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Fortification of wafer cone for icecream with skim milk powder and germinated finger millet flour

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Abstract

Ice cream is the most loved frozen dessert at all age groups. Ice cream cones are a convenient way to eat without need for bowl or spoons. Germinated finger millet flour is a rich source of calcium, iron, dietary fiber, and essential amino acids. SMP provides high-quality proteins and enhances the functional properties of the cones. This research evaluated sensory attributes, ice cream permeability, water activity, texture characteristics, and proximate composition. Ice cream permeability analysis showed enhanced resistance to water absorption, Water activity values for all cones remained below 0.6, indicating microbiological stability. Proximate composition analysis showed significant nutritional enhancement, with higher protein (18.41%), fiber (3.98%), ash (1.97%), carbohydrate (61.36%) and energy value (359.42 kcal). These findings indicate that incorporating germinated finger millet flour and SMP into wafer cones improves their nutritional profile, functional properties, and consumer acceptability, making them a promising alternative to refined wheat flour cone.

Keywords: Wafer cone, icecream, skim milk powder, finger millet, sensory.

1. Introduction

An ice cream cone is a dry, flat waffle in the shape of a cone that can be used to eat ice cream. Ice cream was previously served in cups and dishes. Ice cream cones are a product that everybody can enjoy when serving ice cream (Mhatre *et al.*, 2022) ^[11]. The ice cream cone is a very unique invention in the history of ice cream. Wafer can serve as a carry for other materials because they have no flavour. Wafers are sold for culinary purposes, such as serving with butter, cheese, or ice cream. Wafer cones are hollow and prepared one at a time for use with ice cream. A common wafer batter recipe includes water, refined wheat flour, oil, an emulsifier, and leavening ingredients. (Manikanta *et al.*, 2023) ^[10]. Although refined wheat flour is a major component of this wafer cone, it is deficient in dietary fibre and essential amino acids (Sravani *et al.*, 2023) ^[19].

Skim milk powder is composed of approximately 80% casein and 20% whey proteins, which are essential for muscle repair and growth. The incorporation of skim milk powder can improve the nutritional profile of the wafer cones, making them a source of high-quality protein and essential micronutrients, which are crucial for consumer health (Sánchez *et al.*, 2022) ^[13]. Millets are an ingredient that has recently gained popularity. Consumer awareness of the nutritional, economic, and environmental benefits of consuming millets is increasing (Shah *et al.*, 2021) ^[15]. Millets not only provide nutrients but also aid in managing health conditions such as diabetes, obesity, and hyperlipidemia. (Veena, 2003) ^[21]. Finger millet (*Eleusine coracana*) is a nutrient-dense grain that is particularly rich in calcium, iron, and dietary fiber. Currently, traditional techniques like soaking, germination, and fermentation are employed to enhance the nutritional quality of food (Sharma *et al.*, 2023) ^[16]. Germination, in particular, is an economical method that effectively boosts the nutritional value (Udeh *et al.*, 2018) ^[20]. This research is aimed to develop wafer cone for ice cream utilizing the SMP and germinated finger millet flour.

2. Materials and Methods

2.1 Materials

Skim milk powder (SMP), Finger millet, Refined wheat flour, Lecithin oil, Sodium Meta Bi Sulphite (SMBS) were purchased from local market, Chennai.

2.2 Methods

2.2.1. Preparation of germinated finger millet flour

Finger millet grains were washed and soaked in room temperature water for 24 h before germination. After soaking, the millet grains were drained of excess water. Millet grains were distributed separately on clean jute bags lined with a damp cotton bag. Germination treatment carried out 48 h at room temperature. Water was sprinkled over millet grains during a 4-h interval to promote germination. After germination, germinated grains were drained, and dried for 24 h in shade drying. Dried germinated millet grains were milled and sieved (100 µm mesh sieve) to produce germinated finger millet flour.

