CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

DEVELOPMENT AND QUALITY ANALYSIS OF WAFER PREMIXES USING DIFFERENT TYPES OF MILLETS

Baishakhi Mandal[1]✉ , Surbhi Antarkar[2]✉

[1]*Department of Food Science and Nutrition SNDT Women's University (SNDT College of Home Science), Karve Road, Pune, Maharashtra, India.*

✉*bmandal352k@gmail.com;* ✉*surbhi.antarkar@gmail.com*

https://doi.org/10.34302/crpjfst/2024.16.2.9

Article history:
Received: September 7th, 2023
Accepted: April 22nd, 2024

Keywords:
Wafers;
Finger millet;
Pearl millet;
Sorghum;
Premix;
Gluten free.

ABSTRACT

In the current study, four different varieties of wafer premixes incorporated with malted finger millet flour, pearl millet flour, sorghum flour and mixed millet flour (finger millet, pearl millet and sorghum) were developed by replacing refined wheat flour as millets are rich in dietary fiber, vitamins, and minerals including other nutrients and have several beneficial effects to our health. Malting helps to increase digestibility by breaking down complex substances into simple one and helps in increasing the bioavailability of some nutrients. The variety of developed premixes has four distinct flavours namely, chocolate flavour for ragi wafer premix, cinnamon flavour for bajra wafer premix, vanilla flavour for jowar wafer premix and strawberry flavour for the mixed millet wafer premix. Raw materials were procured from local grocery shops and e-commerce platform. Trials were taken by developing ice cream cones using malted millet flour and other raw materials. The amount of ingredients to be used to develop the premixes was decided through the organoleptic evaluation performed using a 5-point hedonic scale. Among these four premixes, wafers made with ragi (finger millet) wafer premix got the most overall acceptability score followed by jowar (sorghum) wafer premix, mixed millet wafer premix and bajra (pearl millet) wafer premix. Standby pouches made of LDPE were used as packaging material to perform the primary functions of packaging such as protection, preservation, and presentation of the product inside the packet. Developed premixes were subjected to physical, chemical, and microbial analysis to evaluate the quality and storage behaviour. The main motive of this study was to develop healthier version of wafers without compromising their taste as well as texture and to know the effect of using different kind of millets in the processing of wafers. Cereals can be replaced by millets to add more nutrition in daily diet. So, if millets are used in commercial snack products, then it can contribute to the upliftment of total health of a community. Wafers in the form of cones, bowls etc. can contribute to edible cutlery which is sustainable and can reduce the load of waste from the food industry.

1.Introduction

In food technology generally, wafer means light, thin and crispy food items those are baked from batters. In the United States wafers are also known as crisp cookies or biscuits. The word Wafel is originated in German. Some studies found that wafel comes from the Old High German words *waba* and *wabo* (honeycomb). Later the word around 1377 was conjoined into Middle English as wafer. Wafers are available in different shapes namely, flat wafers, communion wafers, fan wafers, wafer sticks or flute wafers, hollow wafers, sandwich wafer bars, noncreamed wafers, wafer breads, wafer cones etc. In industry, wafers are baked in hot metal molds. There are two basic types of wafers-1. No or low sugar wafers 2. Sugar wafers. As suggested by the name no or low sugar wafers contain zero to a few percentages of free sugar on a flour base, while sugar wafers are composed of more than 10% of sugars on a flour base. No sugar wafers are baked in closed molds under pressure and heat. The sugar wafers are given different shapes by rolling, pressing, or deep forming but this is possible while the product is hot, as the sugar resolidifies during the process of cooling down and makes the product crispy (Tiefenbacher, 2017).

Generally refined wheat flour or corn flour is used as a flour base in wafers available in market. But intake of refined-grain foods is linked to a higher risk of weight gain or higher BMIs, according to certain large cohort studies, if intake of refined-grain foods is higher than advised. In areas like India with high carbohydrate and/or rice intakes (>200 g/d), refined-grain foods were linked to an elevated risk of type 2 diabetes (Jones et al., 2020).

With the changes in lifestyle and increment of non-communicable diseases, the need to develop not only tasty but also healthy and nutritious food products has become important. That is why alternating refined flour with a better ingredient without changing the physical characteristics of traditional wafers is also in trend to upgrade the nutritional value of the product.

Zanariah, M. et al. (2019) utilized Saba Banana (Musa bablisiana) peel flour as fiber ingredient in the waffle cones. The high-water holding capacity of banana peel powder caused lowering the tensile strength of wafer cone but low oil holding capacity helps in reducing oil absorption during baking.

Two graduate students' team from department of Animal Sciences and Industry at Kansas State University developed, 'Gluten-Free Fun Flavored Waffle Cones', using brown rice flour and secured first position at the 2009 AACC International Student Division Product Development Competition (Daniel et al., 2010)

"Premix is a combination of two or more fortificants in a specific proportion with or without additives packed and meant for use in formulating a product falling under any category" (FSSAI, 2018).

In this study 4 different variety of premixes of sugar wafers incorporated with malted finger millet flour, pearl millet flour, sorghum flour and mixed millet flour (finger millet, pearl millet and sorghum) were developed by replacing refined wheat flour as millets are rich in dietary fibre, vitamins and minerals including other nutrients and have several beneficial effects to our health. Germination enhances the bioavailability of some micronutrients like calcium and iron while reducing some antinutritional elements like phytates and tannins. By reducing complicated compounds to simple ones, malting enhances the amount of nutrients in food and facilitates digestion. Iron and calcium are two minerals whose bioavailability is improved by malting (Vijay et al., 2021). According to a study germination of finger millet seeds results in elevated protein content of the seeds (Swami et al., 2013). Rice flour was also used to develop the crispy texture of wafer and for binding purpose.

Millet belongs to the cereal of grass family, *Poaceae* and is mainly cultivated for its seeds. Finger Millet's (*Eleusine coracana*) grains vary in colour from white to brown, are consumed in different form including chapati, porridge, cakes by using milled flour (Traditional Crops, FAO). Finger millet is one of the oldest crops in India. Unlike other millets like sorghum, pearl millet, proso millet, and foxtail millet, finger millet has a multilayered (five layered) testa, which may be one of the potential explanations for the increased dietary fiber content of finger millet (Shobana et al., 2013). In native Indian languages, finger millet is also known as ragi (Kannada), nachni (Marathi), mandua (Bengali), ragulu (Telugu), kelvaragu (Tamil), etc. (Dayakar Rao et al., 2017).

Pearl millet (*Pennisetum glaucum)* is a tropical cereal grass with small grains that is also known as *P. typhoides*, *P. americannum*, or *P. spicatum*. India and northern Africa are the primary regions for pearl millet cultivation (Taylor et al., 2006). The pearl millet plant can grow anywhere between 0.5 and 4 meters tall, and the grain can be almost all white, pale yellow, brown, grey, slate blue, or purple. The ovoid grains are substantially larger than those of other millets, measuring between 3 and 4 mm in length, and the average weight of a thousand seeds is 8g (FAO, 1995). In India, pearl millet is also known as bajra (Hindi, Bengali, and Punjabi, sajjai (Kannada), kamboo (Tamil, Malayalam), and bajri (Marathi, Gujrati), among other names (Dayakar Rao et al., 2017).

