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Effect of Maize Flour Incorporation on The Nutritional, Physico-Chemical and Sensory Characteristics Of Waffles

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Abstract

The objective of the study was to incorporate maize flour in waffles. Varying proportions of maize flour (10, 20, 30, 40 and 50%) were mixed into a blend of refined and wheat flour. The quality parameters including nutritional characteristics, antioxidant activity and functional properties of both the flour and waffle treatments were studied. The nutritional profiling presented a significant (p<0.05) decrease in ash, fat, carbohydrate, protein and moisture with the increase in the concentration of maize flour. On the contrary, the antioxidant property; measured in terms of free radical scavenging activity and ferric ion reducing antioxidant power, showed a significant increase (p<0.05) with increased proportions of maize flour. The functional properties included bulk density, oil and water absorption capacity. The result showed that bulk density increased in case of flour blend as well as waffles. Similarly, oil and water absorption capacities increased significantly (p<0.05) in all the treatments by the values of 13.14±0.67 to 17.94±0.71 and 10.24±1.06to 13.82±0.95 % respectively. Post sensory evaluation, it was concluded that the

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waffle with 30% maize flour incorporation was the most acceptable treatment. The shelf life study showed that the most acceptable waffle has 15days of consumable span and the degradation started for HMF, TBA and FFA values.

Keywords: waffles, maize flour, functional, nutritional, sensory, shelf-life

Introduction

Maize (*Zea mays*L.) is a cereal grain that originated in Mexico about 8700 years ago and in Central America (Tenaillon&Charcosset, 2011) and introduced to India in 17th century (Milind &Isha, 2013). Maize is the most cultivated crop along with wheat and rice in the world and is used for the preparation of several food products like beverages, pancakes, snacks, bread, tortillas (Gwirtz&Casal, 2014). Traditionally, maize was used for the preparation of medicines providing relief from dysentery, diarrhea, hypertension, urinary tract disorders, lithiasis, tumor, angina and claims anti-inflammatory, antioxidant, hypoglycemic and diuretic properties (Rouf Shah et al., 2015).Bioactive compounds like carotenoids, anthocyanins, phenolic compounds have been reported in corn, they are known to have disease prevention and health-promotion properties (Rouf Shah et al., 2016). Carotenoids like Lutein and zeaxanthin have been identified with several health-relating properties. They have also been associated for preventing age related macular degeneration which causes early blindness in humans and it is a problem which is similar to cataracts. Anthocyanins present have anti-mutagenic properties as well as performs radical scavenging activities. The phenolic compounds also possess a numerous bioactive and antioxidant activities, such as cell differentiation, pro-carcinogen deactivation, deoxyribonucleic acid repair, inhibition of N-nitrosamine formation and change of estrogen metabolism. An important phenolic compound, the ferulic acid which is found in corn and other cereal grains

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possesses antioxidant properties and as well slows down the ageing process and prevents lipid oxidation (Singh et al., 2011).

In the recent years, the demand of healthier food has increased, henceforth, bakery industry is moving towards the formulation of function foods. Cereals are the most appropriate choice for the production of foods like cookies, snack bars and other bakery goods (Aramouni&Abu-Ghoush, 2011).Waffles are a delicacy which are soft in texture and have properties similar to that of a cake.The formation of waffle during baking is due to steam expansion and starch gelatinization and can be consumed as a snack or a breakfast item. Local traditions and eating habits have brought many waffle products in the market (Huber &Schoenlechner, 2017)

The objective of the study was to determine the impact of maize flour incorporation on the nutritional characteristics, functional properties, antioxidant activity, sensory acceptability and shelf life properties of the waffles.

Materials and methods

Materials

The ingredients used for the preparation of waffles included maize flour (energy 380 kcal/100g, carbohydrate content 76g/100g, protein content 10g/100g, fat content 04g/100g, dietary fiber 7.6g/100g), wheat flour (energy 339kcal/ 100g, carbohydrate content 72.57g/100g, protein content 13.70g/100g, fat content 12.2g/100g), refined wheat flour (energy 352.15kcal/100g, carbohydrate content 74.27g/100g, protein content 10.36g/100g, fat content 0.76g/100g), baking powder (WeiKFiELD) (energy 156kcal/100g, protein content 0.1g/100g, salt 19.73g/100g),

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refined oil (Saffola Gold, Pro Healthy Lifestyle Edible Oil) (energy 90 kcal/100ml, total fat 10g/100g, MUFA 4.8g/100g, PUFA 3.2g/100g, Saturated fats 2g) for preparation of waffles.

