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Study on Development and Quality Evaluation of Chocolate Coated Millet Wafers

A. Sheeba Rani, C. Divya, V. Hema and R. Vidyalakshmi*

Indian Institute of Food Processing Technology, Thanjavur, Tamilnadu, India

**Corresponding author*

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ABSTRACT

The purpose of this work was to develop wafers incorporated with finger millet flour and pearl millet flour in different proportions. The wafers were tested for physical, chemical, microbial and sensorial properties. Based on sensory and nutritional properties one formulation from each millet flour was standardized. The crude fat, protein, ash and energy values of wafers increased with increasing percentage of millet flour. The optimized formulations were coated with chocolate and tested for nutritional, textural, rheological, microbial and sensory analysis. The textural analysis revealed that low hardness and fracturability was defined by millet wafers, where the control wafer showed high hardness values. But these values were not significantly different (p>0.05%) from the control sample. Pasting properties reported that the control sample displays maximum values for constraints such as peak viscosity, viscosity of the trough, and breakdown, final viscosity, and set back except pasting temperature. Microbial analysis showed that all wafers formulations and chocolate coated wafers were found no growth, so these products were safe for consumption.

Introduction

Wafer is a small crisp type scrumptious biscuit generally prepared with wheat flour, where the product will undergo a process of heat treatment which reduces the moisture content to a low level i.e. less than 5%. These products are commonly regarded as biscuits by consumers (Nandini *et al.,* 2019). The wafer industry is expected to grow further because the wafers are light in weight and enjoyed as a special treat by the consumer due to their unique sensorial property. Critical parameters for the quality of wafer biscuits are the level of crispness and its retention over shelf life. These two parameters play a major role in maintaining the quality of wafers. Most of the top-selling confectionery products are made up of wafers which are used as top-selling components. Bread or biscuit making literature shows little similarity to the wafers. Coming to characteristics of wafers, these are of crisp, light, and delicate texture. Due to low residual moisture i.e. in the range of 1 to 2% wafers are very crispy in texture. Wafers require high moisture barrier packaging because they are more hygroscopic in nature and losses their crispness when moisture content increased to 6 to 7% (Dogan and Kokini, 2007).

Millets are a rich source of phytochemicals, dietary fiber and also provides good nutritional health benefits, which increases the use of millets in food preparation (Lansakara *et al.,* 2016). The crop of food security is millets because they can withstand even under adverse agro-climatic conditions (Ushakumari *et al.,* 2004). Millets provide nutritional well-being in the daily diet and also helps in the control of disorders like diabetes mellitus, hyperlipidemia, and obesity (Veena *et al.,* 2003). Different studies on millets had revealed that daily intake of millets into the diet increases the immunity against several diseases (McKeown *et al.,* 2002). Millets supply distinctive support for health well-being, which is a good source of micronutrients, especially minerals, vitamin B, and nutraceuticals. Millets are not important part of their daily diet for American and European people, as these countries have now found the advantages of millets in the multigrain and gluten free cereal items. Though millets are African and Asian people's primary meal, they use millets to prepare products such as porridge, papad, chakli, infant food, bread and snack food (Antony Ceasar *et al.,* 2018).

Studies revealed that finger millet has competed nutritionally with barley, rye, and oats. It can provide the required nutrients for growing children, pregnant women, and aged people (Satish *et al.,* 2017). Many researchers revealed that finger millet has more health benefits (Chandra *et al.,* 2016) (Devi *et al.,* 2014). The consumer is satisfied with low calories because it contains more fiber content which is digested very slowly which helps to prevent consumption of more calories. Studies revealed that finger millet has complete nutritionally with barley, rye, and oats. It is able to provide required nutrients for growing children, pregnant women and aged people (Satish *et al.,* 2017). The first chocolate wafer was packed in a tin along with a sugar wafer and ginger cookie. The sugar wafer and ginger cookie have long since been abandoned but chocolate wafer lives on. The chocolate wafer is a snack item. Initially, it contains processed flour, sugar, and butter. A wafer made from only wheat flour may not be able to provide all the nutrition. Since hygiene is a major concern, safe and balanced commodities are in high demand in our everyday lives. It is therefore essential to growing nutritionally improved goods through the use of millets. With this in mind, by adding millet flour to the chocolate wafer sticks, a new revolutionary concept of creating a snack item, which can be a good vehicle to deliver whole