Sorghum (*Sorghum bicolor (L.) Moench)* is a member of the grass family *Poaceae*'s Andropogonae tribe. Sorghum seems to have come from Ethiopia to eastern Africa around 200 AD or earlier. During the first millennium BC, sorghum was probably carried from eastern Africa to India. The sorghum kernel can be white, reddish-brown, pale yellow, or deep purple-brown, among other colours. Although their size and form might vary, most kernels are spherical (FAO, 1995). Sorghum is primarily a warm-season, daylength-sensitive plant with a C4 metabolism (Blum, 2004). The grain is made up of naked caryopsis, which includes a pericarp, endosperm, and germ. In India, sorghum millet is also known as jowar (Hindi), jola (Kannada), cholam (Tamil, Malayalam), jowari (Marathi), juar (Bengali, Gujrati), among other names (Dayakar Rao et al., 2017).

Millets are a great source of several nutrients; they are superior in nutritive value as compared to major cereals like wheat and rice. Complex carbohydrates are more in millet seeds than the simpler ones. Millets contain a good amount of dietary fibre, for example, finger millet has 18.6% dietary fibre and 3.6% crude fibre (Dayakar Rao et al., 2017). Millets do not contain gluten as a source of protein. Essential amino acids except lysine and threonine are present in millet grains with relatively high amounts of methionine (Abah et al., 2020). The chemical score (a measure of protein quality determined as the ratio of the amount of an amino acid in a test protein over a reference protein expressed as a percentage) of finger millet protein is 52 as opposed to 37 for sorghum and 63 for pearl millet (FAO, 1995). Millets have a good amount of vitamins (vitamin B complex except vitamin B12, vitamins A, D, E and K) and minerals such as calcium, magnesium, phosphorus, iron etc. In comparison to other grains and millets, finger millet has eight times more calcium (344 mg%) (Shobana et al., 2013). Pearl millet has more niacin as compared to other cereal grains and sorghum is high in beta-carotene which the body can convert into vitamin A, leutin, and zeaxanthin (Dayakar Rao et al., 2017). Various functional components such as tannins, flavonoids, polyphenols, phytate and phytic acid are present in millets. Due to this nutritional composition, millets can help to prevent several non-communicable diseases like elevated blood pressure and sugar, obesity, cardiovascular diseases, constipation etc. including different types of cancers.

Trials were taken to standardize the amounts of ingredients to be used and the procedures of making wafer from the premixes. After developing the premixes 100gm LDPE zip lock standy pouches were used for packaging and stored at room temperature away from direct sunlight and moisture. Sensory evaluation was performed while conducting trials as well as in different stages of storage period to know the acceptability of the final products prepared using the premixes. The combination of various modalities of perception that are used in the selection and consumption of food is referred to as sensory quality. The acceptance of the food is determined by appearance, flavour, and texture. In the final analysis, this response, which is heavily influenced by a range of psychological and social elements, is crucial to the acceptance and choice of foods (Srilakshmi, 2018). Proximate analysis, microbial analysis, and chemical analysis were accomplished to evaluate the quality of the premixes and to study their storage behaviour. The motive of this study was to develop a healthier version of wafers from premixes and to study their physical, chemical, and microbial properties.

2.Material and methods

For the preparation of millet wafer premixes materials such as finger millet seeds, finger millet flour, sorghum seeds, pearl millet seeds, rice flour, milk powder, sugar, cocoa powder, cinnamon powder, baking powder and oil were procured from local grocery store in Pune. Vanilla powder and strawberry powder were purchased from an e-commerce platform. For control, All-purpose flour was used along with other ingredients.

Equipment and utensils required for the study were used from the Nutrition and Food Processing laboratory of the Food Science and Nutrition department in S. N. D. T. College of Home Science, Pune.

A standby pouch made of low-density polyethylene (LDPE) was used as a primary packaging material.

Chemicals required for quality analysis were obtained from the Department of Food Science and Nutrition.

2.1. Processing of raw materials

After the procurement of millets (finger millet, sorghum, and pearl millet), they were subjected to sorting, washing, soaking, germinating, drying, roasting, grinding, and sieving. Various steps of processing are given below (Figure 1).

Procurement of millets (finger millet, pearl millet and sorghum)

↓

Sorting
(To eliminate foreign materials like stone, dried stick, husk etc., damaged grains and other edible grains)

↓

Washing
(2-3 times by using tap water to remove dirt, dust, and other adhering impurities)

↓

Soaking
(Soaked or steeped into drinking water at room temperature until softened.
Finger millet: 3-4 hours
Pearl millet: 5-6 hours
Sorghum: 10-12 hours)

↓

Germinating
(Germinated for 1-2 days in room temperature
Finger millet: 24 hours
Pearl millet: 36 hours
Sorghum: 24 hours)

↓

Drying
(After germination the seeds were sun-dried for 1-2 days)

↓

Roasting
(Dry roasted on low flame (45-50º C) until aroma comes out)

↓

Grinding
(Grinded using mixer grinder to get the flour)

↓

Sieving
(Sieved to eliminate the coarse particles)

Figure 1. Processing of raw millets

2.2. Trials

The trials for the product were conducted in the Nutrition and Food Processing Laboratory of S.N.D.T College of Home Science, Pune. Following trials have been made to prepare millet-based wafer premix in the laboratory.

Table 1. Ingredients used to prepare wafers in trials

Ingredients	**Trial 1 for Finger millet wafer premix (T1) (gm)**	**Trial 2 for Finger millet wafer premix (T2) (gm)**	**Trial 3 for Finger millet wafer premix (T3) (gm)**	**Trial 1 for Pearl millet wafer premix (T4) (gm)**	**Trial 1 for Sorghum wafer premix (T5) (gm)**	**Trial 1 for Mixed millet wafer premix (T6) (gm)**	**Trial 2 for Mixed millet wafer premix (T7) (gm)**
Finger Millet Flour	25	25	-	-	-	-	-
Malted Finger Millet Flour	-	-	30	-	-	10	10
Malted Pearl Millet Flour	-	-	-	30	-	10	10
Malted Sorghum Flour	-	-	-	-	30	10	10
Rice Flour	10	15	20	20	20	20	20
Sugar (Powdered)	30	30	30	30	30	30	25
Milk powder	17	12	14	14	14	14	12
Cocoa powder	5	5	5	-	-	-	-
Cinnamon powder	-	-	-	5	-	-	-
Vanilla powder	-	-	-	-	5	-	-
Strawberry Powder	-	-	-	-	-	5	12
Baking Powder	1	1	1	1	1	1	1
Oil	12 ml	12 ml	18 ml	18 ml	18 ml	18 ml	18 ml
Luke warm water	60 ml	68 ml	70 ml	70 ml	70 ml	70 ml	70 ml

Weighing malted millet flour and rice flour, then sieving it

↓

Addition of powdered sugar and baking powder.

↓

Addition of flavouring powder and milk powder, sieving and mixing all the dry ingredients.

↓

Addition of oil and mixing it.