Methods

Flour preparation

The principal waffle recipe and its variations are shown in Table 1. A home-based waffle recipe was used for this study. The amount of each ingredient used was standardized in pre-trials during the course of the study results of which are not mentioned in this document. In order to study the effect of maize flour on the physico-chemical and sensory characteristics of waffles, the base flour (comprising of refined wheat flour and wheat flour in the ratio of 70:30) were incorporated with maize flour in varying proportions as shown in the following table.

Batter preparation

The flour treatments along with other dry ingredients- sugar and baking powder were sieved thoroughly in order to ensure proper mixing of the three flours and enable aeration. The blend was bought in contact with water and oil and first mixed manually by means of a whisker and then subjected to a magnetic stirrer to ensure thorough mixing of the waffle batter ingredients. Mixing of ingredients in this manner is necessary to avoid high shearing of the batter which leads to gluten development which is not desirable in case of waffles(Huber &Schoenlechner, 2017).

Waffle preparation

The waffles were prepared by the modification in the method given by Paucean et al., (2015) as shown in **figure 1**.The prepared batter was deposited on the bottom baking plate of the waffle

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maker which was pre-heated to 150°C. Prior to batter deposition, a constant amount of olive oil was brushed against the surface of the baking plate. Baking was carried out for five minutes. The waffles were then stored in aluminized aseptic bags and sealed (Wellworth Packers Pvt. Ltd., Delhi, India) until further use.

Nutritional profiling

The nutritional profiling which includes moisture, ash, protein, fat, and carbohydrate were determined by standard AOAC procedures (2016).

Functional properties

The water absorption capacity (WAC) and oil absorption capacity (OAC) were analysed by using method given by Singh et al., (2018). The following formula were used-

$$\text{WAC}=\frac{\text{weight of the centrifugetube} + \text{weight of sediment} - \text{weight of empty tube}}{\text{Weight of the sample}}$$

$$\text{OAC}=\frac{\text{weight of the centrifugetube} + \text{weight of sediment} - \text{weight of empty tube}}{\text{Weight of the sample}}$$

The bulk density was evaluated using a previously weighed graduated cylinder (10 ml) and filled with 10 gm of sample by continuous tapping until there was no further change in the volume. The bulk density was calculated after taking the weight of flour divided by volume of flour and reading were recorded in gram per centimeter cube (Onuegbuet al., 2013).

Bioactive properties

The antioxidant activity was analyzed by means of the free radical scavenging activity (DPPH) and the ferric ion reducing antioxidant power (FRAP) of the flour and waffle treatments. The

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free radical scavenging activity of was assessed by the method described by Singh et al., (2018) and Rajkurar and Hande 2011 respectively.The flavonoid content was examined by using method given by NurhananandRosli(2012).

Sensory evaluation

The maize waffles were analyzed for sensory parameters by 20 semi-trained panel members (10 women and 10 men) between the ages of (20-35) years. The parameters to be assessed were color and appearance, flavor (taste and aroma), texture and overall acceptability. Nine-point hedonic scale was used for the sensory evaluation. The panelists were served freshly prepared maize waffles one at a time with an interval of 2 minutes between each sample. Portable water was provided at room temperature to rinse the mouth in between samples (Chelladura et al., 2019).

Shelf Life Analysis

Results obtained from sensory evaluation were used to determine the sample to be subjected to shelf life testing. Shelf life testing was carried out for the most desirable sample (as per sensory evaluation and the test was carried out was carried out on the 0^{th} day, 03^{rd} day, 6^{th} day ,9^{th} day , 12^{th} day and 15^{th} day since waffle preparation stored at room temperature 28-35°C. Moisture content, Free fatty acid (FFA), Thiobarbituric acid (TBA), Hydroxymethyl Furfural (HMF) and total plate count was recorded of each day (Rasane et al., 2018).

