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RESEARCH ARTICLE

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OPTIMISATION AND QUALITY EVALUATION OF FINGER MILLET INCORPORATED NUTRI WAFFLES

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ABSTRACT

Waffles are convenient ready to eat foods made from leavened batter or dough that is cooked between two hot plates and is patterned to give a characteristic size, shape and surface impression. Utilisation of millets is restricted due to non-availability of processed foods in ready to eat form. Millets can be effectively utilised for developing value added products which can improve the overall diet quality. Hence, the present study was carried out to formulate nutritionally superior waffles with finger millet. Finger millet was used as the major ingredient and used in varying proportions starting from 90 to 50 percent along with 10 to 50 per cent refined wheat flour and tapioca flour. The best treatment from each set was selected through sensory evaluation using a score card with a 9 point hedonic scale. Based on organoleptic evaluation, nutri waffle prepared with 50 per cent finger millet flour and 50 per cent refined wheat flour had a maximum mean score of 8.54 for overall acceptability. In finger millet based nutri waffles prepared with tapioca flour (TF), the best treatment was FTT₂ (80% FMF + 20% TF) and secured a mean score of 8.54 for overall acceptability. The study shows the scope for value addition of finger millet grains by the production of millet based nutri waffles incorporated with refined wheat flour and tapioca flour. The physico-chemical qualities of the nutri waffles revealed that the FWT₃ (50% FMF + 50% RWF) contained 4.43 per cent of moisture, 68.28g/100g of total carbohydrate, 6.26g/100g of protein, 2.91g/100g of total fat, 4.18g/100g of total fibre, 39.65g/100g of starch, 115.32 mg/100g of calcium, 1.23 mg/100g of iron, 2.14 mg/100g of sodium and 177.82 mg/100g of potassium. FTT₂ (80% FMF + 20% TF) contained 5.37 per cent of moisture, 60.16g/100g of total carbohydrate, 4.60g/100g of protein, 3.04g/100g of total fat, 5.61g/100g of total fibre, 31.66g/100g of starch, 177.11 mg/100g of calcium, 1.63 mg/100g of iron, 3.84 mg/100g of sodium and 242.72 mg/100g of potassium. As these waffles were nutritionally superior with minerals and other nutrients. The developed nutriwaffles were very cost effective compared to commercially available waffles.

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INTRODUCTION

Millets are termed as "yesterday's coarse grains and today's nutri cereals". Millets are the backbone of dry land agriculture. They are hardy, resilient crops that have low carbon foot print can grow in poor soils with minimum input. Majority of millets are three to five times nutritious than staple grains like rice, wheat and maize. Higher content of vitamins, fibre, proteins and minerals in millets are the viable solution to reduce the aggravating incidence of malnutrition and lifestyle diseases. Because of these reasons millets are termed as 'miracle grains'.

Even though millets have adequate potential to contribute to nutritional security, they still remain as underutilised because of its poor utilization and lack of knowledge on processed products. Millet based value added food products are not yet widely available due to the changes in food habits and a rising reliance on primary cereals like rice and wheat. Recognizing the importance of millets, Government of India observed 2018 as the year of millet to encourage and promote the production of millets. To create domestic and global demand and also to provide nutritious food, Government of India spearheaded the United Nations General Assembly (UNGA) and declared 2023 as "International Year of Millets". After decades of negligence, nutri cereals has made a strong come back in the Indian cereal production segments and ranks first in millet production (41%