The main aim of this research work was to develop wafers incorporated with pearl millet and finger millet flour and standardize one formulation based on the sensory and nutritional analysis. Then millet Chocolate wafers were developed using this standardized formulation, these Chocolate wafers were tested for nutritional, textural, rheological, and sensory properties. All wafer formulations and chocolate coated wafers were tested for microbial analysis.

Materials and Methods

All the ingredients, such as finger millet, pearl millet, dark chocolate, milk chocolate, butter, sugar, were obtained from the local marketplace of Thanjavur for chocolate coated millet wafer preparation. Those millets were washed and milled first. After milling, the remaining process was continued. The process for chocolate wafers was given in the below flow sheet.

Batter preparation

A wafer sheet containing only wheat flour was used as a control because it is the common flour that is used to prepare all bakery products. In all formulations the batter was composed of 100gm flour, 25gm sugar/100gm flour, 10gm butter/100gm flour, and 170 ml of water were needed for batter preparation. All the raw materials were mixed for 3 to 6 minutes using a planetary mixer at 100 rpm, in order to blend the batter properly and to avoid the formation of lumps. After the addition of all ingredients, mixing is continued which helps in the prevention of dough formation between flour and water (Mert *et al.*, 2015).

Processing of chocolate millet wafers

As explained in the above process flow sheet, wafers were prepared in different formulations. The batter was blended properly and kept for baking in a wafer making machine at a temperature of 180°C for 50 seconds and locked with a lower and upper plate of the wafer machine. The thickness of the wafer was depending on the amount of batter we are depositing in the wafer machine. An equal amount of batter is used for processing all the wafers. After processing wafers were cooled to room temperature. The wafer should not have cooled below the dew point because they will gain moisture from the atmosphere. After cooling wafers and cut in to equal sizes and shapes and then coated with melted dark and white chocolate

Formulations

In ten formulations, wafers blended with pearl millet flour and finger millet flour were made. One formulation of each millet flour was selected depending on nutritional and sensory properties, and the influence of millet flour on the quality of wafers was assessed.

The above table shows that different formulations of wafers were prepared, based on nutritional and sensory characteristics, two formulations were standardized, one from finger millet wafers and another from pearl millet wafers, and these optimized formulations were coated with chocolate to enhance flavor and taste. Chocolate coated wafers were tested for proximate, textural, rheological and sensorial properties. All wafer formulations were tested for microbial analysis.

Analysis

Proximate analysis

The nutritional components like protein, fat, carbohydrate, ash, moisture content and fiber were analyzed according to AOAC methods (2005). Nutritional components were tested for all wafers, and after optimizing the formulation, the chocolate-coated wafers were analyzed for nutrients.

Texture

Textural properties of optimized wafer formulations were measured by using a Brookfield texture analyzer. A three-point twist probe was equipped to set the device; compression and trigger force 5.0 g; initial test velocity 2.1 mm/s; after test velocity 10.0 mm/s; and break distance 10 mm. A load cell measuring 30 N was used. Samples with a hardness dimension of 27mm 36mm and fracturability dimension of 53 mm, 94 mm were horizontally mounted on the base of the unit. By calculating the force needed to split them, the fracturability, of the wafer sheet was quantified (Nada *et al.*, 2016).

Rheological properties

The pasting property of standardized batter was analyzed using a Rapid Visco Analyzer

(RVA Newport Scientific Pvt. Ltd., New South Wales, Australia). Flour sample (3g) was mixed with 25 ml of distilled water in the RVA sample canister to make a total of 28 gm of flour suspension. The sample slurry was maintained at 50°C for 1 minute and then increased from 50 to 95°C and held for 3 minutes (Falade & Okafor, 2013). Later on, the paste was cooled to 50°C. Pasting temperature, peak viscosity, trough viscosity, break down point, final, and set back viscosities of standardized flours were determined and compared with control wheat flour.