Results and discussion

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Nutritional profiling

In case of moisture content of flour, a declining trend was noticed in the values. As the percentage of maize flour increased, the capacity to retain water also decreased. The moisture content ranged from 13.8%to 12.4% as shown in Table 2. A significant decrease ($p<0.05$) was thereby observed.In case of waffles, a significant increase ($p<0.05$) in the moisture percentage was observed. The values ranged from 19.8% to 22.1% as shown in table 3. Similar results were recorded by (Amir et al., 2015) who carried out the research on cookies made from composite flours maize, sorghum and wheat. The significant increase ($p<0.05$) in moisture content in flours might be due to higher content of maize flour as compared to maize flour.

As for the fat content, as the concentrationof maize flour increased, a significant increase ($p<0.05$) was observed in both the flour and waffle treatments. Maize flour treatments recorded valuesbetween1.65% to 2.59% as observed in table 2 while, in case of waffles, the values observed were in the range 3.7% to 6.78% as observed in table 3. The increase in fat in case of waffles in comparison to flour blend is due to the addition of oil (15 ml) in the preparation of waffles. A similar trend was observed by Begum et al., 2013 in their study on maize flour incorporated bread where they reported significant increase ($p<0.05$) in fat content from 4.04 to 4.16% as the incorporation of maize flour was increased and this might be due to high content of fat in maize flour (1.15/100g) in comparison to wheat flour (0.85/100 g).

Similarly a significant decrease was observed in the protein content of both the flour and waffle treatments as the concentration of maize flour increased. A decrease in the protein content in case of waffles was because the product was subjected to heat treatment at 350°C for 5 minutes which causes denaturation of protein and thereby loss of protein. The result was in consideration

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withOnuegbu et al., (2013) where they reported the same trend of decrease in protein content from 10.74±0.3 to 9.95±0.05 in maize flour incorporated bread. The decline in protein is observed due to low content of protein of maize flour in comparison to wheat flour and refined flour.

Functional Properties

Bulk density is the property used to determine the requirements for packaging as it is related to the load which is carried by the sample in the condition of rest, when the particles are on one another (Wani& Kumar, 2015). The bulk density of flour blend was assessed and the significant increase (p<0.05) was found as shown in Table 2. The results were in accordance to Mishra et al., 2012 in the development of protein rich soyabean-maize flour cookies. They reported that bulk density significantly increased by the addition of maize flour.Higher the bulk density greater the packaging advantage as more amount of flour can be packed within a constant volume (David et al., 2015).

The increase in the water absorption capacity (WAC) of the flour is associated with the increment in amylose leaching and solubility and loss of crystalline structure of the starch and increased WAC is due to the hydrophilic constituents such as polysaccharides (Chandra et al., 2015). The WAC recorded for flour ranged from 6.19±0.58to 9.19±0.51 %as observed in Table 2. Similarly, significant increase (p<0.05) was observed from10.24±1.06 to 13.82±0.95which could be due to addition of water in the batter. The similar trend has been observed in maize flour supplemented bread. The WAC increased as the maize flour concentration increased from 2.05g/g to 2.52 g/g (Onuegbu et al., 2013). On contrary to these results, maize flour cookies supplemented with soyabean flour showed significant decrease (p<0.05) i.e. from 217% to

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177%. They reported that soyabean flour supplementation increased WAC due to its higher protein content (Mishra et al., 2012).

Oil absorption capacity (OAC) indicates the rate of protein binding with fat in the development food (Onimawo&Akunor, 2012). Fat improves the mouthfeel of food products by retaining the flavor (Balogun&Olatidoye, 2010). The OAC of the flour blend ranged between7.72±0.31(Control) to 9.84±1.59(50 % maize flour incorporation) as observed in Table 2. A significant increase (p<0.05) was observed in case of waffle treatments, ranged from13.14±0.67to 17.94±0.71as represented in Table 3. The values recorded for waffles were higher than that of flour because 15 ml oil was added in the preparation of waffles. The results were in agreement with Rai et al., (2014) in their work on gluten free cookies prepared from different flours. The OAC increased from 0.9 ml/g (wheat flour) to 1.1 ml/g in case of maize meal.