of global production) across the globe. The Union Budget 2022-23 highlighted that support would be provided for post-harvest value addition, enhancing domestic consumption and for branding millet products nationally and internationally (PIB, 2022). Today's consumers demand nutritious convenient foods, and food processing ventures are increasingly targeting production of nutritionally improved food items. To promote food products and for increasing employment opportunities Government of India has approved Production Linked Incentive Scheme (PLI) for food processing industries. Millet based ready to eat products are preferred under this scheme and it has aimed to introduce at least one new product every year (MoFPI, 2022). Finger millet is a good source of micro nutrients and have nutraceutical components. Their consumption has a positive effect on health with regard to several lifestyle diseases. In today's modern life, various ready-to-eat (RTE) foods have become integral part of our food habits. Among the variety of ready to eat products, RTE waffles occupy a significant place. Waffles are convenient foods eaten either as a snack or as a breakfast item. Waffle is a product made from leavened batter or dough that is cooked between two plates that are patterned to give a characteristic size, shape and surface impression. Starch rich staple food sources are used for waffle making and it is eaten throughout the world (Tiefenbacher, 2009). Formulation of healthy novel convenient foods from indigenous food crops is an effect strategy to get more income to the farming population. Hence, the present study entitled 'Optimisation and quality evaluation of finger millet incorporated nutri waffles' was proposed to develop nutri waffles from finger millet with different composite mixes and to evaluate its quality parameters.

MATERIALS AND METHODS

Selection and collection of raw ingredients: Finger millet (*Eleusinecoracana*) was selected as the major ingredient for developing nutri waffles. Tapioca flour and refined wheat flour were also used in combination with finger millet flour for developing nutri waffles. Sugar, oil and vanilla essence were used as the other ingredients and were collected from local market.

Standardisation of finger millet incorporated nutri waffles: The collected finger millet grains were cleaned, washed and germinated by following the standard procedure by Nefale and Mashau (2018). The finger millet was soaked for 10 hour in cold water at room temperature and tied in moist cloth and sprinkled water at 4 hour interval. After 24 hours, the germinated millets were dried, powdered and sieved to get a uniform flour. Tapioca flour was prepared by slicing and blanching the raw tapioca in boiling water for 5-10 minutes. The blanched tapioca was then dried (Nambisan, 1985). The dried chips were milled into flour and sieved through a 40 mesh size to get a fine powder. Finger millet flour, refined wheat flour, tapioca flour was prepared for the preparation of waffles.

Finger millet nutri waffles: Two sets of nutri waffles were prepared using finger millet flour (FMF) as the major ingredient added with two different flours in varying proportions ranging from 10 per cent to 50 per cent. Two flours used were refined wheat flour (RWF) and tapioca flour (TF). Treatment T_0^w (control) contain 100 percentage refined wheat flour and T_0^T (control) contain 100 percentage tapioca flour. The details of treatments and combinations are detailed in Table 1.

Table 1. Details of combinations for finger millet nutri waffles with refined wheat flour

Treatments	Combination
T_0^w (Control)	100% Refined wheat flour (RWF)
FWT_1	90% FMF + 10% RWF
FWT_2	80% FMF + 20% RWF
FWT_3	70% FMF + 30% RWF
FWT_4	60% FMF + 40% RWF
FWT_5	50% FMF + 50% RWF

(*FMF - Finger millet flour, RWF - Refined wheat flour)

$T_0^T - FTT_5$: The same treatments $T_0^w - FWT_5$ were repeated using tapioca flour instead of refined wheat flour.

All the ingredients were measured and mixed well with warm water. A batter was prepared with desirable consistency, then the batter was poured in to the pre heated waffle machine. The mix was baked for 1 minute and 30 seconds at 180^o C. After the baking, the flat waffles were made into desirable shapes. The ingredients used for making waffles are given in Table 2 and the method of preparation of nutri waffles is represented in Figure 1a and 1b.