2.2.2 Treatment details

Optimization of ingredients for development of wafer cone	
Level of skim milk powder	Level of germinated finger millet flour
a. Control – 100% (RWF)	a. Control – 100% (RWF)
b. P1- 1% (SMP)+ 99% (RWF)	b. T1- 100% (GFF)
c. P2--2% (SMP)+ 98% (RWF)	c. T2--90% (GFF)+ 10% (RWF)
d. P3--3% (SMP)+ 97% (RWF)	d. T3--80% (GFF)+ 20% (RWF)
	e. T4--70% (GFF)+ 30% (RWF)

RWF – Refined Wheat Flour; GFF- Germinated Finger millet Flour

2.2.3 Process of preparation of wafer cone

Based on the sensory scores 2% of SMP incorporated wafer cone was scored high level of overall acceptability. Hence 2%

SMP was optimized (Table 1) from the various level of treatments for the development of wafer cone. It was considered as a control for optimizing the level of germinated finger millet incorporated wafer cone. The measured quantities of finger millet flour and refined wheat flour were mixed in a stainless- steel vessel along with water, lecithin oil, skim milk powder and SMBS were put together for batter formation (Table 2). These are mixed to make batter using electric hand mixer at low speed until the batter becomes smooth. Then, pour a specific amount of batter into the ice cream cone making mould (10-15 ml). After that, the ice cream cone mold placed at the ice cream cone making machine. Then, the cone is baked at 180 °C /1.5 seconds (Figure 1). The cone was allowed to cool. The wafer cone was packed in LDPE pockets and stored at air tight container in room temperature.

Table 1: Optimization of SMP level in wafer cone for ice cream (%)

Ingredients	Control	P ₁	P ₂	P ₃
Refined wheat flour (%)	39.66	38.66	37.66	36.66
SMP (%)	-	1.00	2.00	3.00
SMBS (%)	0.03	0.03	0.03	0.03
Oil (%)	3.77	3.77	3.77	3.77
Water (%)	56.54	56.54	56.54	56.54

Table 2: Ingredients required for development of wafer cone for ice cream (%)

Ingredients	Control	T ₁	T ₂	T ₃	T ₄
SMP (%)	2.00	2.00	2.00	2.00	2.00
Germinated finger millet flour (%)	-	37.66	33.89	30.12	26.36
Refined wheat flour (%)	37.66	-	3.76	7.53	11.29
SMBS (%)	0.03	0.03	0.03	0.03	0.03
Oil (%)	3.77	3.77	3.77	3.77	3.77
Water (%)	56.54	56.54	56.54	56.54	56.54

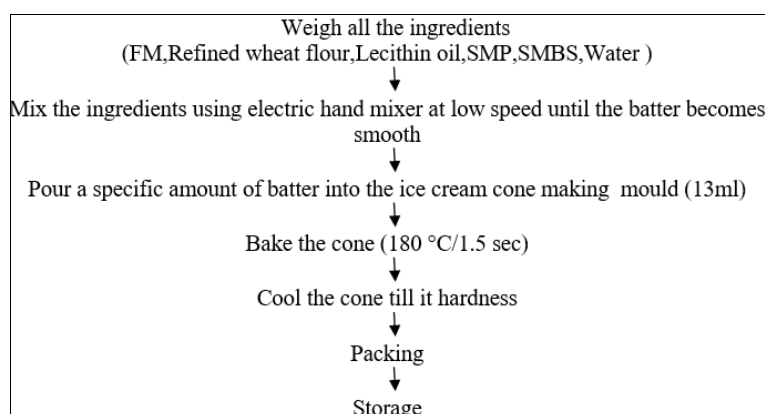


Fig 1: Optimized flow chart of preparation of wafer cone for ice cream



Fig 2: Development of wafer cone

2.3 Analysis of wafer cone for ice cream

The proximate parameters viz., Moisture content, protein (Kjeldahl method), fat (Soxhlon fat extractor), fibre (Fibron fibre analyser), ash, carbohydrate and energy value were analysed for control and optimized wafer cone (AOAC, 2000) [3]. Sensory evaluation of ice-cream cones was carried out by 15 trained panelists ranging from 23 to 55 years. Panelists followed sensory parameters like colour and appearance,

flavour, body and texture, colour and overall acceptability for rating the product based on a 9-point scale (Amerine *et al.*, 1965) [1]. The Texture Profile Analysis (TPA) test was carried out in triplicate using an instrumental texture profile analysis. The compression is performed using a P/75 probe. The pre-test, test, and post-test speeds were set to 1 mm/s, 5 mm/s, and 5 mm/s, respectively. The trigger force was set to auto at 5 g (Sravani *et al.*, 2023) [19]. The ice cream permeability (Kigozi

et al., 2014) [7]. Electric dew point water activity meter (Lab Touch - aw System, Novasina AG) was used (Selvapraakash, 2022) [14]. The experimental data were presented as the mean $\pm$ standard deviation (SD) from triplicate samples. A one-way ANOVA was conducted, followed by Duncan's post hoc test, with a significance level set at $p < 0.05$ (SPSS, Version 20) (Snedecor and Cochran, 1995) [18].

