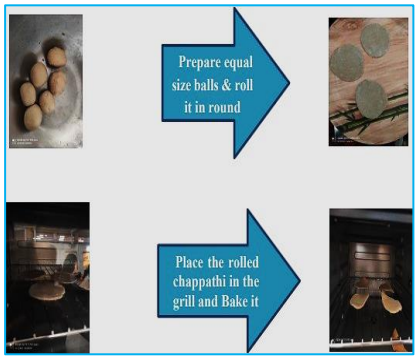

Fig 5-6 Formulated tacos

Table 1 Variation table

Ingredients (Gm/Ml)	Control	Sample S1	Sample S2	Sample S3
Sorghum flour	100	75	50	25
Cassava flour	-	25	50	75
Oil	-	2	2	2
Salt	-	2	2	2

RESULTS AND DISCUSSION

The development of gluten-free sorghum tacos incorporated with cassava is investigated. Quality features such as physical qualities, proximate principles, and microbiological safety were assessed when gluten-free sorghum tacos incorporated with cassava were made. The nutritional composition, sensory evaluation, Phytochemical, antioxidant analysis, and shelf life of Sorghum tacos with Cassava were all evaluated.

Table 2 Mean acceptability and standard deviation scores of Tacos

Treatments	Appearance	Color	Taste	Texture	Flavor	Overall acceptability
Control	7.53±0.30	7.33±0.48	7.82±0.50	7.45±0.41	7.52±0.45	7.32±0.48
Sample 1 (S1)	8.25±0.22	8.27±0.41	8.42±0.37	8.13±0.34	8.0±0	8.49±0.17
Sample 2 (S2)	7.3±0.72	7.12±0.25	7.02±0.51	7.33±0.53	7.22±0.22	7. 33±0.61
Sample 3 (S3)	7.0±0	7.04±0.32	7.22±0.44	7.09±0.30	7.19±0.84	7.17±0.48

*The values obtained are triplicate mean ± SDNOTE: Mean ± Standard deviation

Inference: 9- Extremely good; 8- very good; 7-Good;

Control – 100% of Sorghum flour;

Sample 1- 75% sorghum flour and 25% cassava flour.

Sample 2 – 50% sorghum flour and 50% cassava flour;

Sample 3 – 25% sorghum flour and 30% cassava flour

Organoleptic evaluation of the formulated products

The tacos were made in varied amounts and tasted to see how they tasted. The untrained 20 panelists used a '9-point Hedonic Rating Scale' to assess the tacos' organoleptic quality. The different aspects examined for organoleptic evaluation are appearance, color, taste, texture, flavor, and overall acceptability. The mean organoleptic evaluation scores are shown in (Table 2).

Physico-chemical properties of raw materials

Physical qualities such as thousand-grain weight, thousand-grain volume, hydration capacity, hydration index, and water and oil absorption capacity are crucial for nutrition, consumer acceptance, processing, and storage time. The mean scores of the Physicochemical Properties of Sorghum Grain are shown in (Table 3).

Table 3 Physico-chemical properties of sorghum grain

Physical and chemical properties	Sorghum grain
Thousand-grain weight (g)	33.7±0.45
Thousand-grain volume (ml)	41.2±0.33
Hydration capacity (g)	0.49±0.46
Hydration index (%)	0.55±0.05

*The values obtained are triplicate mean ± SD

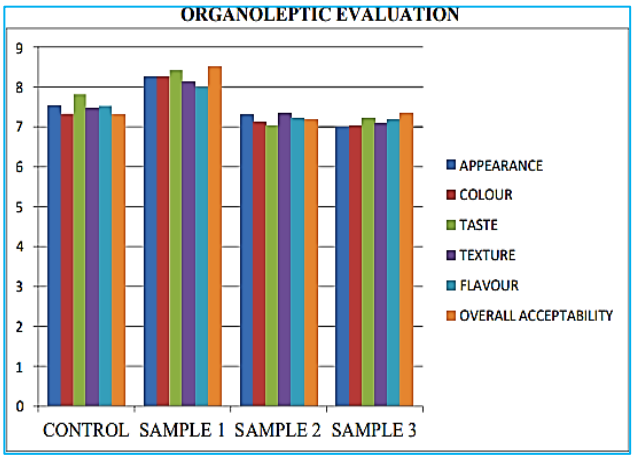

Fig 7 Organoleptic mean score of control and sample Tacos

Thousand-grain weight - The method for estimating thousand-grain weight and volume was adapted from [8], Thousand-grain volume - As the moisture level grew, the weightof a thousand grains was increased [8].