Microbial analysis

Microbial analysis was done for all wafer formulations and after standardization of wafer formulation, the chocolate-coated wafers were prepared with 50% formulation of finger millet flour and pearl millet flour. These wafer sticks were analyzed for microbial analysis in terms of TPC, yeast, and fungal growth.

Sensory analysis

Sensory analysis is done for all wafer formulations, by 15 trained panel members. The panel evaluated taste, texture, appearance, color, and overall acceptability of the product by using a 9-point hedonic scale, where 9= extremely like and 1= extremely dislike. Chocolate coated wafers are also evaluated for sensory analysis. chocolate-coated wafers of 2 formulations were undergone for sensory evaluation, in that one is the standardized formulation of 50% finger millet wafer and another one is 50% pearl millet wafer formulation (Kokani *et al.*, 2015.

Statistical analyses

The mean and standard error of means of triplicate analysis were calculated. The analysis of variance was performed to determine the significant difference between the means, while the means were separated using the Tukey test. SPSS statistical software is used for all analysis.

Results and Discussion

Proximate composition of different plane wafer formulations and chocolate wafers

Initially, the proximate composition of different wafer formulations was determined and from that, the standardized formulation is preferred for chocolate coated wafer preparation. Chocolate wafer sticks prepared with 50% formulation of finger millet flour and another one with 50% formulation of pearl millet flour were analyzed for moisture, protein, fat, ash, fiber, and carbohydrate. The moisture content of plain ragi millet and pearl millet wafers were determined. Even though all the wafer formulations were subjected to the same baking and drying time but the moisture content is varied from one formulation to another, it may be due to an increase in the millet flour content. Samples B, C, D, E are significantly different ($p<0.05$%) from the control sample, and there is no significant difference ($p>0.05$%) in the moisture content of sample A and the control sample. Similar results were represented by (Nandini *et al.,* 2019). Results showed that samples F, G, H, I, J were significantly different ($p<0.05$) from the control sample. Ash content keeps on increasing when there is an increase in the proportion of millet flour. In A, B, C, D, E samples of finger millet wafers sample E contains the highest amount of ash content due to the high proportion of millet flour, and in samples, F, G, H, I, J samples of pearl millet wafers sample J contains highest ash content. There is no significant difference ($p>0.05$%) between the ash content of sample A and sample F when compared with the control sample. Sample E followed by sample J contains the highest mineral content, it might be due to an increase in millet flour proportion. The results in table 2 represented that protein content was found to be highest in sample E followed by sample J. when compared with the control sample, only E and J are significantly different ($p<0.05\%$), and remaining all samples are not significantly different ($p>0.05\%$). The fiber content of the wafers was increased with an increase in the millet flour content. Sample E in finger millet wafers and sample J of pearl millet wafers resulted from high fiber content.

In table 2, results represented that the fat content of the wafer samples was increased with an increase in millet flour addition. Even though the same amount of butter was added to the formulation but different formulations showed different results. The highest fat content was found in sample E of finger millet wafers and sample J of pearl millet wafers. Carbohydrate content was decreased with an increase in the amount of millet flour, similar results were reported by (Nandini *et al.*, 2019).

Table.1

Ingredient	**Control**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Wheat flour(g)	100	90	80	70	60	50	90	80	70	60	50
Finger millet flour(g)	-	10	20	30	40	50	-	-	-	-	-
Pearl millet flour (g)	-						10	20	30	40	50
Butter (g)	15	15	15	15	15	15	15	15	15	15	15
Sugar (g)	50	50	50	50	50	50	50	50	50	50	50
Water (ml)	170	170	170	170	170	170	170	170	170	170	170