3. Results and Discussion

3.1. Effect of treatments on Icecream permeability of wafer cone

The water activity was estimated for both control and all

treatments of wafer cone (Figure 3). Values of Icecream permeability(min) of control, T1, T2, T3 and T4 were found to be 4.40 ± 0.10 min, 4.44 ± 0.15 min, 4.42 ± 0.07 min, 4.41 ± 0.09 min and 4.38 ± 0.06 min respectively. Statistical analysis revealed that there was a highly significant difference $P \leq 0.01$ was observed in ice cream permeability of control and treatments. Ice cream permeability value was lower in control compared to all the treatment of wafer cone. It is effect of water absorption capacity of germinated finger millet flour. The results were controversial to the findings of Kushwaha *et al.* (2023) [9].

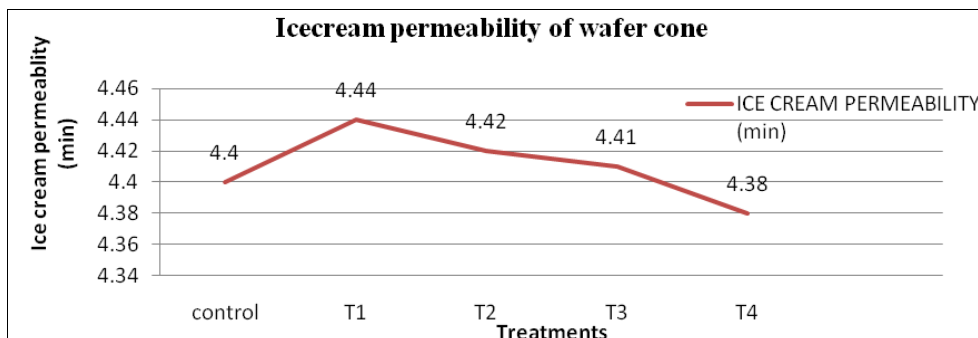


Fig 3: Icecream permeability of wafer cone

3.2 Effect of treatments on water activity of wafer cone

The water activity were estimated for both control and all treatments of wafer cone (Figure 4). The values of water activity of control, T1, T2, T3 and T4 were found to be 0.491 ± 0.025 , 0.633 ± 0.016 , 0.502 ± 0.015 , 0.52 ± 0.013 and 0.47 ± 0.014 respectively. Statistical analysis revealed that there was a highly significant difference $P \leq 0.01$ was observed in water activity of control and treatments.

Every food product characteristic of water activity which define the degree of binding of the water contained in the food and its availability to act as a solvent and participate in chemical reactions. Bacteria and fungi are required minimum 0.91 water activity and 0.7 water activity for their growth. Since below 0.6 water activity microorganisms cannot survive. From the result table 9, it was showed that the highly significant difference between the treatments. The water activity of all treatments value less than 0.6 where it is considered as microbiologically stable. Similar results was observed by selvapraakash, (2022) [14].

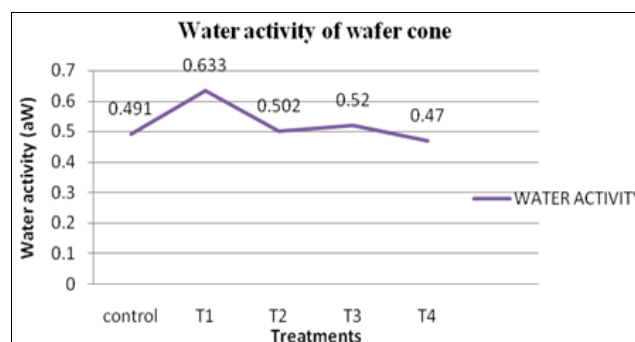


Fig 4: Water activity of wafer cone

3.3 Effect of treatments on sensory scores of wafer cone

The sensory attributes includes colour and appearance, flavour, Body and texture, taste and overall acceptability were evaluated for both control and all treatment of wafer cone (Table 3).