Table 2. Ingredients used for making waffles

Treatments	Flour	Sugar	Oil	Flouring agent	Salt	Water
Control (100% RWF)	60g	26g	10 ml	2 ml	2g	100 ml
Control (100% TF)	60g	26g	10 ml	2 ml	2g	125 ml

(FMF - Finger millet flour, RWF - Refined wheat flour)

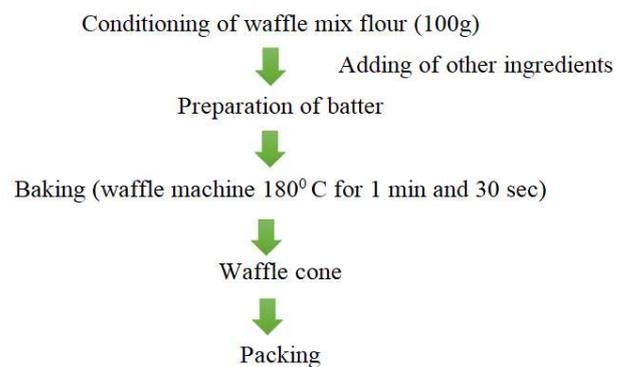


Fig. 1a. Flowchart for the formulation of nutri waffles

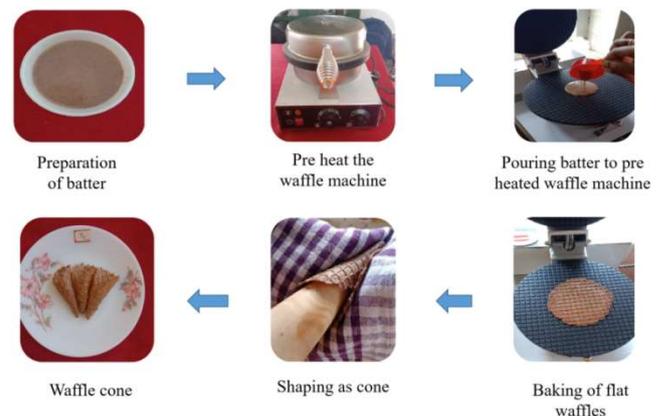


Fig. 1b. Diagrammatic representation of formulation of nutri waffles

Organoleptic evaluation: A series of acceptability trails were carried out using simple triangle test at the laboratory level and selected a panel of fifteen judges between the age group of 18- 35 years as suggested by Jellineck (1985). The organoleptic evaluation of the nutri waffles were carried out. The reconstituted nutri waffles were evaluated organoleptically by the judges using a 9 point hedonic scale.

Physico-chemical analysis: The physico-chemical qualities like moisture, protein (A.O.A.C. 1980), total carbohydrate, starch (Sadasivam and Manickam, 1992), total fibre and fat (Sadasivam and Manickam, 1997), calcium, iron (Perkin and Elmer, 1982), sodium and potassium (Jackson, 1973) of best selected finger millet flour incorporated nutri waffles were determined initially. Analyses were carried out in triplicate.

Statistical analysis: The observations were tabulated and analysed statistically as T test by using GRAPES statistical software. The scores of organoleptic evaluations were assessed by Kendall's coefficient of concordance (w).

Cost of Production: The cost of production of the most acceptable combinations of finger millet flour incorporated nutri waffles were computed based on the market price of procured ingredients used for preparation of products along with labour charge, fuel charge, electricity charge and packaging cost. The cost was calculated for 100g of the product and compared with similar products available in the market.

RESULTS AND DISCUSSION

Organoleptic evaluation: Sensory evaluation is used to measure, analyse and interpret how the attributes of a product are perceived by peoples. These sensory attributes are the combination of characteristics that together produce a sensory experience (texture, aroma, colour, flavour) and the human senses like sight, hearing, taste, smell and touch are used to measure the attributes. The suitability of finger millet flour in combination with refined wheat flour and tapioca flour for the development of nutri waffles were assessed.