Bioactive properties

Analysis of flavonoid content showed a significant decrease (p<0.05) in case of both flour and waffle treatments. The maximum flavonoid content was found in 10% flour 5±0.21 mg QE/100 gwhich then reduced to 1.84±0.20 in 50% flour concentration as shown in Figure 3(A). In waffles, the lowest flavonoid content was found in 50% of 1.05±0.56mg QE/100 g. The values of waffles ranged between 1.05±0.56 to 2.89±0.22mg QE/100 g. The results were in agreement with Simic et al., (2018) who reported high in flavonoid content after addition of 30% of blue maize flour in whole wheat flour. The decrease from blend to waffles is due to the nature of flavonoids which are less thermally stable unlike total phenolics.

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The antioxidant activity of the extracts on DPPH radicals were measured in terms of hydrogen donating or radical scavenging activity. Greater the free radical scavenging activity greater the antioxidant content (Páramo-Calderón 2018). The free radical scavenging activity has shown a significant increase ($p<0.05$) in case of both flour and waffle treatments. In case of flour treatments, the values ranged from 67±0.68 % in the 10% treatment to 71±1.97 % in the 50% treatment as shown in Figure 3(B). The ascend in the free radical scavenging activity of waffles from 32±1.17% in waffles prepared from 10% maize flour incorporation to 37±0.82s% in waffles prepared from 50% maize flour incorporation was observed. This is because maize flour has an antioxidant capacity of 36.3±0.3 while wheat flour records 19.9±0.3 (Simic et al., 2018).The results were in consideration with Kaur and Aggarwal 2017 in their work of development of maize-tortilla chips. The antioxidant content decreased and reported in range of 62.87% and 59.10%,due to the addition of potato flour which shows that maize flour has good antioxidant activity. Thus, with the increase in the concentration of maize flour, an increase in the free radical scavenging activity was observed.

The Ferric ion reducing Antioxidant Power test measures the ferric ion to ferrous ion reducing power of the substrate(Topal et al., 2016). FRAP test values resulted in a significant increase ($p<0.05$) in the ferric ion reducing antioxidant power in case of both flour and waffle treatments. Flour treatments showed an increase from 45.12±0.02 in 10% maize flour treatments to 59.2±0.02% in 50% maize flour treatment as shown in Figure 3(C). The control flour with no maize flour has shown the highest value which is 79.36. This rise was also observed in waffles with 13.12±0.52 in 10% maize flour treatment and 15.38±0.92 in 50% maize flour treatments as shown in figure. Waffles recorded lower values of FRAP as thermal processing affects the antioxidant properties. Similar results were observed by Camelo-Mendez et al., 2017 who

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studied the effect of blue maize flour on gluten-free pasta quality and antioxidant retention characteristics and observed an increase in the retention of the ferric ion reducing antioxidant power of the gluten-free pasta after extrusion and cooking.

Sensory evaluation

The acceptability of the maize based waffles was determined by sensory scores.For the sensory analysis, five parameters were included by the name of color and appearance, taste, aroma, texture and overall acceptability. The panelist awarded highest score to the 30% waffle treatment which was the most acceptable one followed by control, 10, 20and40%. Waffles containing 10 % maize flour and control does not show any significant difference and 50% waffle treatment was the least accepted. However, waffles containing 30% maize flour was the most acceptable one in terms of sensory analysis as shown in Table 4. The highest concentration of maize waffles (50%) was not accepted by the panelists and they reported that the sample was very hard and sandy which may be due to less gluten which is required for baking quality and bread sensory analysis as reported by Begum et al., 2013.

Shelf life analysis

Shelf analysis of the most acceptable treatment i.e. waffle prepared from 30% maize flour (which was obtained from sensory evaluation) was carried out. The 30% treatment was subjected to 05 major tests over a span of 15 days. The results obtained are shown in Table 5.