Table.2 Proximate compositions of plain and chocolate coated wafers

S.no	**Sample**	**Moisture (%)**	**Ash (%)**	**Protein (gm)**	**Fiber (gm)**	**Fat (gm)**	**Carbo-hydrate (gm)**	**Energy (Kcal)**
1	control	$1.36^{a}\pm0.1$	$0.60^{a}\pm0.1$	$11.00^{a}\pm0.01$	$2.1^{a}\pm0.01$	$2.19^{a}\pm0.01$	83.35	397
2	A	$1.96^{abcd}\pm0.91$	$0.91^{a}\pm0.91$	$11.60^{ab}\pm0.1$	$2.167^{a}\pm0.05$	$2.23^{a}\pm0.057$	81.14	388
3	B	$2.09^{bc}\pm0.19$	$1.26^{b}\pm0.115$	$11.63^{ab}\pm0.22$	$2.280^{a}\pm0.1$	$2.24^{a}\pm0.095$	80.64	389
4	C	$2.2^{c}\pm0.197$	$1.37^{b}\pm0.06$	$11.76^{ab}\pm0.11$	$2.33^{b}\pm0.09$	$2.71^{ab}\pm0.580$	79.64	389.9
5	D	$2.3^{d}\pm0.167$	$1.42^{ab}\pm0.577$	$11.81^{ab}\pm0.21$	$2.39^{bc}\pm0.05$	$2.90^{bc}\pm0.421$	79.18	390
6	E	$2.5^{e}\pm0.14$	$1.81^{bc}\pm0.44$	$12.013^{b}\pm0.94$	$2.46^{bcd}\pm0.02$	$2.99^{bc}\pm0.034$	78.227	387
7	F	$1.97^{ab}\pm0.56$	$0.61^{bc}\pm0.06$	$11.64^{c}\pm0.015$	$2.48^{cd}\pm0.01$	$2.62^{bc}\pm0.011$	79.17	388
8	G	$2.01^{bc}\pm0.85$	$0.89^{bc}\pm0.05$	$11.72^{c}\pm0.005$	$2.82^{d}\pm0.05$	$3.04^{bc}\pm0.011$	78.53	389.3
9	H	$2.2^{bc}\pm0.19$	$1.2^{c}\pm0.196$	$11.89^{cd}\pm0.003$	$3.18^{d}\pm0.02$	$3.46^{bc}\pm0.090$	77.56	390.6
10	I	$2.43^{cd}\pm0.15$	$1.75^{cd}\pm0.05$	$11.91^{cd}\pm0.045$	$3.54^{d}\pm0.75$	$3.83^{cd}\pm0.06$	77.22	391.6
11	J	$2.52^{cd}\pm0.34$	$1.79^{cd}\pm0.288$	$12.01^{d}\pm0.152$	$3.91^{d}\pm0.23$	$4.23^{d}\pm0.015$	76.61	393.2
12	T1	$4.2^{a}\pm0.01$	$1.80^{a}\pm0.02$	$12.64^{a}\pm0.04$	$3.86^{a}\pm0.02$	$4.57^{a}\pm0.04$	78.93	406
13	T2	$4.5^{a}\pm0.02$	$1.79^{a}\pm0.01$	$13.01^{b}\pm0.18$	$4.32^{b}\pm0.01$	$4.82^{b}\pm0.02$	77.85	406.42

Note: Different letters a, b, c & d in the superscript within the same column represent the significant differences among the samples ($p<0.05$, Tukey posthoc test)

Table.3 Microbial analysis of wafers

Sample	Bacteria (cfu/gm)	Fungi (cfu/gm)
control	NG	NG
E	NG	NG
J	NG	NG
T1	NG	NG
T2	NG	NG

Note:Cfu/g: colony forming unit per gram, NG: No growth detected, A: wheat flour wafers, E: 50% Finger millet flour wafers, j: 50% pearl millet flour wafers, T1: finger millet chocolate wafer, T2: pearl millet chocolate wafer

Table.4 Textural properties of optimized formulations

Sample	Hardness (g)	Fracturability (mm)	Puncture strength (N/mm^2)
Control	901.02±107.35[a]	68.34±0.49[a]	2.73±0.23[a]
E	869.62±104.54[a]	67.60±0.56[b]	2.17±0.34[a]
J	861.54±110.48[a]	67.31±0.34[b]	2.37±0.70[a]