(8.59), FWT₃ (8.62) and FWT₄ (8.64). For taste, T^W₀, FWT₁, FWT₂, and FWT₄ obtained mean scores of 8.47, 8.32, 8.35, 8.47 and 8.67 respectively. For texture, the mean score of 8.73 was observed both in FWT₄ (60% FMF and 40% RWF) and FWT₂ (80% FMF and 20% RWF). FWT₁ (90% FMF and 10% RWF) obtained mean score of 8.69, followed by FWT₃ (70% FMF and 30% RWF) and T^W₀ (100% RWF) for which the mean scores of 8.67 (texture) was recorded. In all the treatments, the mean scores obtained were 8.20 for flavour, except for T^W₀ (8.24) and FWT₅ (8.27). The mean scores of colour were also highest for FWT₅, FWT₁ and FWT₂ (8.73), followed by FWT₄ (8.64), FWT₃ (8.58) and T^W₀ (8.51) respectively. Whereas for the appearance, T^W₀ and FWT₃ (8.67) obtained the mean score of 8.67, followed by FWT₂ (8.60), FWT₄ (8.57) and FWT₁ (8.40). From this, the sensory mean scores have clearly shown that FWT₅ (50% FMF + 50% RWF) obtained the highest mean score and rank score for all the parameters of sensory evaluation. Therefore, from this experiment, nutri waffles prepared with 50 per cent FMF and 50 per cent RWF were found to be having best organoleptic qualities. Research findings have revealed that substitution of forty per cent wheat flour with finger millet flour in baked products like cake and biscuits is acceptable. The different flavoured cakes, soup sticks, rusk and muffins prepared with finger millet have good appearance, texture, flavour and overall acceptability scores (Begum *et al.*, 2003; Yenagiet *et al.*, 2013).

Table 3. Mean scores for organoleptic qualities of finger millet nutri waffles incorporated with refined wheat flour

Treatment	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
T ^W ₀ (100% RWF)	8.67 (3.63)	8.51 (3.23)	8.24 (3.63)	8.67 (3.43)	8.47 (3.33)	8.67 (3.77)	51.23
FWT ₁ (90% FMF + 10% RWF)	8.40 (3.17)	8.73 (3.63)	8.20 (3.43)	8.69 (3.50)	8.32 (3.20)	8.41 (2.60)	50.75
FWT ₂ (80% FMF + 20% RWF)	8.60 (3.47)	8.73 (3.63)	8.20 (3.43)	8.73 (3.53)	8.35 (3.30)	8.59 (3.13)	51.20
FWT ₃ (70% FMF + 30% RWF)	8.67 (3.63)	8.58 (3.43)	8.20 (3.43)	8.67 (3.43)	8.47 (3.17)	8.62 (3.37)	51.21
FWT ₄ (60% FMF + 40% RWF)	8.57 (3.27)	8.64 (3.43)	8.20 (3.43)	8.73 (3.40)	8.67 (3.73)	8.64 (3.63)	51.45
FWT ₅ (50% FMF + 50% RWF)	8.73 (3.83)	8.73 (3.63)	8.27 (3.63)	8.87 (3.70)	8.73 (4.27)	8.71 (4.50)	52.04
Kendall's value	0.095**	0.067**	0.053**	0.029**	0.139**	0.282**	

(FMF- Finger millet flour, RWF- Refined wheat flour); Value in parentheses are mean rank score based on Kendall's W test;

** Significant at 1% level

Table 4. Mean scores for organoleptic qualities of finger millet nutri waffles incorporated with tapioca flour

Treatment	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
T ^T ₀ (100% TF)	7.13 (2.10)	7.87 (2.50)	7.67 (3.93)	7.47 (2.13)	8.27 (3.97)	7.68 (2.47)	46.09
FTT ₁ (90% FMF + 10% TF)	8.22 (2.70)	8.44 (4.30)	8.29 (2.87)	8.55 (3.53)	7.11 (1.10)	8.14 (2.33)	48.75
FTT ₂ (80% FMF + 20% TF)	8.53 (4.63)	8.47 (3.40)	8.47 (4.33)	8.82 (3.93)	8.51 (4.40)	8.54 (4.47)	51.34
FTT ₃ (70% FMF + 30% TF)	8.51 (4.57)	8.35 (2.53)	8.24 (3.23)	8.71 (3.20)	8.02 (2.83)	8.37 (2.97)	50.20
FTT ₄ (60% FMF + 40% TF)	7.98 (2.03)	8.47 (3.40)	8.35 (3.73)	8.78 (4.27)	8.44 (4.43)	8.48 (4.17)	50.50
FTT ₅ (50% FMF + 50% TF)	8.58 (4.97)	8.64 (4.87)	8.15 (2.90)	8.82 (3.93)	8.49 (4.27)	8.51 (4.60)	51.19
Kendall's value	0.618**	0.356**	0.145**	0.224**	0.534**	0.309**	