Table 3: Effect of treatment on sensory scores of wafer cone (Mean $\pm$ SE)@

Sensory Attributes	C	T ₁	T ₂	T ₃	T ₄	F value
Colour and Appearance	8.63 ^a $\pm$ 0.09	8.16 ^a $\pm$ 0.15	8.46 ^a $\pm$ 0.15	8.60 ^a $\pm$ 0.11	8.63 ^a $\pm$ 0.09	2.64*
Flavour	7.83 ^a $\pm$ 0.15	8.53 ^b $\pm$ 0.13	8.50 ^b $\pm$ 0.13	8.33 ^b $\pm$ 0.09	8.26 ^b $\pm$ 0.18	3.77*
Body and texture	8.53 ^c $\pm$ 0.09	6.90 ^a $\pm$ 0.15	7.13 ^b $\pm$ 0.16	8.60 ^c $\pm$ 0.11	8.66 ^c $\pm$ 0.07	48.43**
Taste	7.80 ^c $\pm$ 0.15	8.60 ^a $\pm$ 0.11	8.56 ^b $\pm$ 0.09	8.50 ^d $\pm$ 0.09	8.36 ^d $\pm$ 0.11	8.02**
Overall Acceptability	8.30 ^c $\pm$ 0.06	8.03 ^a $\pm$ 0.06	8.14 ^b $\pm$ 0.08	8.60 ^e $\pm$ 0.05	8.55 ^d $\pm$ 0.08	11.72**

@ Average of 15 trials; (Mean $\pm$ SE)@ Non significant – $P > 0.05$, *Significant – $0.01 < P \leq 0.05$, **Highly significant- $P \leq 0.01$; Means bearing different superscripts within columns differ significantly.

3.3.1. Colour and Appearance

The values of colour and appearance for control, T₁, T₂, T₃ and T₄ were found to be 8.63 ± 0.09 , 8.16 ± 0.15 , 8.46 ± 0.15 , 8.60 ± 0.11 and 8.63 ± 0.09 respectively. There is significant $0.01 < P \leq 0.05$ difference observed between the treatment. Control and T₃ has higher value compared to T₁, T₂ and T₄. SMP and germinated finger millet flour increased sensory scores decreased for colour attributes. Similar results were observed by Vinay *et al.*, (2023) [22].

3.3.2. Flavour

The values of flavour for control, T₁, T₂, T₃ and T₄ were found to be 7.83 ± 0.15 , 8.53 ± 0.13 , 8.50 ± 0.13 , 8.33 ± 0.09 and 8.63 ± 0.09 respectively. Flavour attributes showed significant $0.01 < P \leq 0.05$ for both control and all treatment of wafer cone. SMP and germinated finger millet flour increased sensory scores increased for flavour attributes. Control value was lower when compared to all the treatment of wafer cone. Similar observation found by Sinha and Sharma, (2017) [17]

whereas the SMP and germinated finger millet content increase the scores of flavour increased.

3.3.3 Body and Texture

The values of body and texture for control, T₁, T₂, T₃ and T₄ were found to be 8.53± 0.09, 6.90± 0.15, 7.13± 0.16, 8.60± 0.11 and 8.66 ± 0.07 respectively. Body and Texture attributes showed highly significant (P≤0.01) or both control and all treatment of wafer cone. SMP and germinated finger millet flour increased sensory scores was decreased for body and texture attributes. Similar findings was observed by Tanahy *et al.* (2021)^[5].

3.3.4 Taste

The values of taste for control, T₁, T₂, T₃ and T₄ were found to be 7.80± 0.15, 8.60± 0.11, 8.56 ± 0.09, 8.50± 0.09 and 8.36± 0.11 respectively. Taste attributes showed highly significant for both control and all treatment of wafer cone. The lowest score was obtained for the control compared to all treatment of wafer cone. SMP and germinated finger

millet flour decreased that sensory scores was decreased for taste attributes. Similar trends were findings by Sinha and Sharma (2017)^[17].

3.3.5 Overall acceptability

The values of overall acceptability for control, T₁, T₂, T₃ and T₄ were found to be 8.30± 0.06, 8.03 ± 0.06, 8.14 ± 0.08, 8.60 ± 0.05 and 8.55 ± 0.08 respectively. Overall acceptability showed highly significant for both control and all treatment of wafer cone. The higher scores were obtained in the T₃ treatment from 80:20 ratio of optimized germinated finger millet flour and refined wheat flour. Based on sensory evaluation, the highest scores were obtained for (T₃) composition, it was taken for further analysis.

3.4 Texture characteristics of optimized wafer cone

The values of texture characteristics such as hardness, fracturability, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience were analysed for control and optimized wafer cone (figure 5).