Hydration Capacity and Hydration Index - The hydration capacity of sorghum grain was found to be 0.49±0.46 which was higher than the value observed. The percentage of water absorbed by grains immersed in water is referred to as the hydration index [6] proposed a formula for calculating the hydration index.

Physico-chemical properties of the sample Tacos

Diameter of the Tacos

The electronic weighing equipment was used to determine the weight of the tacos. The weight of the sample 1 tacos was found to be 6.39±0.25gm, with sample 1 consisting of 75% sorghum flour and 25% cassava flour.

Thickness of the Tacos

The tacos' height was measured using a device known as a vernier caliper. Sample 1, which is made out of 75% sorghum flour and 25% of cassava flour, measures 1.6±0.01cm.

Water and oil absorption capacity of tacos

Water Absorption Capacity (also known as Water Hydration or Water Absorption) is a product that allows you to absorb water. OAC has an impact on flavour, texture, mouthfeel, and yield [4]. (Table 4), depicts the water and oil absorption capacity of Tacos.

Table 4 Water and oil absorption capacity of Tacos

Physico-chemical properties	Tacos
Water absorption capacity	2.81±0.07
Oil absorption capacity	0.92±0.03

pH of Tacos

The pH of the sample 1 taco was found to be **6.47±0.05** in 1% solution, with sample 1 consisting of 75% sorghum flour and 25% cassava flour.

Color analysis of tacos

The color of the sample 1 taco is shown in the (Table 5).

Table 5 Colour analysis

Name of the samples	Colour coding			
	Parameters			
	L* Lightness/ Luminance	a* Red/Green value	b* Blue/Yellow value	dE* Delta-E
White Tile	94.39	-2.00	3.70	34.54
Sample 1(S1)	68.3±1.3	2.5±0.4	23.85±0.3	30.8±1.3
Control	63.33±0.5	1.2±0.2	18.5±1.2	28.25±0.2

*Average ± mean of duplicates

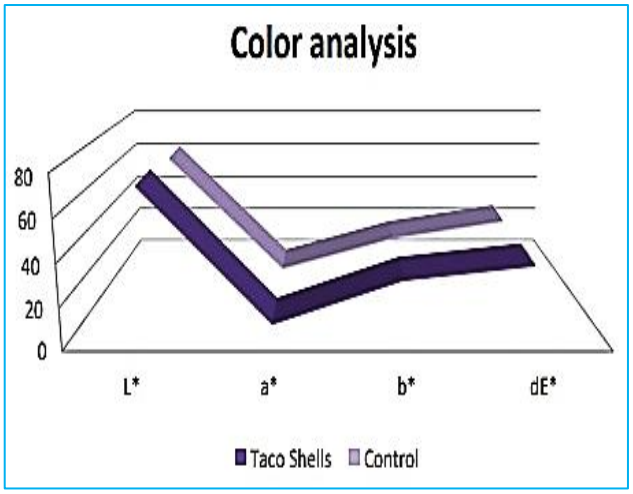

Fig 9 Color analysis of tacos

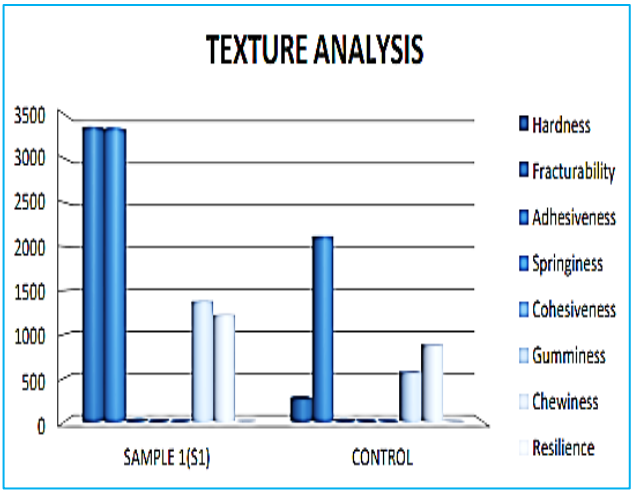

Fig 10 Texture analysis of tacos

Texture analysis of Tacos

The parameters like Hardness, Fracturability, Adhesiveness, Springiness, Cohesiveness, Gumminess, Chewiness, and Resilience were analysed for texture Analysis of the sample taco was shown in (Table 6).

