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Development of Instant Mix with Sprouted Millets for Alleviation of Obesity and Promotion of Health among Adolescents

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Abstract: The rising prevalence of adolescent obesity poses significant health risks, necessitating innovative dietary interventions. This study aimed to develop and evaluate a sprouted millet-based instant mix to alleviate obesity and promote health among adolescents aged 13–19 years. The intervention involved formulating a nutrient-dense instant mix, standardizing its composition, conducting sensory evaluation, and assessing its efficacy through a 3-month supplementation trial with 60 obese adolescents (30 boys, 30 girls). Evaluation was carried out by taking Anthropometric measurements. Nutrient profile as well as microbial analysis were performed to see the efficacy of mix. Results demonstrated significant reductions in body weight and BMI, improved nutritional status and high sensory acceptability. Microbial analysis confirmed the mix's stability for three months. The sprouted millet-based instant mix offers a culturally relevant, effective and sustainable solution to address adolescent obesity.

Keywords: Sprouted millets, adolescent obesity, instant mix, health promotion, sensory evaluation, microbial analysis, anthropometric assessment.

Introduction

Adolescence, spanning approximately ages 10 to 19, is a critical period of physical, emotional and psychological development. Rapid growth during this phase makes dietary patterns pivotal for long-term health. The global surge in adolescent obesity, driven by poor dietary choices and sedentary lifestyles, increases risks of chronic conditions such as type 2 diabetes, cardiovascular diseases, and psychological disorders. In the United States, obesity is the second leading preventable cause of death, distinct from being overweight, as defined by body mass index (BMI) thresholds (American Heart Association, 2005).

Millets, including finger millet (ragi), sorghum (jowar) and pearl millet (bajra) are nutrient-rich grains with high dietary fiber, essential amino acids and minerals. A low glycemic index making them ideal for metabolic health. Sprouting enhances their digestibility and nutrient bioavailability, positioning them as a promising ingredient for combating obesity and malnutrition. Specific qualities of the ingredients are amazing in reducing weight and promoting health. Finger millet

or ragi is exceptionally high in dietary fiber, resistant starch, minerals (notably calcium, iron, and magnesium) and essential amino acids. Sorghum is a gluten-free grain rich in both insoluble and soluble fiber, along with beneficial phytochemicals such as polyphenols and tannins that slow carbohydrate digestion.Pearl millet is a nutrient-dense, gluten-free grain full of protein, fiber, iron, magnesium and antioxidants. Green gram is a legume rich in plant protein and dietary fiber. Sago primarily contributes quick digesting carbohydrates, offering immediate energy. Though low in fiber, the small amount helps maintain taste and caloric balance when counterbalanced with fiber dense millets and legumes. Barley is a whole grain rich in soluble β-glucan fiber which slows digestion, boosts satiety, lowers cholesterol and dampens blood sugar spikes-a powerful trio for weight control.Cumin seeds are rich in antioxidants and contain bioactive peptides with antimicrobial, anti-inflammatory and hypoglycemic properties. Carom Seeds (Ajwain) is traditionally valued for digestive benefits; it alleviates bloating and indigestion, improves metabolic rate and supports comfortable fat metabolism. Dry ginger has thermogenic effects that boost metabolism and marginally increase energy expenditure. Black pepper contains piperine, a compound known to enhance digestion and nutrient absorption, with mild thermogenic properties that may slightly elevate metabolic rate. Salt ensures electrolyte and mineral balance, essential for physiological function. With all these wonderful ingredients, the present study developed a convenient sprouted millet-based instant mix to address adolescent obesity by evaluating its nutritional content, sensory acceptability, microbial safety and efficacy in reducing BMI.

Objectives

1. Assessment of obesity for screening the subjects.
2. Standardization of the instant mix to finalize ingredient proportions.
3. Organizing sensory evaluation to test its acceptability.
4. Administration of standardized mix to selected adolescents.
5. Calculation of nutritive values of the mix.
6. Assessing the shelf life through microbial analysis.

Materials and Methods

Sample Selection

Sixty obese adolescents (30 boys and 30 girls) aged 13–19 years with BMI above the 85th percentile were selected via purposive sampling from Guntur and Vijayawada cities. Baseline anthropometric measurements (height, weight) were taken to assess BMI.