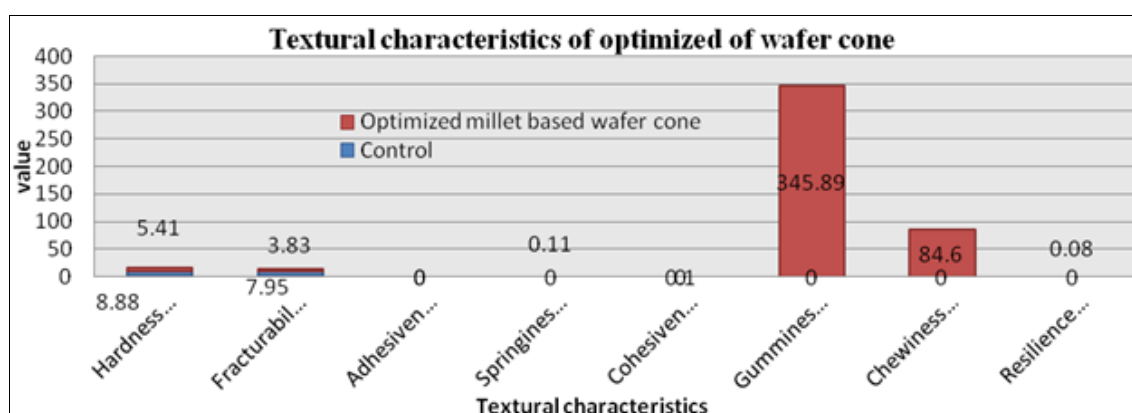


Fig 5: Texture characteristics of optimized wafer cone

Statistical analysis revealed that there was a highly significant difference $P \leq 0.01$ was (kgf), Fracturability (kgf), Adhesiveness (g.sec), Springiness (%), Cohesiveness (%), Gumminess (%), Chewiness (%) and Resilience (%) of control were found to be 8.88 ± 0.004 , 7.95 ± 0.005 , 0.00 ± 0.00 , 0.00 ± 0.00 , 0.00 ± 0.00 , 0.00 ± 0.00 , 0.00 ± 0.00 and 0.00 ± 0.00 respectively. The values of Hardness (kgf), fracturability (kgf), Adhesiveness (g.sec), Springiness (%), Cohesiveness (%), Gumminess (%), Chewiness (%) and Resilience (%) of T₃ were found to be 5.41 ± 0.006 , 3.83 ± 0.005 , 0.00 ± 0.00 , 0.11 ± 0.008 , 0.10 ± 0.0003 , 345.89 ± 12.4 , 84.6 ± 1.83 and 0.08 ± 0.004 respectively.

From this result hardness and factorability values were higher in control than the optimized wafer cone. Hardness and factorability values was highly significant difference between the control and optimized wafer cone. This may be due to the high fibre and protein content of germinated finger millet flour. From this result springiness, cohesiveness, gumminess, chewiness and resilience values were lower in control than the optimized wafer cone. Springiness, cohesiveness, gumminess, chewiness and resilience values were highly significant difference between the control and optimized wafer cone. It might be due to the germinated finger millet flour and skim

milk powder. Similar trend was observed by khadese *et al.* (2024)^[6], that the value of chewiness was higher in kulfi due to higher water absorption capacity of incorporated finger millet flour.

3.5 Proximate composition of optimized wafer cone

The proximate composition includes moisture, fat, protein, carbohydrate, energy value, fibre and ash were estimated for both control and optimized wafer cone (Table 4). Statistical analysis revealed that there was a highly significant difference $P \leq 0.01$ was observed in all proximate composition between the control and developed wafer cone. The values of proximate composition such as moisture (%) of control and optimized millet based wafer icecream cone were found to be 10.60 ± 0.22 and 9.78 ± 0.19 respectively. The moisture content of control has higher value when compared to optimized wafer cone. There was a highly significant difference observed in moisture content of control and optimized wafer cone. This might due to the water holding capacity of germinated millet flour. The lower moisture content indicate that it will increase the shelf life of the cone. Similar findings were observed by Shilar *et al.* (2024)^[12] and Manoharan *et al.* (2022)^[4].

Table 4: Proximate composition of optimized wafer cone (Mean $\pm$ SE)@

Proximate composition	Control	Optimized wafer cone	t value
Moisture (%)	10.60 $\pm$ 0.22	9.78 $\pm$ 0.19	4.817**
Crude protein (%)	10.49 $\pm$ 0.51	18.41 $\pm$ 0.41	11.933**
Crude fat (%)	4.48 $\pm$ 0.06	1.18 $\pm$ 0.02	49.749**
Crude fibre (%)	1.97 $\pm$ 0.04	3.98 $\pm$ 0.07	24.436**
Ash (%)	1.42 $\pm$ 0.05	1.97 $\pm$ 0.04	7.190**
Carbohydrate (%)	74.32 $\pm$ 0.55	61.36 $\pm$ 0.17	22.415**
Energy (kcal)	349.91 $\pm$ 0.78	359.42 $\pm$ 0.63	9.428**