Table 6 Texture analysis of tacos

Name of the samples	Sample 1(S1)	Control
Hardness	3556.5 ± 690.7	265.23 ± 38.56
Fracturability	3343.35 ± 138.9	2123.21 ± 144.6
Adhesiveness	-12.317 ± 0	9.8 ± 1.21
Springiness	0.885 ± 0.04	0.128 ± 0.07
Cohesiveness	0.39 ± 0.04	0.31 ± 0.04
Gumminess	1378.7 ± 274.8	564.8 ± 123.4
Chewiness	1221.7 ± 254.1	879.42 ± 234.5
Resilience	0.58 ± 0.03	0.32 ± 0.02

*Average ± mean of duplicates

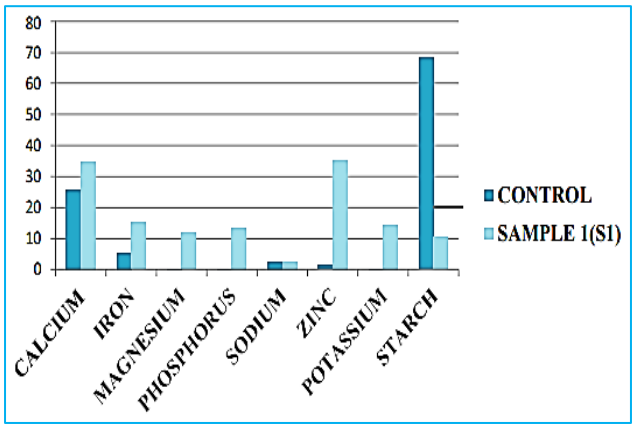

Fig 11 Nutritional composition of micro minerals in tacos

Proximate composition

The quantitative measurement of macromolecules in food is referred to as proximate analysis. Protein, fat, moisture, ash, and carbs contents are determined using a mixture of techniques such as extraction, Kjeldahl, and NIR. The nutritional composition of macronutrients in gluten-free sorghum tacos incorporated with cassava is shown in (Table 7).

Table 7 Nutritional composition of macronutrients in gluten-free sorghum tacosincorporated with cassava

Macro nutrients	Control	Sample
Energy (kcal)	128.7±0.88	168.5±0.05
Protein (g)	12.3±0.20	31.2±0.03
Fat (g)	2.2±0.35	3.4±0.01
Carbohydrate (g)	1.2± 0.30	3.3±0.22
Fibre (g)	9.6±0.17	2.9±±0.02
Ash (% W/W)	2.0±0.45	1.4±0.03

*Average ± mean of duplicates

The control tacos had an energy content of 128.7 kcals/gm, which was lower than the sample 1 tacos prepared with 75 percent sorghum flour (168.5 kcals/gm). The protein level of extremely acceptable sample 1 (75 percent sorghum flour and 25% cassava flour) was determined to be 31.2gm/100gm. The ash content of the sample 1 tacos was 1.4±0.03gm/100g. A study done by [10] reveals that the ash content of the sorghum was 4.09gm/100gm. while sample 1 tacos had a moisture content of 1.5±0.01gm/100gm.

Table 8 Nutritional composition of Micro nutrients in gluten-free sorghum tacos incorporated with cassava

Micro nutrients	Control	Sample (S1)
Calcium	25.8±3.11	34.9±4.80
Iron	5.4±2.24	15.1±0.33
Magnesium	0.08±0.02	11.8±3.25
Phosphorus	0.05±0.01	13.4±0.40
Sodium	2.5±0.65	2.44±0.22
Zinc	1.2±0.08	35.47±1.55
Potassium	0.2±0.13	14.3±1.25
Strach	68.2±2.18	10.44±0.42

*Average ± mean of duplicates

The Nutritional Composition of Micronutrients in Gluten-Free Sorghum Tacos incorporated with Cassava is shown in (Table 8).

The sample 1 tacos which were prepared with 75 percent sorghum flour had (34.9±4.80gm/100gm) of calcium and (15.1±0.33gm/100gm) of iron. The starch content of the control tacos was 68.2±2.18gm/100gm, which was higher than the starch content of the sample 1tacos made with 75 percent sorghum flour (10.44±0.42gm/100gm). The starch content of Sample1 was found to be lower than that of the control tacos. This could be due to the sorghum flour being used (75 percent). The starch content of sorghum was found to be 53.5gms/100g whichwas reviewed by [2].