↓

Addition of lukewarm water and mixing.

↓

Stirring until proper lumps-free consistency is achieved.

↓

Heating a flat pan on low flame.

↓

Taking a spoon of the mixture and spreading it with the back of the spoon (as thin as possible) when the pan is not so hot.

↓

Cooking it for a few minutes on low flame.

↓

The desired shape (cone or roll) was given after flipping.

↓

Cook for a few minutes more from every side until gets crispy.

↓

Keeping it to cool down.

Figure 2. Procedure of making wafers

Table 2. Ingredients used to prepare premixes (in 100 gm): -

Ingredients	**Control (all-purpose flour) (gm)**	**Finger millet wafer premix (gm)**	**Pearl millet wafer premix (gm)**	**Sorghum wafer premix (gm)**	**Mixed millet wafer premix (gm)**
All-purpose flour	35	-	-	-	-
Malted Finger Millet Flour	-	30	-	-	10
Malted Pearl Millet Flour	-	-	30	-	10
Malted Sorghum Flour	-	-	-	30	10
Rice Flour	20	20	20	20	20
Sugar (Powdered)	30	30	30	30	25
Milk powder	14	14	14	14	12
Cocoa powder	-	5	-	-	-
Cinnamon powder	-	-	5	-	-
Vanilla powder	-	-	-	5	-
Strawberry Powder	-	-	-	-	12
Baking Powder	1	1	1	1	1

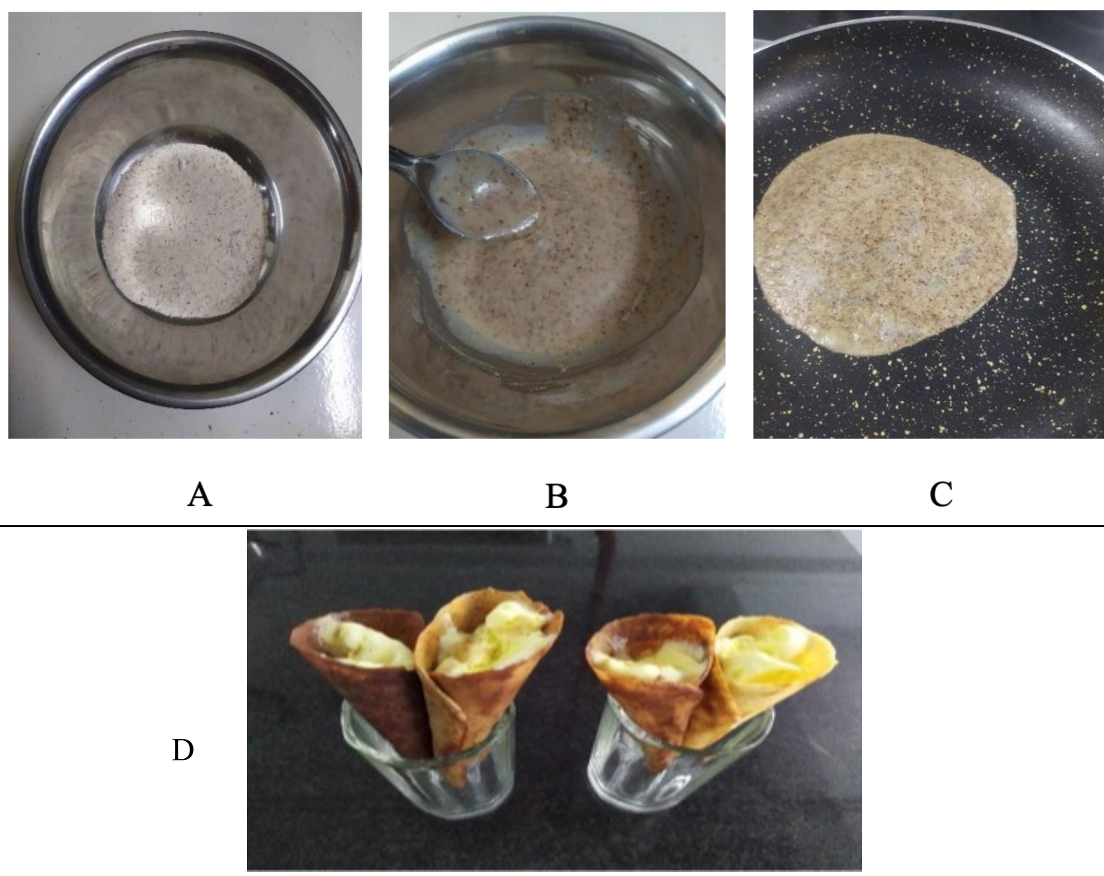


Figure 3. Processing of wafers
(A) Developed premix, (B) Prepared mixture by addition of oil and water, (C) Cooking of wafer, and (D) Prepared ice-cream cones from different premixes (1. Finger millet wafer, 2. Mixed millet wafer, 3. Pearl millet wafer and 4. Sorghum wafer)

2.3. Sensory evaluation

Sensory evaluation of the test samples was done using the 5-point Hedonic Rating Scale for parameters: Taste, Appearance, Colour, Flavour, Texture and Overall Acceptability. Organoleptic analysis was performed for the sample size (n) of 30 people in SNDT College of Home Science to know the acceptability of the product.

2.4. Packaging

Packaging of the premixes was done as per FSSAI standard [Food safety and standards (packaging and labelling) regulations, 2011]. Standy pouches made of LDPE were used as packaging material to perform the primary functions of packaging such as protection, preservation, and presentation of the product inside the packet.

2.5. Quality evaluation:

After developing the premix, quality was checked by physical analysis, physicochemical analysis, microbial analysis, and sensory evaluation. Finished goods were subjected to the following tests-Parameters for testing millet wafer premixes:

A. Physicochemical Analysis:
- Moisture content (FSSAI, 2015)
- Estimation of total sugar (FSSAI, 2015)
- Estimation of alcoholic acidity (IS: 1155-1968)
- Estimation of carbohydrate content (calculated by using the food composition table given by ICMR, 2017)
- Estimation of protein content (calculated by using the food composition table given by ICMR, 2017)
- Estimation of fat content (calculated by using the food composition table given by ICMR, 2017)

B. Microbial Analysis:
- TPC (Total Plate Count) (FSSAI, 2012)

A. Physicochemical Analysis:

2.5.1. Moisture estimation of developed premix:

The standard method of oven drying as mentioned in the FSSAI manual was followed to calculate the moisture content of the sample (FSSAI, 2015).

$$\text{Moisture (\%)} = \frac{(W1 - W2)}{W1 - W} X\ 100 \quad (1)$$

Where,

W1 = Weight in gm of the dish with the material before drying

W2 = Weight in gm of the dish with the material after drying

W = Weight in gm of the empty dish

1. Estimation of total sugar: -

To estimate the reducing sugar, total reducing sugar, and total sugar Lean and Eynon method was referred from FSSAI manual (FSSAI, 2015).