Note: All values are expressed in mean standard ± deviation for triplicate experiments. Different letters indicate significant differences from one sample to another sample (p<0.05%)

Table.5 Pasting properties of optimized millet flours

Sample	PV	TV	BD	FV	SB	PT(^{0}C)
Control	1460	835	625	1835	1011	82
E	689	500	190	1158	897	84.7
J	590	463	123	1075	659	86.3

Notes: PV=Peak viscosity, TV=Trough viscosity, BD=Bulk density, FV=Final viscosity, SB=Set back, PT=Pasting temperature

Table.6 Sensory analyses of plain wafers and chocolate coated wafers

Sample	Color	Appearance	Texture	Flavor	Taste	Overall acceptability
Control	8.1±0.9932	8.6±0.8984	8.1±0.5323	8.1±0.2831	8.6±0.6521	8.2±0.2165
A	6.6±0.1321	6.3±0.2165	7.1±0.2457	7.3±0.5813	6.8±0.2314	7.5±0.9041
B	6.7±0.2434	6.4±0.3578	7.1±0.4632	6.2±0.1694	7.0±0.2467	7.4±0.5921
C	6.8±0.6543	7.2±1.9382	7.5±0.9547	7.1±0.8029	6.9±0.2051	7.3±0.9413
D	7.5±0.4652	7.2±0.3587	7.5±0.6153	7.2±0.8239	7.1±0.1563	7.2±0.5774
E	7.7±0.3564	7.3±1.5642	7.9±0.2176	7.3±0.0492	7.5±0.2916	7.5±0.5931
F	7.6±0.9980	7.8±0.2984	7.2±0.2745	7.5±0.4517	7.9±0.6152	7.8±0.9622
G	7.3±0.5689	7.5±0.8975	7.5±0.5392	7.4±0.2882	7.2±0.4953	7.6±0.8641
H	7.1±0.9876	7.3±0.7853	7.4±0.275	7.3±0.2902	7.3±0.2164	7.3±0.5681
I	7.2±0.3462	7.1±1.3862	7.1±0.9053	7.0±0.4215	7.1±0.5032	7.1±0.8632
J	7.0±0.6754	7.3±0.4137	7.3±0.2857	7.0±0.1954	6.9±0.2476	7.4±0.2157
T1	7.5±0.001	8.7±0.532	7.4±0.0023	7.9±0.4932	8.2±0.6478	7.9±0.0021
T2	7.7±0.0089	8.9±0.003	7.6±0.0281	8.0±0.0732	8.5±0.001	8.5±0.0026

Fig.1 Process flow sheet for chocolate coated wafers

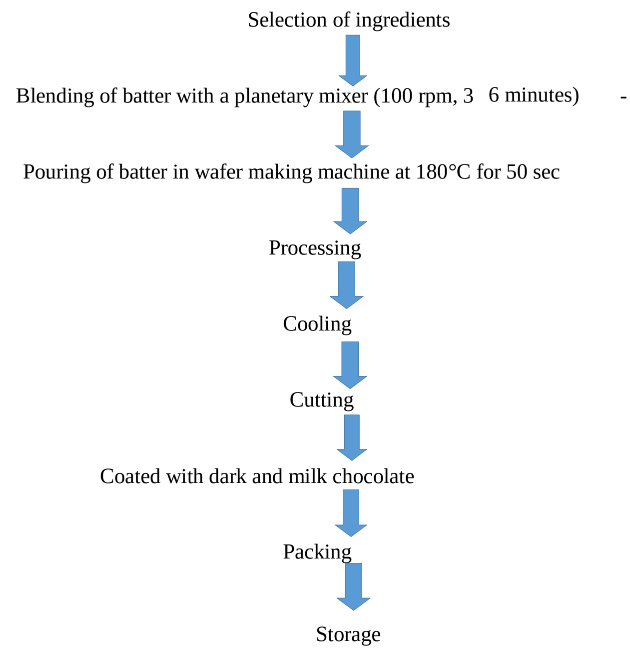

Table 2 shows the proximate composition of standardized millet wafer sticks. Samples T1 and T2 were standardized formulations for chocolate wafer stick development. Results found that the moisture content of the T1 sample is around 3.88% and T2 is around 3.89%. There is no significant difference (p>0.05%) between the samples. Ash content was found 2.13% in the T1 sample and 2.59 in sample T2. There is no significant difference (p>0.05%) in the ash content of both samples. Results showed that there is no significant difference (p>0.05%) between the fat content of the samples, similarly, fiber, protein, and carbohydrate content also showed a non-significant difference (p>0.05%) when compared with normal plane wafers. Here plane wafers of standardized formulations i.e. E and J should be kept as control.