Hydroxymethyl furfural(HMF) is the end product formed after the progression of Maillard reactions and it increases with increase in storage temperature and time (Jha and Patel 2012). The waffle treatment was subjected to the same for a span of 15 days and it was observed that

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the degradation increased gradually over the 15 days with 7.18±0.04 µmoles/g being the highest recorded value at the end. It is responsible for changes in color and flavor of food and thus is used as an indicator of excessive-heat treatment, spoilage and adulteration. Singh et al., 2013 also reported increase in HMF values in multigrain dalia mix prepared from pearl millet, sorghum and maize. The values increased significantly from 5.02µmol/g to 27.21 µmol/g at different temperatures after 180 days of storage. They concluded that HMF value increases as increase in the storage temperature.

Thiobarbituric acid (TBA)determines the formation of secondary oxidation products such as carbonyls which further undergoes physical and chemical changes and form low molecular weight compounds like ketones, aldehydes and lactones with the loss of sensory quality (Semma 2002). The TBA values increased significantly ($p<0.05$) 2.82±0.04 at 0^{th} day to 6.45±0.04 (mg malenaldehyde/kg) at 15^{th} day. Similar observations were made by Singh et al., 2013, the TBA values in the instant dalia increased in the span of 180 days of storage at different temperatures.

Free fatty acid (FFA) are formed after microbial or enzymatic degradation of lipids and its analysis provides information about stability of fat during storage. In the present study, FFA of maize waffle increased significantly ($p<0.05$) from 0 to 15 time interval. The initial mean FFA of waffles was 6.73±0.28 % which significantly increased to 10.78±0.5after 15 days.The similar results were reported by Kaur and Aggarwal 2017 for the development of maize tortilla chips. They reported the declinefrom 0.21% to 0.39 % in the span of 3 months.

Total plate count increased from 0to $9.72*10^7$cfu/gover a span of 15 days. Due to increase in microbial activity the product becomes less suitable for consumption. Similar line of work was reported by Shobha et al., 2015 for the preparation of maize flour vermicelli. They reported the

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increment in the yeast and mold count in the span of six months in the high quality protein maize based vermicelli from the range of 0.00 in case of fresh vermicelli to 1.62 ±0.10 Cfu/g(10^{-5}) after 6 months of storage and for bacterial count significant increase from 2.58 ±0.02 to 2.9 ±0.20 after 3 months of storage after that a decline was observed.The result concludes that these organisms are not that high to cause food spoilage and poisoning henceforth, waffles incorporated with maize flours can be stored in LDPE covers upto 15 days.

Moisture content showed a decline over the 15 days of testing. A significant difference ($p<0.05$) was observed in between the range from 15.7±0.5to 11.4±0.6 at 15th day. The results were in accordance with Abadi and Naser 2019 who studied the effect of wet gluten addition for the preparation of barley bread from different varieties of barley flour. The significant decrease ($p<0.05$) in moisture content was observed in the barley bread crumbs in 72 hours of storage period.

Conclusion

This study revealed that bakery products like waffles could be prepared by incorporating maize flour upto 30%. The nutritional quality of maize based waffles. With the increase in concentration of maize flour, fat, ash, protein and carbohydrate decreased significantly. Furthermore, the water absorption capacity and oil absorption capacity showed a significant increased ($p<0.05$). The antioxidant activity of the waffles and flour significantly increased. On the basis of sensory analysis, the highest overall acceptability was observed in 30% of maize flour incorporation and the shelf life analysis results showed that the waffles will be consumable up to 15 days.