(FMF- Finger millet flour, TF- Tapioca flour)

Value in parentheses are mean rank score based on Kendall's W test

** Significant at 1% level

The nutri waffles based on finger millet flour were standardised with different proportions of refined wheat flour (Fig.2). The mean scores and the mean rank scores for different quality attributes of finger millet based nutri waffles with refined wheat flour are presented in Table 3. Among the various treatments, FWT₅ (50% FMF and 50% RWF) scored the highest mean score for all organoleptic qualities like overall acceptability (8.71), texture (8.87), flavour (8.27), taste, colour and appearance (8.73). The mean scores obtained by overall acceptability of other treatments were T^W₀ (8.67), FWT₁ (8.41), FWT₂

The finger millet nutri waffles were standardised using finger millet flour in combination with different proportions of tapioca flour and is shown in Fig.3. The mean scores and the mean rank scores for different quality attributes of finger millet nutri waffles incorporated with tapioca flour are presented in Table 4. The organoleptic evaluation of finger millet nutri waffles incorporated with tapioca flour revealed that the mean scores obtained for appearance by FTT₅ (50% FMF + 50% TF), FTT₂ (80% FMF + 20% TF), FTT₃ (70% FMF + 30% TF), FTT₁ (90% FMF + 10% TF), FTT₄ (60% FMF +

40% TF) and T^T_0 (100% TF) were 8.58, 8.53, 8.51, 8.22, 7.98 and 7.13 respectively. The highest mean score for colour were observed in FTT_5 (8.64), followed by FTT_2 and FTT_4 (8.47), FTT_1 (8.44), FTT_3 (8.35) and T^T_0 (7.87). Among the finger millet nutri waffles incorporated with tapioca flour, the maximum mean score for flavour was obtained by FTT_2 (8.47) followingly FTT_4 , FTT_1 , FTT_3 , FTT_5 and T^T_0 with mean scores of 8.35, 8.29, 8.24, 8.15 and 7.67 respectively. For texture, of FTT_2 and FTT_5 , obtained the mean score of 8.82, followed by FTT_4 (8.78), FTT_3 (8.71), FTT_1 (8.55) and T^T_0 (7.47). FTT_2 obtained the highest mean score 8.51 for taste, followed by 8.49 (FTT_5), 8.44 (FTT_4), 8.27 (T^T_0), 8.02 (FTT_3) and 7.11 (FTT_1). Based on various sensory parameters of each treatment, the overall acceptability of finger millet based nutri waffles incorporated with tapioca flour (FTT_2) obtained the highest mean score of 8.54 for overall acceptability, followed by FTT_5 (8.51), FTT_4 (8.48), FTT_3 (8.37), FTT_1 (8.14) and T^T_0 (7.68). FTT_2 (80% FMF + 20% TF) obtained the maximum scores in organoleptic evaluation than other treatments. Based on organoleptic scores, FTT_2 (80% FMF + 20% TF) was selected as the best treatment. Khatri and Acharya (2021) formulated cassava incorporated biscuits. Biscuits were prepared by mixing cassava and wheat flour. Six treatments were prepared by adding 10%, 20%, 30%, 40% and 50% cassava flour with wheat flour. Incorporation of 20 per cent cassava flour in 80 per cent wheat flour (sample C) showed significantly better sensory property for color, flavor, texture and overall acceptability.