$$\text{Fehling Factor (for Invert Sugar)} = \frac{Titre\ x\ Weight\ of\ sucrose\ in\ gm}{500} \quad (2)$$

$$\text{Reducing sugar \% (as invert sugar)} = \frac{Dilution\ x\ Factor\ of\ Fehling\ (in\ gm) x\ 100}{Weight\ of\ sample\ x\ titre} \quad (3)$$

$$\text{Total reducing sugars \% (as invert sugar)} = \frac{Dilutions\ x\ Fehling\ factor\ x\ 100}{Weight\ of\ sample\ x\ titre} \quad (4)$$

2.5.2. Estimation of alcoholic acidity in developed premix:

Standard procedure of alcoholic acidity with 90 % alcohol as given by BIS was followed and calculated as H_2SO_4 on dry basis (IS: 1155-1968, 2006). Due to less time the sample solution was allowed to stand for 3 hours with manual shaking.

$$\text{Alcoholic acidity (as } H_2SO_4) = 24.52\ X \frac{AN}{W} \quad (5)$$

Where,

A = volume in ml of standard NaOH used in titration

N = normality of standard NaOH solution used in titration (i.e., 0.05 N)

W= weight in gram of the sample taken for analysis

B. Microbial analysis:

To estimate the microbial load of the product standard procedure given by FSSAI for total plate count was followed with three dilutions ($10^{-1,}$ 10^{-2} and 10^{-3}) and spread plate technique (FSSAI, 2012).

$$\text{Colony Forming Unit / ml} = \frac{no.of\ colonies}{volume\ used}\ x\ dilution\ factor \quad (6)$$

2.5.3. Storage studies for quality evaluation

Changes in quality during storage of the product were examined by determination of physicochemical constituents, microbial examination, and organoleptic evaluation for about 30 days of storage period by conducting random sampling at an interval of 15 days for physicochemical analysis and 30 days for microbial examination and organoleptic evaluation.

2.5.4. Statistical analysis

Mean and standard deviations of the data were calculated using Microsoft Excel.

3.Result and Discussion:

3.1. Sensory evaluation of wafers prepared using developed premixes:

For sensory evaluation the first two trials (T1 and T2) were conducted with finger millet flour and two different variations were prepared. To increase the digestibility and palatability malted flour has been added to prepare the product in third trial. As mentioned in Table 3 The third trial (T3) obtained maximum, acceptability; 4.48 ±0.50, 4.32 ±0.56, 4.46 ±0.44, 4.40 ±0.57, 4.43 ±0.45 and 4.40 ±0.42 for texture, colour, appearance, taste, flavour, and overall acceptance. The amount of dry ingredients used in this trial was the final amount to develop the chocolate flavour finger millet wafer premix. We have observed that the malting process helped to decrease the cooking time as compared to that of the flour without malting, also the acceptability (Figure 4) was comparably better.

To develop the pearl millet wafers (T4) equal quantity of ingredients was used as finger millet wafer premix as well as the time consumed for cooking and other proportions was the same. In organoleptic evaluation pearl millet wafers obtained 4.13 ±0.71, 4.05 ±0.58, 4.08 ±0.68, 4.03 ±0.74, 3.85 ±0.73 and 4.05 ±0.65 for texture, colour, appearance, taste, flavour, and overall acceptability (Table 4). This indicates that the developed premix based experimental wafer was found to be fallen under the category of “very good to excellent” according to overall acceptability. An equivalent amount of dry ingredients was taken to prepare the cinnamon flavour pearl millet wafer premix.

Another trial (T5) was taken with malted sorghum flour to develop a vanilla-flavoured sorghum wafer premix. An equal amount of ingredients was taken to get the desired characteristics of the wafers. The time consumption for the sorghum wafer was observed to be more than that of the ragi wafer. As mentioned in Table 4, the obtained score of sorghum wafer cones indicates that the experimental wafer was to fall under the category of “very good to excellent.” Premix was developed with the same amount of ingredients.

Lastly, to develop strawberry flavoured mixed millet wafer premix same amount (T6) of ingredients was taken as the above-mentioned wafer cones. In the prepared cones though, the proper texture was achieved but, the flavour of the strawberry was not noticeable. That is why the quantity of ingredients was modified to develop proper taste and flavour with the same cooking time as finger millet and pearl millet wafers. In sensory evaluation mixed millet wafer cones obtained 4.12 ±0.73, 4.18 ±0.58, 3.95 ±0.71, 4.02 ±0.74, 3.85 ±0.79and 4.08 ±0.67 for texture, colour, appearance, taste, flavour, and overall acceptability (Table 4) respectively. So, the amount of dry ingredients used in the last trial (T7) was the final amount to develop a mixed millet wafer premix.

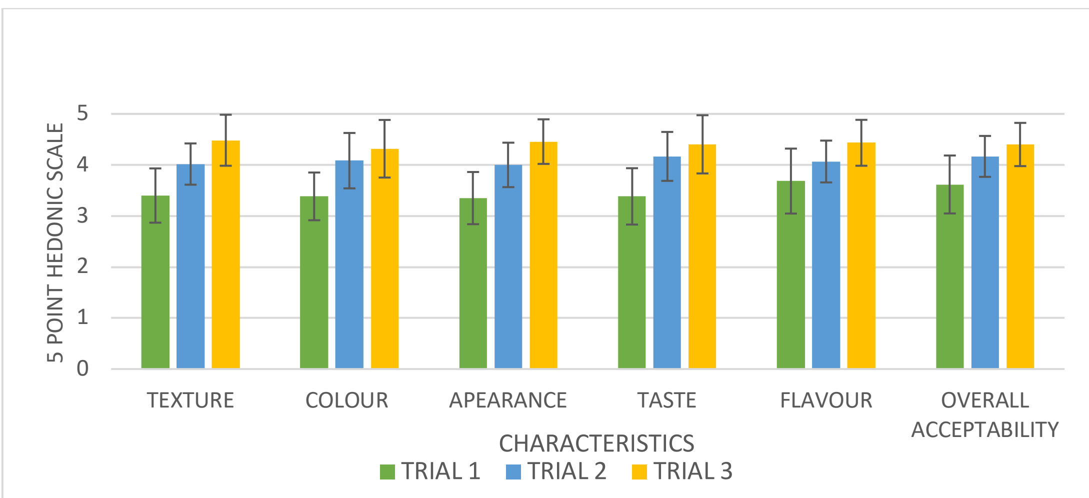
Among these four different varieties of wafers, finger millet wafer cones scored highest based on texture, appearance, taste, flavour, and overall acceptability, while sorghum millet cones obtained the highest score in colour. Mixed millet wafer cones obtained the lowest score for texture, appearance, and taste while pearl millet wafer cones obtained the lowest for colour and overall acceptability. For flavours, both pearl millet and mixed millet wafer cones got 3.85 which is the lowest. The graph of sensory evaluation (Figure 5) shows that all the millet-based wafer cones come under the category of "very good to excellent" according to their overall acceptability.