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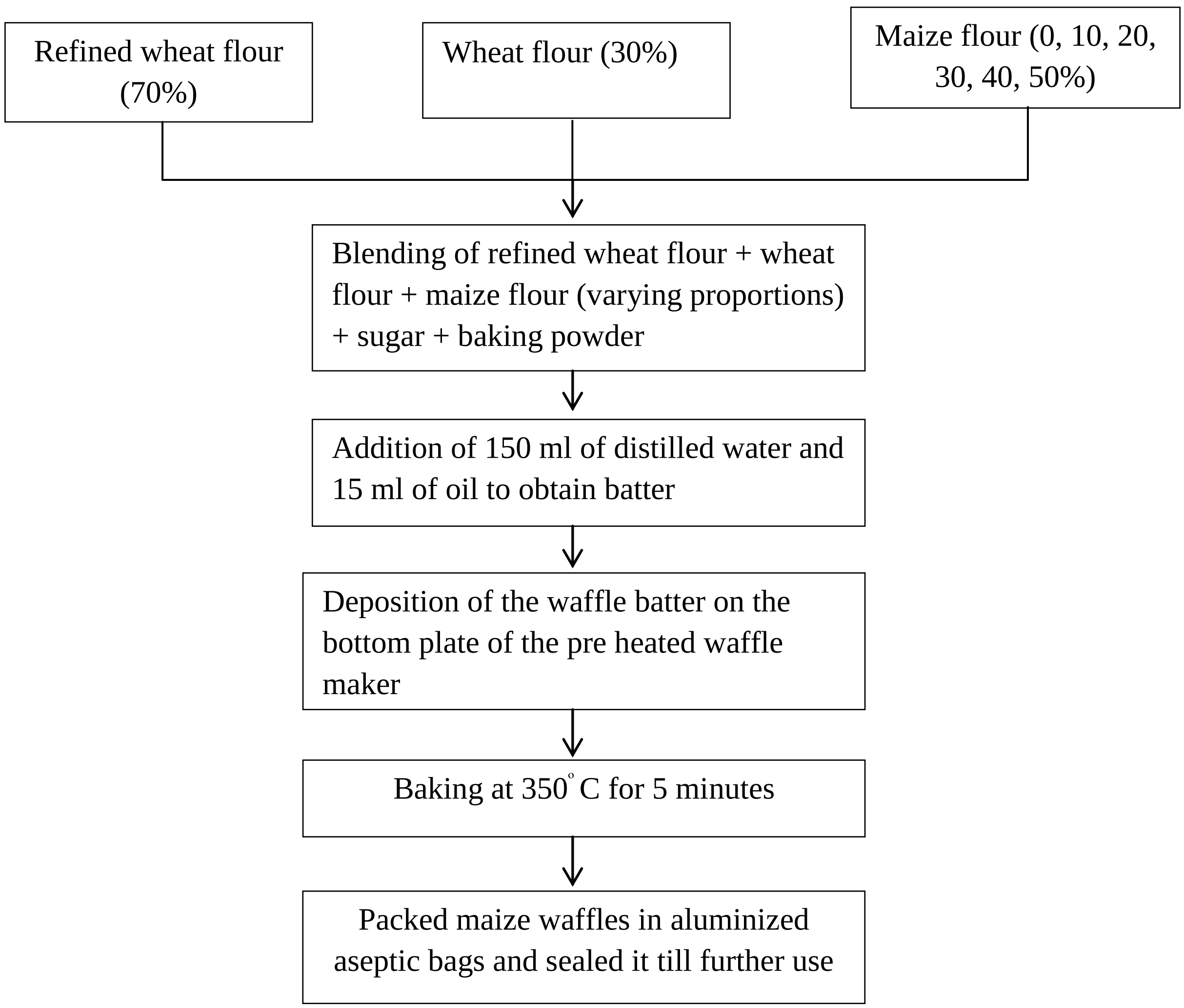