@ Average of 6 trials; (Mean $\pm$ SE)@ Non significant – P > 0.05, *Significant – 0.01 < P $\leq$ 0.05, **Highly significant- P $\leq$ 0.01;

The values of proximate composition of protein (%) for control and optimized millet based wafer icecream cone were found to be 10.49 $\pm$ 0.51 and 18.41 $\pm$ 0.41 respectively. The protein content of optimized wafer cone was higher than the control sample. There was a highly significant difference in protein content of control and optimized wafer cone. Germinated finger millet flour and skim milk powder are contributed to increase the protein content of optimized millet base wafer cone. Similar findings were observed by Shilar *et al.* (2024) [12]. Anju and Sarita, (2010) [2] also observed the protein content is 11% for biscuits made from 45: 55 ratios of barnyard and refined wheat flour compared to control sample. The values of proximate composition of Fat (%) for control and optimized finger millet based wafer icecream cone were found to be 4.48 $\pm$ 0.06 and 1.18 $\pm$ 0.02 respectively. Analysis revealed that there was a highly significantly difference in fat content of control and optimized wafer cone. The fat content of optimized wafer cone was higher than the control sample. This may be due to fat content of germinated finger millet flour. These results are nearly in agreement with those reported by Tanahy *et al.* (2021) [5].

The values of proximate composition of fibre (%) for control and optimized millet based wafer icecream cone were found to be 1.97 $\pm$ 0.04 and 3.98 $\pm$ 0.07 respectively. The crude fibre content of the optimized wafer cone was increased when compared to control. There was a highly significantly difference in crude fibre content of control and optimized wafer cone. Germinated millet flour increases the crude fibre content in optimized wafer cone whereas refined wheat flour had low fibre content compared to germinated finger millet flour. Similar increase trends were observed by Sinha and Sharma, (2017) [17] the crude fibre content was 1.09% higher in cookies made from 50: 50 ratio of finger millet flour and refined wheat flour.

The values of proximate composition of ash (%) for control and optimized millet-based wafer icecream cone were found to be 1.42 $\pm$ 0.05 and 1.97 $\pm$ 0.04 respectively. The ash content of optimized wafer cone was higher than the control sample. There was a highly significant difference in ash content of control and optimized wafer cone. The observed higher value of ash content in optimized wafer one might be contributed from germinated finger millet flour. similar results were observed by Sinha and Sharma, (2017) [17].

The values of proximate composition of carbohydrate (%) for control and optimized millet based wafer icecream cone were found to be 74.32 $\pm$ 0.55 and 61.36 $\pm$ 0.17 respectively. The value of carbohydrate for optimized wafer cone was lower when compared to the control. There was a highly significant difference observed in carbohydrate content of control and optimized wafer cone. Due to an inverse in the activity of the enzyme responsible for breaking down complex carbohydrate into simple sugars, in the process of germination. Similar results were obtained by Kumar *et al.* (2021) [8].

The values of proximate composition of Energy(kcal) for

control and optimized wafer icecream cone were found to 349.91 $\pm$ 0.78 and 359.42 $\pm$ 0.63 respectively. The energy value of optimized wafer cone reported a higher value when compared to control. There was a highly significantly difference observed in energy value of control and optimized wafer cone. Tanahy *et al.* (2021) [5] observed the same trends of energy value.

From the Table 4 the results revealed a highly significant difference among the control and optimized wafer cone. These results indicated that replacement of refined wheat flour with finger millet flour in wafer cone formulation can enhance the nutrient composition of the wafer cone.

4. Conclusion

This study successfully demonstrated that incorporating skim milk powder (SMP) and germinated finger millet flour into wafer cones significantly enhances their nutritional and functional properties. Sensory evaluation confirmed that the optimized wafer cone achieved superior scores in flavor, texture, taste, and overall acceptability compared to the control. The improved ice cream permeability and lower water activity values of the developed cones ensured structural integrity and microbiological stability. Optimized cone showed good textural characteristics and proximate composition showed increase in protein, fiber, and ash content.

Overall, the study highlights the potential of utilizing germinated finger millet flour and SMP to develop innovative wafer cones, offering a healthier and more sustainable alternative to refined wheat wafer cone.

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Conflict of Interest

Not available

Financial Support

Not available

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