After 30 days no significant change in sensory parameters was observed. Finger millet wafer cones secured the highest score based on appearance, taste, and flavour (4.28± 0.52, 4.35± 0.51, 4.46± 0.46) while cones made of sorghum millet obtained the highest score in texture and colour (4.37± 0.49, 4.17± 0.48). Both the finger millet wafer cone and sorghum millet wafer cone got maximum overall acceptancy (4.35). This time, pearl millet wafers obtained lowest score based on texture and taste (4.13 ±0.71 and 4.03 ±0.74) whereas in the case of colour, appearance, flavour, and overall acceptance both pearl millet wafer cones and sorghum wafer cones scored almost same marks as shown in Table 5. The graph of sensory evaluation after 30 days (Figure 6) shows that all the millet-based wafer cones still come under the category of "very good to excellent" according to their overall acceptability.

Table 3. Mean values of sensory evaluation of wafers prepared from finger millet

TRIAL NO.	TEXTURE	COLOUR	APPEARANCE	TASTE	FLAVOUR	OVERALL ACCEPTANCY
TRIAL 1 (T1)	3.40 ±0.53	3.38±0.47	3.35 ±0.51	3.38 ±0.55	3.68 ±0.64	3.62 ±0.57
TRIAL 2 (T2)	4.02 ±0.40	4.08 ±0.54	4.00 ±0.43	4.17 ±0.48	4.07 ±0.41	4.17 ±0.40
TRIAL 3 (T3)	4.48 ±0.50	4.32 ±0.56	4.46 ±0.44	4.40 ±0.57	4.43 ±0.45	4.40 ±0.42

*Data represents mean ±standard deviation for (n= 30)



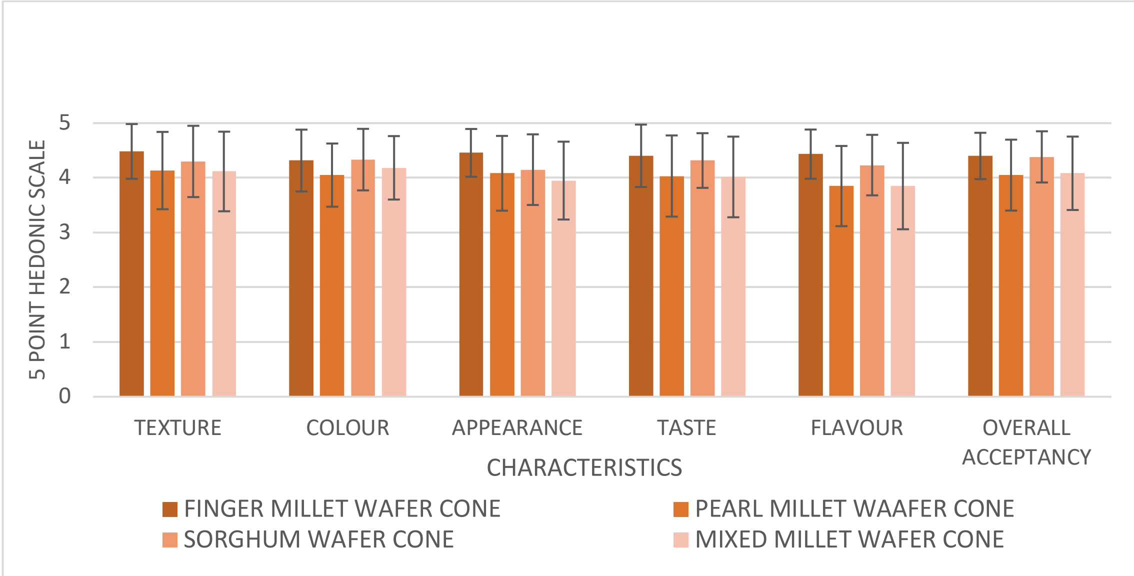
*Data represents mean ±standard deviation for (n= 30)

Figure 4. Comparison between sensory evaluation of wafers prepared from finger millet

Table 4. Mean values of sensory evaluation of wafers prepared from different millets

NAME OF THE WAFER	TEXTURE	COLOUR	APPEARANCE	TASTE	FLAVOUR	OVERALL ACCEPTANCY
Finger millet wafer cone	4.48 ±0.50	4.32 ±0.56	4.46 ±0.44	4.40 ±0.57	4.43 ±0.45	4.40 ±0.42
Pearl millet wafer cone	4.13 ±0.71	4.05 ±0.58	4.08 ±0.68	4.03 ±0.74	3.85 ±0.73	4.05 ±0.65
Sorghum wafer cone	4.30 ±0.65	4.33 ±0.56	4.15 ±0.64	4.32 ±0.50	4.23 ±0.55	4.38 ±0.47
Mixed millet wafer cone	4.12 ±0.73	4.18 ±0.58	3.95 ±0.71	4.02 ±0.74	3.85 ±0.79	4.08 ±0.67

*Data represents mean ±standard deviation for (n= 30)



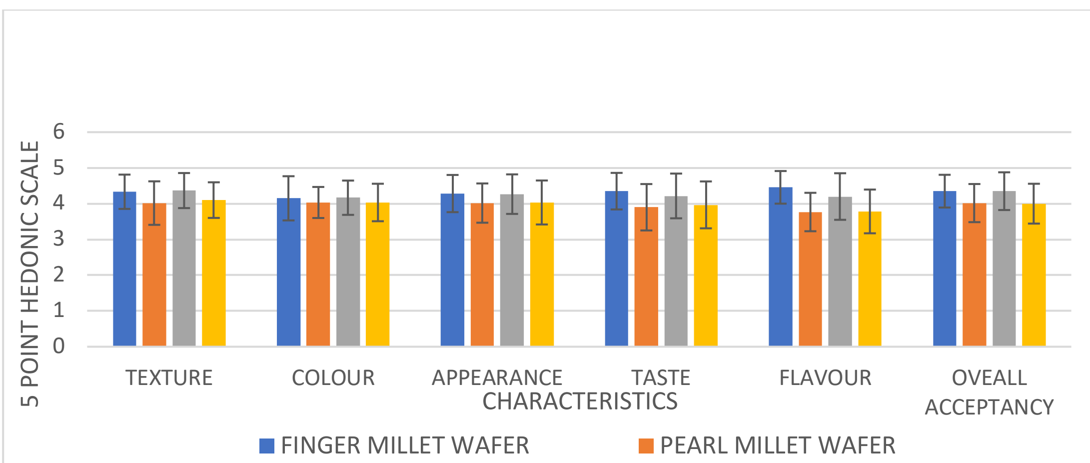
*Data represents mean ±standard deviation for (n= 30)

Figure 5. Comparison between sensory evaluation of wafers prepared from different millets

Table 5. Mean values of sensory evaluation of wafers prepared from different millets after 30 days:

NAME OF THE WAFER	TEXTURE	COLOUR	APPEARANCE	TASTE	FLAVOUR	OVERALL ACCEPTANCY
Finger millet wafer cone	4.33± 0.48	4.15± 0.62	4.28± 0.52	4.35± 0.51	4.46± 0.46	4.35± 0.46
Pearl millet wafer cone	4.01± 0.61	4.03± 0.43	4.01 ± 0 .52	3.90 ± 0.65	3.77 ± 0.54	4.02± 0.53
Sorghum wafer cone	4.37± 0.49	4.17± 0.48	4.27± 0.55	4.22± 0.63	4.20± 0.65	4.35± 0.53
Mixed millet wafer cone	4.10± 0.50	4.03± 0.52	4.03± 0.61	3.97± 0.65	3.78± 0.61	4.00± 0.56