Microbial analysis

Microbiological analysis of freshly made plain wafers and chocolate wafers, revealed that there was no evidence for any microbes observed in the fresh plane wafers and chocolate wafer sticks. This may be due to the baking of the wafers at a high temperature which can destroy a large number of micro-organisms (Wijesinghe and Kumarasiri, 2019). Similarly, the chocolate wafer sticks also didn't observe any microbial growth. Therefore, these wafers were suitable for consumption. The total plate count of wafers was determined using nutrient agar containing Petri dishes followed by the spread plate method. Table 3 shows the microbial analysis of wafers.

Textural properties

For standardized E sample formulation and J, sample formulations were investigated for hardness, fracturability, and puncture strength. The samples incorporated with millet flour were characterized by low hardness when compared with the control sample. The lowest value was found for the J sample. Millet flour doesn't show any effect on the fracturability of wafer samples.When compared with control samples E and J have low values, but these values are not significantly different (p>0.05%) from the control wafer sample (Nada *et al.*, 2016).

Pasting properties of optimized formulations

The results of pasting properties of finger millet-wheat composite flour, pearl millet-wheat composite flour, and refined wheat flour were obtained by RVA and expressed in (Table 5). The findings showed that maximum values for pasting parameters such as peak viscosity, trough viscosity, breakdown, final viscosity and set back except for pasting temperature are seen in the control sample. The results showed that, with the increase in the incorporation of millet flour, pasting parameters were reduced. But pasting temperature is slightly increased in pearl millet and finger millet flour formulation. It was observed that the addition of millet flour resulted in viscosity decrement when compared with wheat flour batter which indicates that the starch present in millet flours was more resistant to swelling and rupture towards shear. The size and shape of the starch molecules, the ionic charge on the starch, the form and elemental composition within the granules, the existence or absence of fat and protein, and perhaps the molecular size and level of dividing of the starch fractions maybe factors affecting this property.

Sensory analysis of freshly made plain wafers and chocolate wafers

Sensory evaluation was conducted for wafer formulations and optimized chocolate coated wafers. The comparison was based on different sensory features and rated on the 9-point hedonic scale. The mean values of the sensory panel rating of wafers and chocolate wafers were presented in Table 5. Significant differences were observed in the sensory scores of all wafer formulations (Kokani *et al.*, 2019). The effect of millet flour on the sensory characteristics of wafers was presented in Table 5. With an increase in the level of millet flour in the formulation, the sensory scores for color, flavor, crispiness, taste, and overall acceptance attribute of wafers decreased.

In conclusion this research work has comprehensively investigated the and functional and nutritional properties of wafers incorporated with pearl millet and finger millet flour and a chocolate coated wafers developed from the optimized formulation. Compositions for chocolate wafer development have been optimized based on nutritional and sensory characteristics. The influence of millet flour on the consistency and functional properties of wafers has been assessed. In all formulations, it was observed to be significant variation with the addition of millet flour to the wafers. It was found that the texture and hardness of the wafers were also affected but no significant difference between the optimized formulation and control wafer formulation. The results indicated that pasting parameters of optimized flour (peak viscosity, trough viscosity, breakdown, final viscosity, and setback) were decreased with the increase in the addition of millet flour in the formulation. But pasting temperature is slightly increased with an increase in the incorporation of millet flour when compared with control wheat flour. Microbial analysis of freshly prepared wafers revealed that no growth was found in the plane wafers and chocolate wafers therefore these are safe for consumption.

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