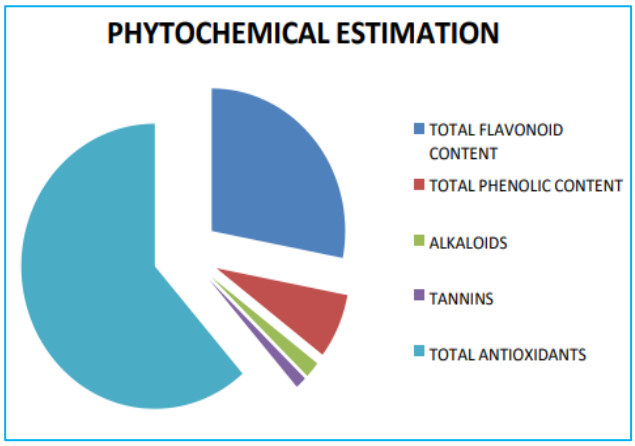

Fig 12 Estimation of phytochemical and antioxidant activity in tacos

Phytochemical and antioxidant estimation

The Parameters like Total flavonoid content, Total phenolic content, Alkaloids, Tannins, and Total antioxidants were estimated for Phytochemical and antioxidant activity, and the values are shown in (Table 9).

Table 9 Estimation of phytochemical and antioxidants activity

Phytochemicals	Content (Mg)
Total flavonoid content	20.33
Total phenolic content	5.33
Alkaloids	1.34
Tannins	0.98
Total antioxidants	44.55

Microbial analysis

The total bacterial count (TBC) is the amount of bacterial colony-forming units per gram found in a food sample. TBC is a measure of food sample hygiene and handling. Yeasts are eukaryotic organisms that belong to the fungus family of organisms, which also includes molds. The

Estimated values of Total Bacterial Count and Total Yeast and Mold count are shown in (Table 10).

Table 10 Estimation of microbial analysis

Microbial Tests	Count
Total bacterial count	1×10^4
Total yeast and mold count	1×10^4

Shelf-life analysis

In shelf -life analysis, the sample is examined for 60 days and analyzed for Total Bacterial count and Total Yeast and mold count are recorded on the 1st, 15th, 30th, 45th, and 60th day. (Table 11) shows the shelf-life Analysis estimation.

Storage studies

The sample was stored and examined in 3 different types of packaging material – LDPE Zip Lock bag, Aluminium box, Air Tight Box over 60 days. In all the 3 packaging materials until the 30th day, it showed no changes in color, flavor, and appearance and no visible microbial growth.

During the 45th-day and 60th-day observations, it showed changes in color, flavor, texture, and appearance. (Table 12), depicts the storage studies of sample tacos in LDPE Ziplock bag, Aluminium box, and Airtight Containers over 60 days.

Table 11 Estimation shelf- life analysis

Days	Bacterial count * 10^4	Yeast or mold count
1st	1	0
15th	1.7	0
30th	3	0
45th	4	0
60th	6	0

Table 12 Storage studies of tacos

Packaging day	LDPE zip lock bag	Aluminum box	Air tight box
1st Day	No visible changes in the flavor, texture or appearance of the tacos.	No visible changes in the flavor, texture or appearance of the tacos.	No visible changes in the flavor, texture or appearance of the tacos.
15th Day	No visible changes in the texture, flavor and appearance of the tacos.	No visible changes in the flavor, texture or appearance of the tacos.	No visible changes in the flavor, texture or appearance of the Tacos.
30th Day	No Changes in texture of the sample. No change in flavor or appearance. No visible microbial growth on the tacos	No changes in texture of the gummies. No visible microbial growth on the tacos.	No changes in texture of the sample. No change in flavor or appearance. No visible microbial growth on the tacos.
45th Day	Changes in texture of the tacos. Changes in flavor, change in appearance. No visible microbial growth on the tacos.	No visible microbial growth on the tacos. No Change in texture.	Changes in texture of the sample. changes in flavor or appearance. No visible microbial growth on the tacos.
60th day	Changes in texture of the tacos. Changes in flavor, change	Visible changes of texture and appearance. No visible microbial growth on the tacos	Changes in texture of the sample. changes in flavor or appearance. No visible microbial growth on the tacos.

Statistical analysis

Student's t-test (t-test), analysis of variance (ANOVA), and analysis of covariance (ANCOVA) are statistical methods used in the testing of hypotheses for comparison of means between the groups. The Student's t-test is used to compare the means between two groups, whereas ANOVA is used to compare the means among three or more groups [5].

The (Table 14) depicts the statistical analysis for the sensory evaluation of tacos. The sensory evaluation shows that Sample 1 (S1) significantly outperforms the control in appearance, color, texture, flavor, and overall acceptability, but not in taste, where there is no significant difference. This suggests that Sample 1 is generally preferred over the control based on these organoleptic attributes.