*Data represents mean ±standard deviation for (n= 30)



*Data represents mean ±standard deviation for (n= 30)

Figure 6. Comparison between sensory graphs of wafers made of different millets after 30 days

3.2. Quality evaluation

3.2.1. Physicochemical analysis:

3.2.1.1. Moisture estimation of developed premix:

The developed premixes were subjected to moisture determination test by oven drying method. The change in moisture content is shown in Table 6. The initial moisture content of the finger millet wafer premix, pearl millet wafer premix, sorghum wafer premix and mixed millet wafer premix were 5.92%, 5.76%, 4.89% and 4.68%. After 15 days there were little moisture gain has been observed specifically, in the sorghum wafer premix and mixed millet wafer premix while finger millet wafer premix and pearl millet wafer premix had no such changes in moisture content. After 30 days increased moisture content was observed in the pearl millet wafer premix, in the sorghum wafer premix and in mixed millet wafer premix whereas moisture content of the finger millet wafer was approximately same as before. According to FSSAI moisture content of millets should not be more than 16% by weight [Food safety and standards (food products standards and food additives) regulations, 2011]. As per the specification these premixes matched the standard.

Table 6. Moisture content of developed premixes

DAYS	CONTROL MOISTURE %	MOISTURE % (IN FINGER MILLET WAFER PREMIX)	MOISTURE % (IN PEARL MILLET WAFER PREMIX)	MOISTURE % (IN SORGHUM WAFERPREMIX)	MOISTURE % (IN MIXED MILLET WAFER PREMIX)
0^{th} day	3.52	5.92	5.76	4.89	4.68
15^{th} day	3.22	5.98	5.71	5.24	4.89
30^{th} day	2.98	5.94	5.88	5.86	4.92
SE$\pm$	0.271	0.031	0.087	0.491	0.131

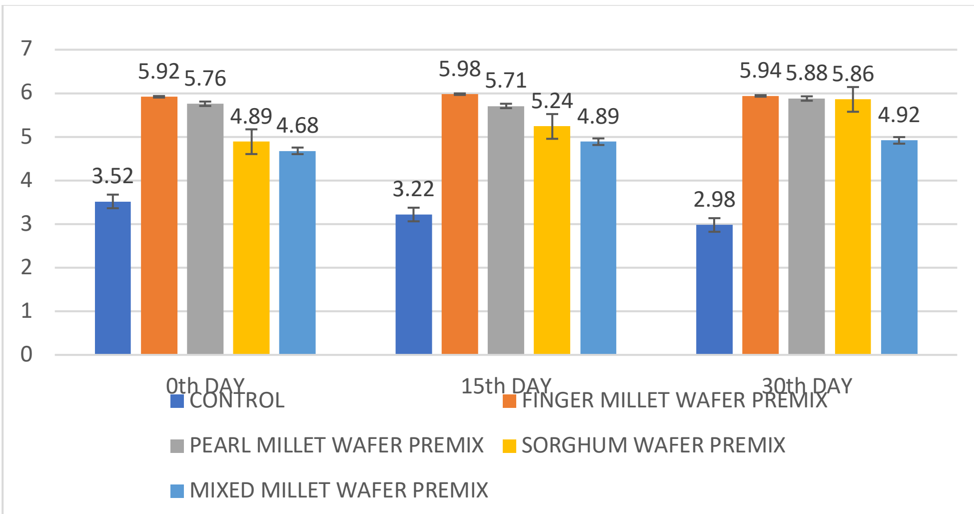


Figure 7. Comparison between moisture content of developed premixes

3.2.1.2. Estimation of total sugar:

Total sugar content of the developed premixes was estimated by Lean and Eynon method. Initially total sugar content of finger millet wafer premix, pearl millet wafer premix, sorghum wafer premix and mixed millet wafer premix were 19.33 gm, 18.60 gm, 20.86 gm, and 27.83 gm per 100 gm respectively. After 15 days and 30 days the amount of total sugar decreased gradually as shown in Table 7. This decrease in sugar content might be due to microbial activity in the premixes during storage.

Table 7. Total sugar content of developed premixes:

DAYS	CONTROL (% OF TOTAL SUGAR)	% OF TOTAL SUGAR (IN FINGER MILLET WAFER PREMIX)	% OF TOTAL SUGAR (IN PEARL MILLET WAFER PREMIX)	% OF TOTAL SUGAR (IN SORGHUM WAFER PREMIX)	% OF TOTAL SUGAR (IN MIXED MILLET WAFER PREMIX)
0^{th} day	Reducing sugar =3.88 Non reducing sugar=17.88 Total sugar = 21.76	Reducing sugar = 3.22 Non reducing sugar=16.11 Total sugar = 19.33	Reducing sugar = 3.26 Non reducing sugar = 15.34 Total sugar = 18.60	Reducing sugar = 2.70 Non reducing sugar = 18.16 Total sugar = 20.86	Reducing sugar = 4.86 Non reducing sugar = 22.97 Total sugar = 27.83

15th day	Reducing sugar = 3.78 Non reducing sugar=17.76 Total sugar = 21.54	Reducing sugar = 2.84 Non reducing sugar=16.16 Total sugar = 19.00	Reducing sugar = 3.22 Non reducing sugar = 15.11 Total sugar = 18.33	Reducing sugar = 2.36 Non reducing sugar = 18.30 Total sugar = 20.66	Reducing sugar = 4.59 Non reducing sugar = 22.70 Total sugar = 27.29
30th day	Reducing sugar = 3.72 Non reducing sugar=17.56 Total sugar = 19.33	Reducing sugar = 2.48 Non reducing sugar=15.89 Total sugar = 18.37	Reducing sugar = 3.00 Non reducing sugar = 14.79 Total sugar = 17.79	Reducing sugar = 2.08 Non reducing sugar = 17.65 Total sugar = 19.73	Reducing sugar = 4.39 Non reducing sugar = 21.78 Total sugar = 26.17
SE±	1.344	0.488	0.412	0.603	0.847