Formulation and Standardization of the Instant Mix

The instant mix was formulated using the following ingredients and standardized proportions per 100g serving:

- Ragi (finger millet): 30g
- Jowar (sorghum): 15g
- Bajra (pearl millet): 15g
- Green gram: 10g
- Sago: 10g
- Barley: 10g
- Cumin seeds: 5g
- Carom seeds: 2g
- Dry ginger: 2g
- Pepper: 1g
- Salt: as required

Procedure: Ingredients were cleaned. Ragi (finger millet), Jowar (sorghum), Bajra (pearl millet) and Green gram were soaked for 24hours and then sprouted for another 48hours and then sun-dried and grounded into a fine powder. Then it was subjected to standardization procedure to get the appropriate composition in the mix by involving trial-and-error adjustments. And finally sensory evaluation was done to measure its acceptability levels.

Supplementation

Participants have consumed 30g of the instant mix daily in the form of porridge in the morning, after breakfast. The supplementation period was from January 1, 2024 to March 31st, 2024 (3 months).

Data Collection

Anthropometric Measurements: Height, weight, BMI before and after supplementation.

Nutritional Analysis

The nutritional composition per 100g of the instant mix was:

- Energy: 310.4 kcal
- Carbohydrates: 60.6 g
- Protein: 10.2 g
- Fat: 3.2 g
- Fiber: 3.37 g
- Calcium: 240.8 mg
- Iron: 4.52 mg
- Vitamin A: 92.8 µg
- Thiamine: 0.45 mg
- Vitamin C: 2.2 mg

Sensory Evaluation

Sensory evaluation was conducted using a 9-point hedonic scale to assess taste, texture, aroma and overall acceptability among adolescents.

Microbial Shelf-Life Analysis

Total Plate Count (TPC) was measured over three months (0, 30, 60 and 90 days) to ensure microbial safety.

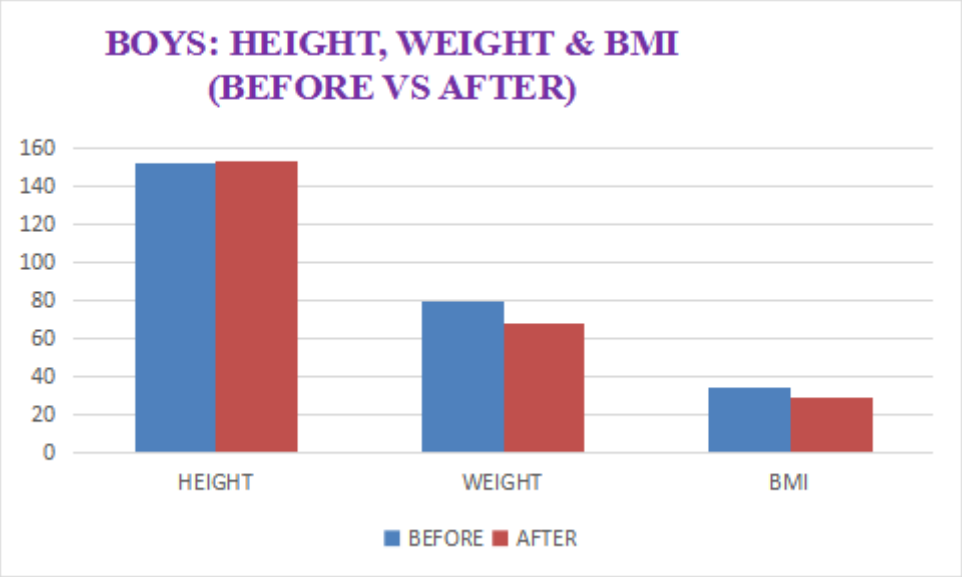
Statistical Analysis

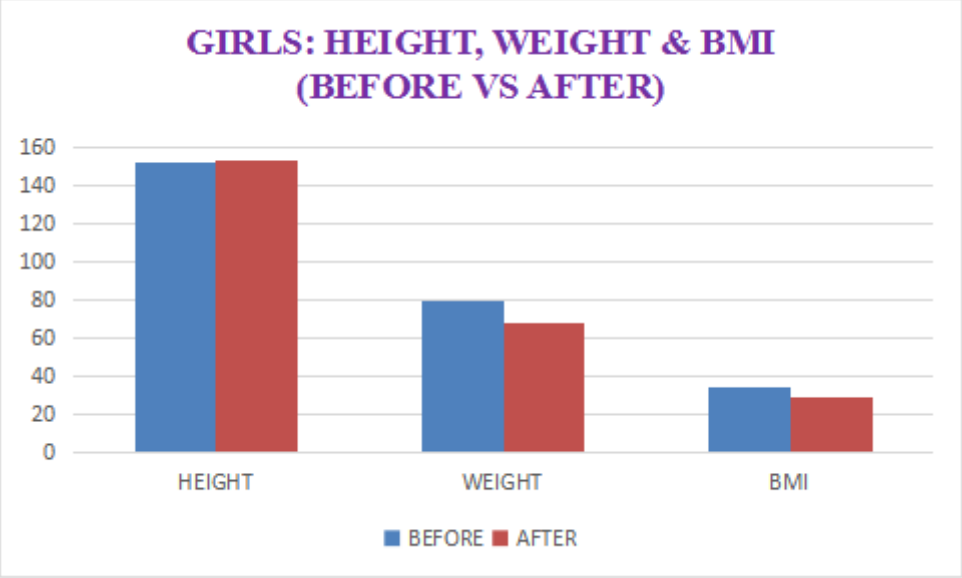
Anthropometric changes were analyzed using ANOVA as well as paired t-test to determine the significance of differences before and after supplementation ($p < 0.05$).