Based on the organoleptic qualities, the most acceptable treatments from each set was selected. Selected combinations of nutri waffles from set 1 and 2 are specified as Nutri waffle 1 (NW.1) and Nutri waffle 2 (NW.2), which are shown in Table 5.

Physico-chemical analysis of nutri waffles: Based on sensory evaluation, the treatments NW.1 (50% FMF + 50% RWF). The nutritive value of selected finger millet flour nutri waffle prepared with refined wheat flour observed to have moisture (4.43%), total carbohydrate (68.28g/100g), protein (6.26g/100g), total fat (2.91g/100g), total fibre (4.18g/100g), starch (39.65g/100g), calcium (115.32 mg/100g), iron (1.23 mg/100g), sodium (2.14 mg/100g) and potassium (177.82 mg/100g) content of NW.1 found to be lower than that of control waffle. Statistically, all these difference between the waffles were significant. The physico-chemical qualities of selected and control waffles are furnished in Table 6. Chaitra *et al.* (2020) studied the impact of replacement of wheat flour with finger millet and pearl millet flours in Belgian waffles and evaluated the use of millets in the formulation increased its total dietary fiber (6g), iron (12 mg), magnesium (60 mg), zinc (2 mg) and calcium (119 mg) of the waffles and lowered the total sugar (TS) content in the millet waffles. And there is a significant increase in the mineral content in all millet waffles. On the basis of their observation, they found that the use of millets can effectively enhance the nutritional profile of waffles.



Fig. 2. Finger millet nutri waffles incorporated with refined wheat flour

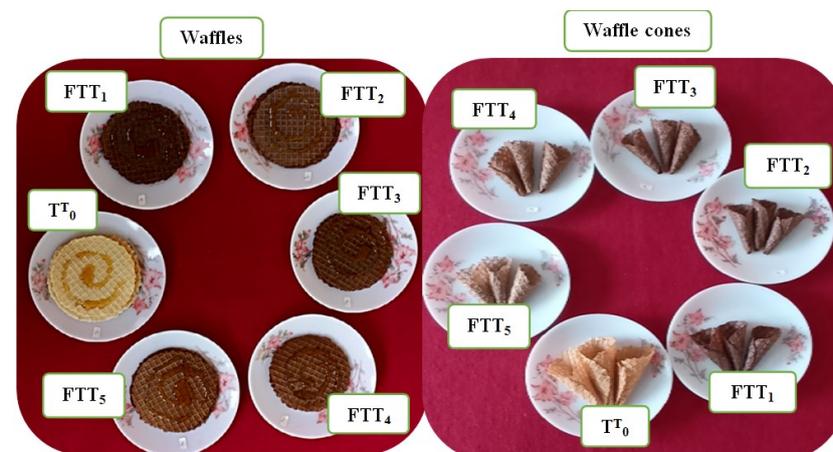


Fig. 3. Finger millet nutri waffles incorporated with tapioca flour

Table 5. Combinations of selected nutri waffles

No.	Sets	Nutri waffles	Selected treatment	Combinations
1	Set 1	Nutri waffles 1 (NW.1)	FWT ₅	(50% Finger millet flour + 50% Refined wheat flour)
2	Set 2	Nutri waffles 2 (NW.2)	FTT ₂	(80% Finger millet flour + 20% Tapioca flour)

Table 6. Nutritional qualities of finger millet nutri waffles incorporated with refined wheat flour

Treatment	T ^W ₀	NW.1	t value
Moisture (%)	5.87	4.43	1.44 ^{NS}
Total carbohydrate (g/100g)	70.56	68.28	2.28*
Protein (g/100g)	6.22	6.26	0.04 ^{NS}
Total fat (g/100g)	2.56	2.91	0.35 ^{NS}
Total fibre (g/100g)	1.66	4.18	0.09*
Starch (g/100g)	42.02	39.65	2.90*
Calcium (mg/100g)	12.24	115.32	126.25*
Iron (mg/100g)	0.06	1.23	2.03 ^{NS}
Sodium (mg/100g)	1.18	2.14	1.18 ^{NS}
Potassium (mg/100g)	89.32	177.82	108.39*