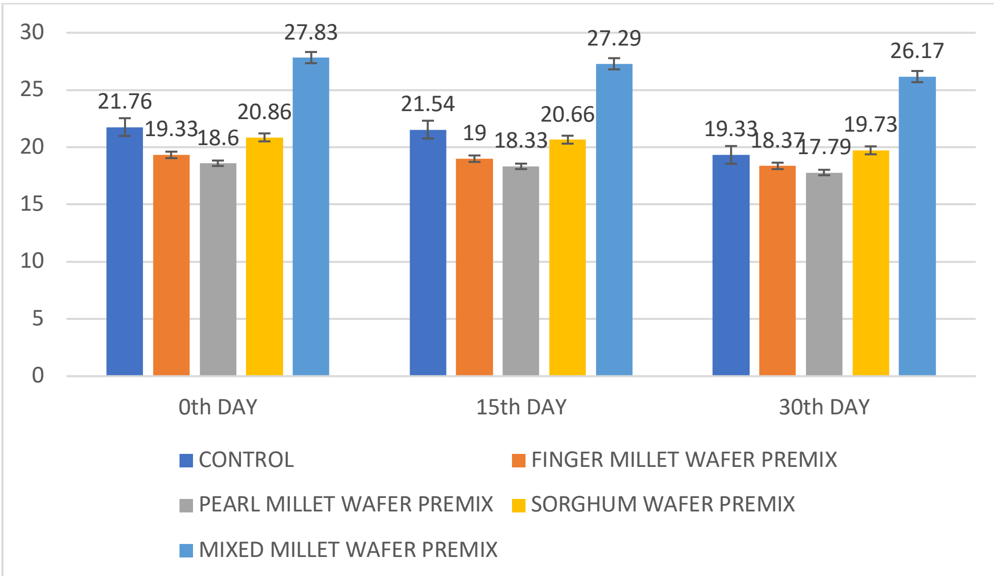


Figure 8. Comparison between total sugar content of developed premixes

3.2.1.3. Estimation of alcoholic acidity in developed premix

Alcoholic acidity (The amount of H_2SO_4 (mg) needed in 100 g of the sample to produce the equivalent amount of alcohol-soluble acids is known as the alcoholic acidity) is determined to check the quality of flour (egyankosh). Lower the alcoholic acidity means fresher the flour. Initial alcoholic acidity of finger millet wafer premix, pearl millet wafer premix, sorghum wafer premix and mixed millet wafer premix were 0.133%, 0.135%, 0.101% and 0.135% respectively. After 15 days and 30 days the percentage of alcoholic acidity increased. It can be due to the enzymatic hydrolysis of phytin, protein and/or fat.

Table 8. Alcoholic acidity of developed premixes: -

DAYS	CONTROL	% OF ALCOHOLIC ACIDITY (IN FINGER MILLET WAFER PREMIX)	% OF ALCOHOLIC ACIDITY (IN PEARL MILLET WAFER PREMIX)	% OF ALCOHOLIC ACIDITY (IN SORGHUM WAFER PREMIX)	% OF ALCOHOLIC ACIDITY (IN MIXED MILLET WAFER PREMIX)
0th day	0.150	0.133	0.135	0.101	0.135
15th days	0.145	0.175	0.133	0.180	0.168
30 days	0.166	0.223	0.166	0.224	0.223
SE±	0.011	0.045	0.019	0.062	0.044

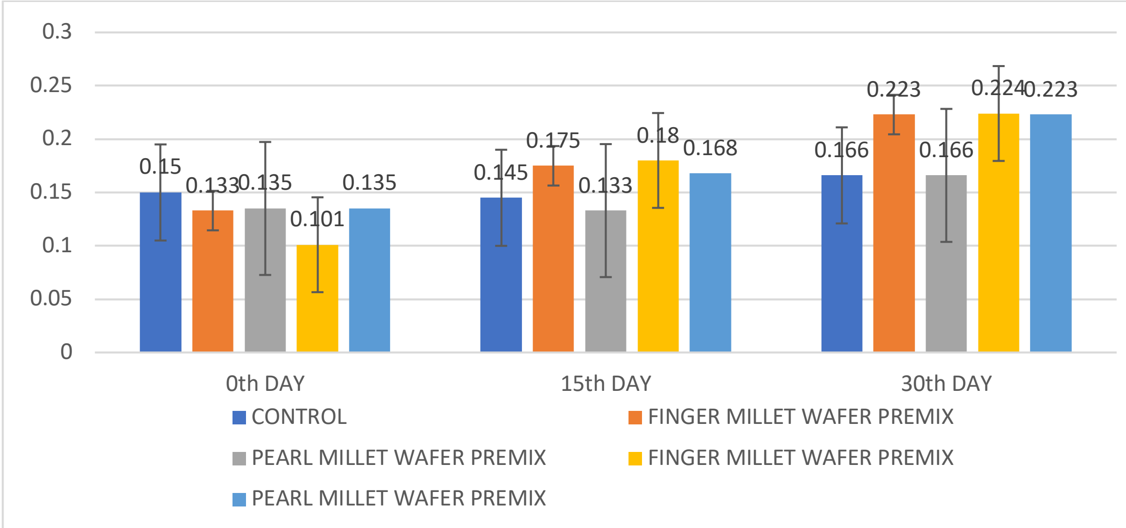


Figure 9. Comparison between alcoholic acidity of developed premixes

3.2.1.4. Estimation of carbohydrate, protein, and fat in developed premixes:

The nutritive values of developed premixes were calculated with the help of 'Food Composition Table' by ICMR (Longvah et al., 2017). Table 9 shows the total carbohydrate (CHO), protein and fat content of the developed premixes.

Table 9. Carbohydrate, protein, and fat content of developed premixes: -

NUTRIENT	CONTROL	FINGER MILLET WAFER PREMIX	PEARL MILLET WAFER PREMIX	SORGHUM WAFER PREMIX	MIXED MILLET WAFER PREMIX
CHO (gm)	72.100	68.295	66.783	68.553	62.613
Protein (gm)	8.210	9.611	10.751	10.454	9.419
Fat (gm)	2.181	0.742	1.795	0.685	1.064

3.2.1.5. Microbial analysis: -

Microbial load of the developed premixes was estimated by spread plate technique. According to a study by K. Geetha, Geetha M. Yankanchi and Netravati Hiremath (2019) the range of total bacterial count in millet based high fibre food mix was 3550 CFU/ ml to 5120 CFU/ ml from initial to 30th day of storage. In this study initially microbial growth was found on the plates with 10^{-1} and 10^{-2} dilution after 48 hours of incubation. On 30th day microbial growth was increased with the storage period as mentioned in Table 10.

Table 10. Total Plate Count of developed premixes

DAYS	CFU/ml (IN FINGER MILLET WAFER PREMIX)	CFU/ml (IN PEARL MILLET WAFER PREMIX)	CFU/ml (IN SORGHUM WAFER PREMIX)	CFU/ml (IN MIXED MILLET WAFER PREMIX)
0th day	2050.00	1900.00	2000.00	2600.00
30th day	3600.00	2650.00	3400.00	3850.00