Results and Discussion

60 participants were selected according within the age group of 13–19 years. Care has been taken to see that equal number of boys and girls were included in each group.

Parameter	**BOYS**		**ANOVA**	**GIRLS**		**ANOVA**
	Before	**After**		**Before**	**After**	
Height	155.43± 5.12	156.28±5.41	0.00011	152.16± 4.88	153.03± 5.06	0.00009
Weight	82.47± 10.37	71.65 ± 9.88	0.01745	78.92 ± 11.23	67.43 ± 8.95	0.01821
BMI	34.25 ± 1.32	29.39 ± 1.17	0.01376	33.98 ± 1.44	28.68 ± 1.26	0.01287





Paired T-Test Results

Parameter	Group	Df	t-statistic	p-value	Significance
Height	Boys	29	-0.979	0.3358	Not Significant
	Girls	29	-0.554	0.5837	Not Significant
Weight	Boys	29	4.188	0.00024	Significant
	Girls	29	3.347	0.00227	Significant
BMI	Boys	29	12.380	4.24×10^{-13}	Highly Significant
	Girls	29	23.870	1.29×10^{-20}	Highly Significant

Interpretation:

Height (Boys & Girls):

The p-values (> 0.05) indicate no statistically significant change in height after supplementation. Therefore, any slight increase in height is likely due to natural adolescent growth and not due to the intervention.

Weight (Boys & Girls):

The p-values (< 0.01) indicate a statistically significant reduction in weight after intervention for both boys and girls. The instant mix likely contributed to effective weight management.

BMI (Boys & Girls):

Extremely low p-values ($p < 0.00001$) indicate a highly significant reduction in BMI, confirming that the developed sprouted millet mix had a strong anti-obesity effect among adolescents.

Microbial Analysis

1.Total Plate Count (cfu/g)

Day	Control	T1	T2	T3
0	$3.2x10^3$	$1.8 x10^3$	$2.5 x10^3$	$1.5 x10^3$
30	$5.8 x10^3$	$3.0 x10^3$	$4.1 x10^3$	$2.0 x10^3$
60	$7.2 x10^3$	$5.0 x10^3$	$6.7 x10^3$	$3.5 x10^3$
90	$8.4 x10^3$	$6.7 x10^3$	$9.2 x10^3$	$4.5 x10^3$
120	$1.2 x10^4$	$7.0 x10^3$	$1.2 x10^4$	$6.5 x10^3$

2.Yeast & Mould Count (cfu/g)

Day	Control	T1	T2	T3
0	$2.5x10^2$	$1.8 x10^2$	$2.1 x10^2$	$1.5 x10^2$
30	$3.0 x10^2$	$2.0 x10^2$	$3.0 x10^2$	$1.8 x10^2$
60	$5.5 x10^2$	$3.0 x10^2$	$5.0 x10^2$	$2.7 x10^2$
90	$6.8 x10^2$	$5.5 x10^2$	$6.5 x10^2$	$3.2 x10^2$
120	$8.5 x10^2$	$7.0 x10^2$	$9.2 x10^2$	$6.8 x10^2$

3.Pathogen Screening

- Escherichia coli
- Staphylococcus aureus
- Salmonella spp.
- Listeria monocytogenes

Result: Absent in all samples up to 120 days

4.Interpretation: All microbial counts remained within permissible FSSAI limits (TPC$\leq 10^5$ cfu/g; Y&M$\leq 10^3$ cfu/g)

Microbial Shelf-Life Analysis

Total Plate Count remained below 1000 CFU/g over three months, confirming the mix's microbial safety and shelf stability.

Discussion

The current study was conducted with the objectives of developing a nutritionally rich, shelf-stable instant mix using sprouted millets and evaluating its impact on obesity alleviation among adolescents. A total of 30 obese boys and 30 obese girls were selected and supplemented with the developed mix for 90 days. The efficacy and safety of the product were analyzed through a series of well-established statistical and microbiological tests.