Sensory evaluation

Table 14 Statistical analysis for sensory evaluation of Tacos

Organoleptic evaluation	Values (Mean / SD)	t Test ($\alpha = 0.05\%$)	Hypothesis rejection (H0) / acceptance (H1)
Appearance Control	7.53±0.30	1	Rejection (H0)
Sample 1 (S1)	8.25±0.22		
Color Control	7.33±0.48	0.64	Rejection (H0)
Sample 1(S1)	8.27±0.41		
Taste Control	7.82±0.50	0.0002	Acceptance (H1)
Sample 1(S1)	8.42±0.37		
Texture Control	7.45±0.41	0.35	Rejection (H0)
Sample 1(S1)	8.13±0.34		
Flavor Control	7.52±0.45	0.65	Rejection (H0)

Sample 1(S1)	8.0±0		
Overall acceptability Control	7.32±0.48	0.28	Rejection (H0)
Sample 1(S1)	8.49±0.17		

*t Value of Organoleptic evaluation ≤ is significant i.e. (Acceptance)
*t Value of Organoleptic evaluation ≥ is non-significant i.e. (Rejection)

Table 15 Statistical analysis of macro nutrients of tacos

Nutrients	Control	Sample 1 (S1)	t Value	P Value (α = 0.05)	Hypothesis Rejection (H0) / Acceptance (H1)
Energy (Kcal)	128.7±0.88	168.5±0.05	618.8	0.00002	Rejection
Protein (g)	12.3±0.20	31.2±0.03	312.8	0.00006	Rejection
Fat (g)	2.2±0.35	3.4±0.01	6.023	0.07012	Acceptance
Carbohydrate (g)	1.2±0.30	3.3±0.22	12.8	0.02232	Rejection
Fiber (g)	9.6±0.17	2.9±0.02	63.34	0.0014	Rejection
Ash (% W/W)	2.0±0.45	1.4±0.03	5.4	0.0808	Acceptance
Moisture (% W/W)	0.1±0.04	1.5±0.01	7.58	0.0512	Acceptance

*t Value of proximate analysis ≤ is significant i.e. (Acceptance)
*t Value of proximate analysis ≥ is non-significant i.e. (Rejection)
*Critical value = 7.7086

Table 15 Statistical analysis of macro nutrients of tacos

Micro nutrients	Control	Sample 1 (S1)	t Value	P Value (α = 0.05)	Hypothesis Rejection (H0) / Acceptance (H1)
Calcium	25.8±3.11	34.9±4.80	93.59	0.00063	Rejection
Iron	5.4±2.24	15.1±0.33	113.18	0.00044	Rejection
Magnesium	0.08±0.02	11.8±3.25	244.53	0.00009	Rejection
Phosphorus	0.05±0.01	13.4±0.40	336.77	0.00004	Rejection
Sodium	2.5±0.65	2.44±0.22	0.1405	0.72675	Acceptance
Zinc	1.2±0.08	35.47±1.55	1076.71	0.000005	Rejection
Potassium	0.2±0.13	14.3±1.25	315.26	0.000059	Rejection
Starch	68.2±2.18	10.44±0.42	6859.82	0.00000001	Rejection

*t Value of proximate analysis ≥is significant i.e. (Acceptance)
*t Value of proximate analysis ≤ is non-significant i.e. (Rejection)
*Critical value = 7.7086

Proximate analysis

The data depicted in (Table 15) shows the Statistical Analysis of the Macro Nutrients of Tacos, the table includes values for energy, protein, fat, carbohydrate, fiber, ash, and moisture. It evaluates the significance of differences between the control and S1 based on t values and p values, with a significance level (α) of 0.05. Hypotheses are tested, resulting in either rejection (H0) or acceptance (H1) based on whether the t value exceeds the critical value of 7.7086 and (Table 16), shows the Statistical Analysis of the Micro Nutrients of tacos. Tacos are becoming an essential source of nourishment for many people. Typically produced from corn and cooked in an alkaline environment through nixtamalization, tacos benefit from enhanced nutritional profiles. Sorghum (*Sorghum bicolor* (L.) Moench), the world's fifth most important crop after wheat, rice, maize, and barley, highlights the global significance of grains in human nutrition. The analysis shows significant increases in most micronutrients (calcium, iron, magnesium, phosphorus, zinc, and potassium) in Sample 1 compared to the control. The sodium content shows no significant difference, and starch content significantly decreases. These findings highlight the potential nutritional benefits of the enhanced taco formulation in Sample 1.

CONCLUSION

The present study concluded that developed gluten-free sorghum tacos incorporated with cassava contain a bunch of nutrients. The developed product is very rich in protein and calcium. It is considered microbially safe for consumption. It can be recommended for celiac patients. The antioxidant content of the tacos is generally high when compared to other tacos. Hence, it is concluded that the gluten-free sorghum tacos incorporated with cassava provide a scrumptious taste and have proven to be highly nutritious.

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