Figure 1: Process flow chart for the preparation of maize incorporated waffles

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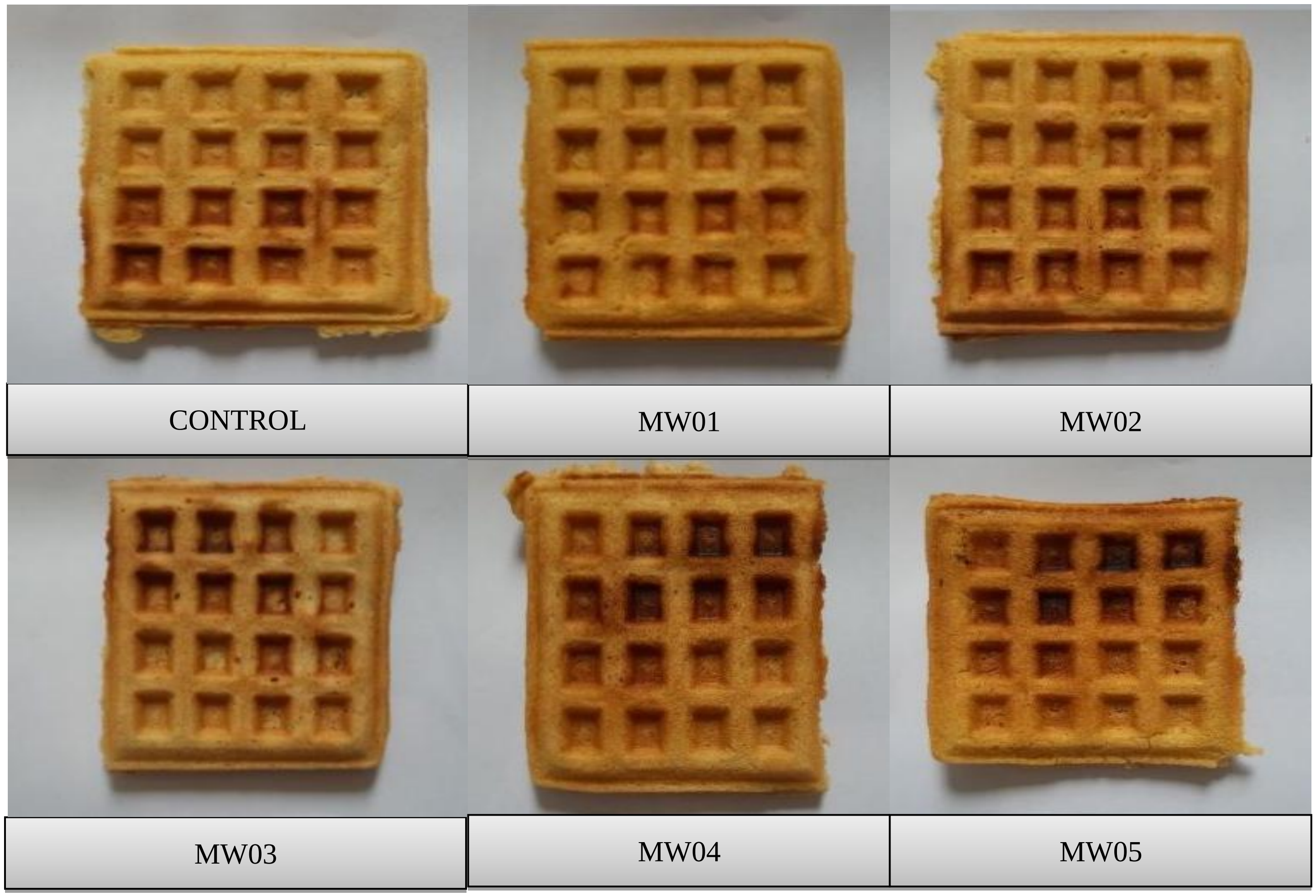

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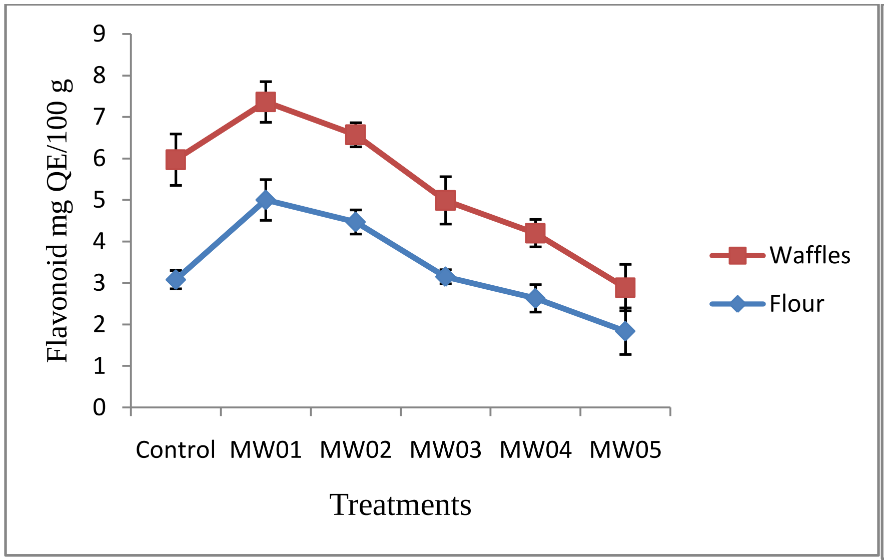
Figure 2: Different proportions of maize incorporated waffles, where CONTROL-100:0, MW01-90:10, MW02-80:20, MW03-70:30, MW04- 60:40, MW05-50:50 of Wheat flour:Riceflour in the proportion of 70:30 respectively.