Tests Performed in the Study

To scientifically validate the intervention, the following tests and evaluations were conducted:

1. Anthropometric Measurements

- Height, Weight, and Body Mass Index (BMI) were recorded before and after supplementation.

2. Statistical Tests

- One-way ANOVA was applied to evaluate mean differences of pre- and post-intervention.
- Paired t-tests were conducted to determine whether the changes in anthropometric parameters were statistically significant or not within the same group over time.

3. Microbial Analysis

- Total Plate Count (TPC) and Yeast & Mould (Y&M) Counts were assessed at 0, 30, 60, 90, and 120 days of storage.
- Pathogen Screening was conducted to check for the presence of E. coli, S. aureus, Salmonella spp., and Listeria monocytogenes.

These comprehensive assessments ensured both the efficacy and safety of the developed product.

1. Anthropometric variations

a. Height

There was a minor increase in height during the intervention:

Boys: from 155.43 ± 5.12 cm to 156.28 ± 5.41 cm

Girls: from 152.16 ± 4.88 cm to 153.03 ± 5.06 cm

Although the ANOVA p-values were slightly significant (boys: 0.00011; girls: 0.00009), the paired t-test yielded non-significant p-values (boys: 0.3358; girls: 0.5837), indicating that the increase was not a direct result of supplementation.

Interpretation: The height changes are might be due to natural growth spurts during adolescence, not the intervention.

b. Weight

A significant reduction in body weight was observed:

Boys: from 82.47 ± 10.37 kg to 71.65 ± 9.88 kg

Girls: from 78.92 ± 11.23 kg to 67.43 ± 8.95 kg

Both ANOVA ($p < 0.05$) and paired t-test (boys: 0.00024; girls: 0.00227) confirmed that the weight changes were statistically significant.

Interpretation: The effect is attributed to the high dietary fiber and protein content in sprouted millets, which may promote satiety, reduce calorie intake, and improve metabolism. Also the added potential ingredients like Sago, Barley, Cumin seeds, Carom seeds, Dry ginger and Pepper might have lead to this effect.

c. BMI

BMI showed a substantial and statistically robust decrease:

Boys: from 34.25 ± 1.32 to 29.39 ± 1.17 kg/m²

Girls: from 33.98 ± 1.44 to 28.68 ± 1.26 kg/m²

Paired t-test p-values (boys: 4.24×10^{-13}, girls: 1.29×10^{-20}) confirmed highly significant reductions, further supported by ANOVA.

Interpretation: The reduction in BMI reinforces the anti-obesity potential of the instant mix, showing promise as a therapeutic dietary intervention.

2. Microbial Quality and Shelf-Life Evaluation

a. Total Plate Count (TPC)

Initial TPC (Day 0): ranged from 1.5×10^3 to 3.2×10^3 cfu/g

Final TPC (Day 120): ranged from 6.5×10^3 to 1.2×10^4 cfu/g

Interpretation: All values remained well below the FSSAI limit of $\leq 10^5$ cfu/g, indicating good microbial safety throughout the storage period.

b. Yeast and Mould Count

Progressively increased, but remained within safe range ($\leq 10^3$ cfu/g)

Final count in T3 was 6.8×10^2 cfu/g, indicating good fungal control

Interpretation: The product demonstrated excellent stability against fungal spoilage, likely due to low moisture content and proper packaging.

c. Pathogen Screening

All four critical foodborne pathogens-Escherichia coli, Staphylococcus aureus, Salmonella spp., and Listeria monocytogenes-were absent in all samples across the 120-day storage period.

Interpretation: This confirms that the product was produced under hygienic conditions and is safe for human consumption.

Functional Properties of Sprouted Millets

The success of the intervention can be credited to the use of sprouted millets (ragi, bajra, foxtail) which are:

- High in dietary fiber and bioactive compounds
- Low in glycemic index

- Rich in resistant starch, antioxidants, and micronutrients
- Known to enhance digestion, metabolism, and insulin sensitivity

These qualities contribute to weight loss, improved metabolic health, and better satiety, aligning with the goals of the study. There are several studies conducted by several authors and proved that there was reduction in the weight (Flechtne M M et al.,(2010), Layman DK et al.,(2009), Hochstenbach WA et al.,(2009) and Geetha K et al.,(2019)

Conclusion

The study has shown significant reductions in body weight and BMI of obese adolescent boys and girls, no adverse microbial contamination over 120 days in the mix, complied with all FSSAI food safety standards, long-term shelf life with low-cost, culturally acceptable and nutritionally effective dietary intervention for combating adolescent obesity.

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