(T^W₀ - 100% RWF; NW.1 -50% FMF + 50% RWF; FMF- Finger millet flour, RWF- Refined wheat flour and NW-Nutri waffles)
T test (t) values are significant at 5% level

The physico-chemical qualities of finger millet nutri waffles incorporated with tapioca flour (NW.2) and 100 per cent tapioca flour waffles (T^T₀) were analysed. The physico-chemical qualities of finger millet nutri waffles (NW.2) along with control (T^T₀) were tabulated in Table 7. As per Table 7, moisture (5.37%), total carbohydrate (60.16g/100g), protein (4.60g/100g) total fat (3.04g/100g), total fibre (5.61g/100g), starch (31.66g/100g), calcium (177.11 mg/100g), iron (1.63 mg/100g), sodium (3.84 mg/100g) and potassium (242.72 mg/100g) of NW.2 found to be higher than its control waffle (100% TF). Zacharia (2020) developed finger millet nutri flakes with tapioca flour (60% FMF with 30% TF) had 7.73 g/100g protein, 44.32 g/100g carbohydrate, 2.86 per cent total fibre, 195 mg/100g calcium, 5.58 mg/100g iron and it provides 219.54 kcal energy. Begum *et al.* (2003) carried out experiments on nutritional enhancement of *papads* by substituting conventional grains to millet. Acceptable *papads* were developed by using finger millet (60%), sago (20%), black gram (20%) and spices. Calcium content was observed to be exceptionally higher in *papads* with finger millet (156 mg/100g) as compare to traditional *papads* (82 mg/100g).

Table 7. Nutritional qualities of finger millet nutri waffles incorporated with tapioca flour

Treatment	T ^T ₀	NW.2	t value
Moisture (%)	7.03	5.37	12.83*
Total carbohydrate (g/100g)	36.69	60.16	10.57*
Protein (g/100g)	0.62	4.60	1.43 ^{NS}
Total fat (g/100g)	2.22	3.04	4.62*
Total fibre (g/100g)	1.2	5.61	2.23*
Starch (g/100g)	9.22	31.66	4.46*
Calcium (mg/100g)	15.53	177.11	3.11*
Iron (mg/100g)	0.05	1.63	1.87 ^{NS}
Sodium (mg/100g)	6.78	3.84	6.49*
Potassium (mg/100g)	153.52	242.72	11.66*

(T^T₀ - 100% TF; NW.2 -80% FMF + 20% TF; FMF- Finger millet flour, TF- Tapioca flour and NW-Nutri waffles)
T test (t) values are significant at 5% level

Cost of Production: The cost production of finger millet incorporated nutri waffles were 18.85 Rs/100g for refined wheat flour combination and 21.19 Rs/100g for finger millet with tapioca flour combination. Zacharia (2020) observed that the cost of finger millet based nutri flakes varied from Rs. 21.55 to Rs. 24.1 / 100 g of nutri flakes.

CONCLUSION

Waffles are eaten all over the world, particularly in Belgium, which has over a dozen regional varieties. It is a convenience food eaten either as a snack or as a breakfast. Finger millet flour incorporated waffles had high organoleptic qualities. The treatments FWT₅ (50% FMF + 50% RWF) and FTT₂ (80% FMF + 20% TF) were the most acceptable combinations.

It is a good source of protein, carbohydrate and fibre. From the study it is evident that highly acceptable nutri waffles could be prepared from finger millet flour. The present study concluded that finger millet was underutilised grains, can be effectively used in development of millet based nutri waffles incorporated with refined wheat flour and tapioca flour. The study also revealed that millet incorporated waffles were nutritionally superior and hence can be included in the daily diet.

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