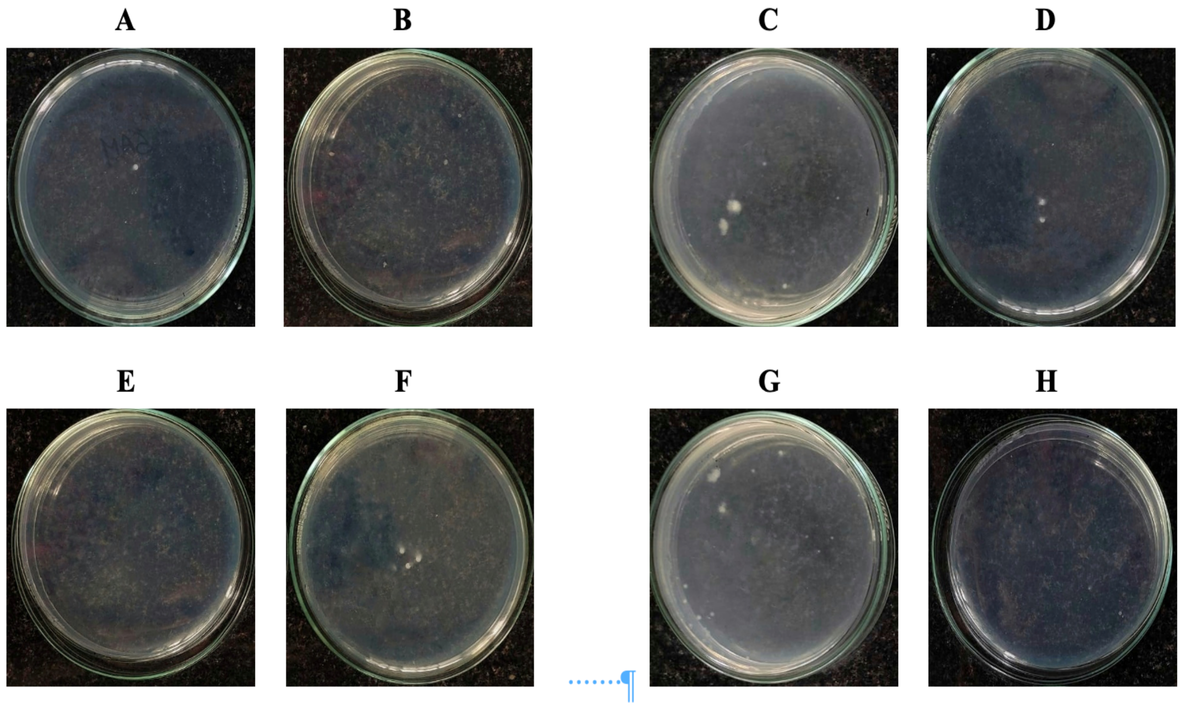


Figure 10. Microbial growth on agar plates with 10^{-1} & 10^{-2} dilution respectively on 0th day (A & B. Finger millet wafer premix, C & D. Pearl millet wafer premix, E & F. Sorghum wafer premix, G & H. Mixed millet wafer premix)

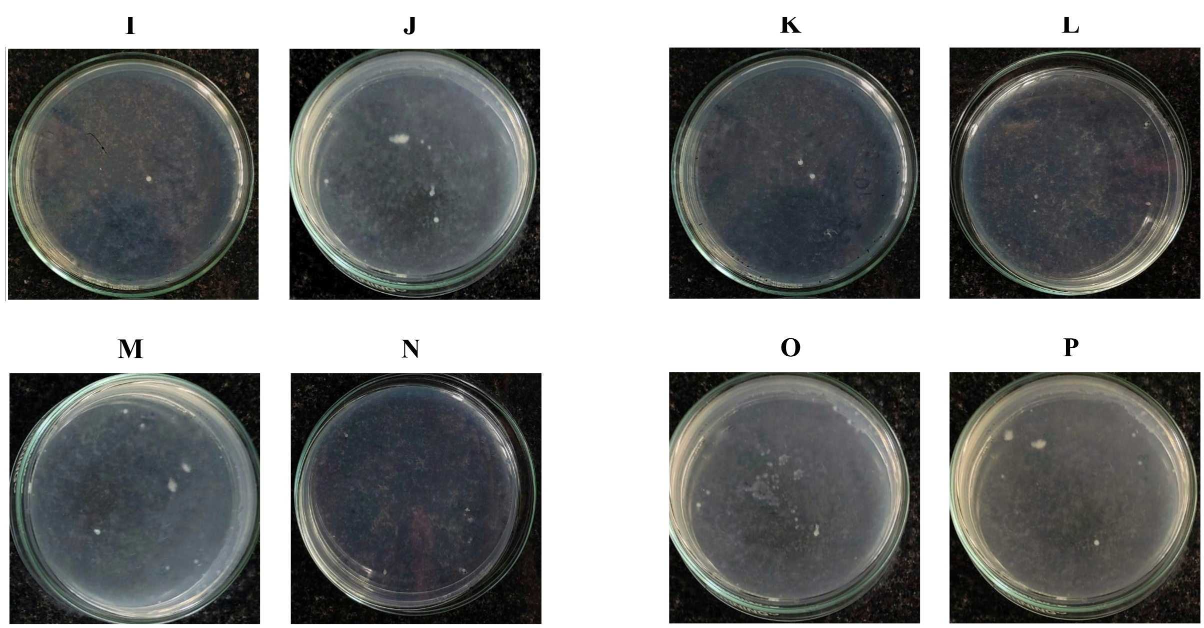


Figure 11. Microbial growth on agar plates with 10^{-1} & 10^{-2} dilution respectively on 30th day (I & J. Finger millet wafer premix, K & L. Pearl millet wafer premix, M & N. Sorghum wafer premix, O & P. Mixed millet wafer premix)

4.Conclusions

In this study 4 different varieties of millet-based wafer premixes: finger millet wafer premix with chocolate flavour, pearl millet wafer premix with cinnamon flavour, sorghum wafer premix with vanilla flavour and mixed millet wafer premix with strawberry flavour were developed which were of acceptable quality according to the chemical, microbial and sensory evaluation. The final products were accepted by the sensory panel members. It has been observed that malting helped to reduce the preparation time of the wafers. Due to the germination of the seeds, the bioavailability of nutrients should be increased. Rice flour was added to improve the textural quality. According to the sensory panel wafers made of finger millet wafer premix and sorghum millet wafer premix with chocolate and vanilla flavour respectively got more acceptability.

Developed premixes matched the standard moisture content given by FSSAI, which is below 16% by weight. The sugar content of the premixes gradually decreased with storage, while alcoholic acidity increased. This may cause due to physical changes and/or microbial activity. There were no significant changes both in quality and sensory aspects during the study period. After 30 days also all the premixes were acceptable.

As the products are millet based, they contain high amounts of fibre and minerals such as iron, calcium, phosphorus etc. Millets contain more amount of complex carbohydrates rather than simpler ones and due to this property millets can help to reduce the risk of elevated blood pressure, blood sugar and other non-communicable diseases. Various essential amino acids and unsaturated fatty acids are present in millet. Millets do not contain gluten so; it can be consumed by celiac patients. Millets are called ‘superfoods’ due to their functional properties. They are proven antioxidants and show antimicrobial and anticarcinogenic activity. By using millets in commercial snack products, the upliftment of the total health of a community is possible. More over wafers in the form of cones, bowls etc. can contribute to edible cutlery which is sustainable and can reduce the load of waste from the food industry.

The accurate shelf life of the products can be studied in future as there were no significant changes observed in the product’s quality during this study. Different packaging technology such as vacuum seal packaging can be introduced, moreover, we can think about better options for the packaging material rather than LDPE to make it eco-friendly as well as to protect the quality of the product inside for a longer time. Further study can be conducted to understand the effect on the products after malting and to compare the changes in the nutrient content of developed premixes with and without malting of millets. Also, by using minor millets like proso millet, foxtail millet etc. a new product can be developed. Future study can be conducted to develop new flavours. Last but not the least by modifying the amount of water and baking powder or by modifying the composition of the ingredients premix for muffins or cupcakes can be developed by following the same process.

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