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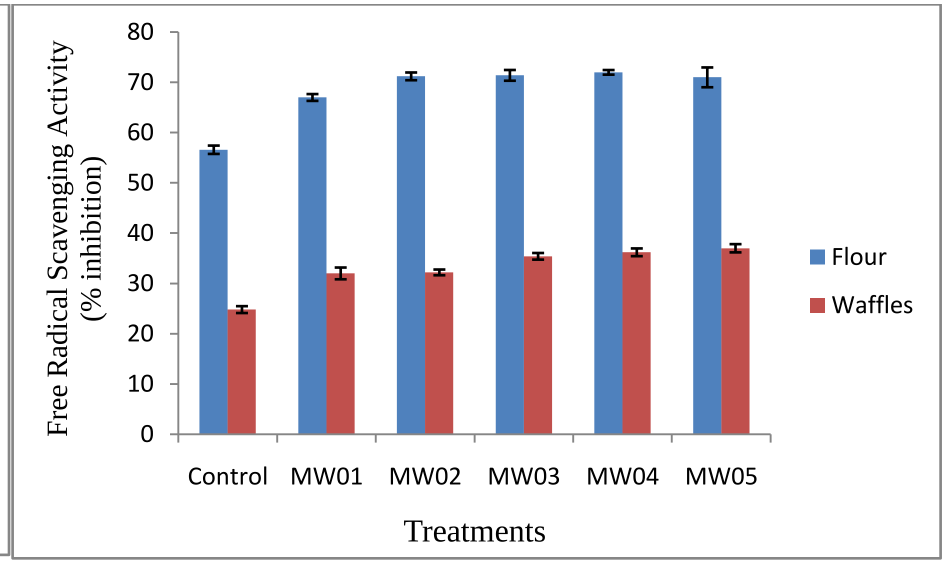

B

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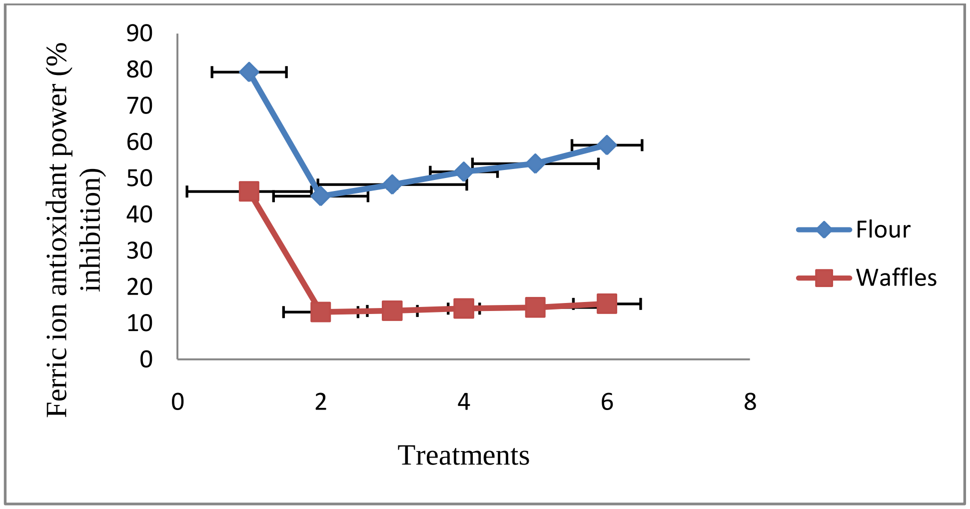

C

Figure 3: Graphical presentation of A: Flavonoid content of different treatments of maize waffles, B: Free Radical Scavenging Activity of different treatments of maize waffles and C: Ferric ion antioxidant Power of different treatments of maize waffles

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Table 1-The different treatments of flour of varying ratios used in the preparation of Waffles

Treatments	Base Flour (Refined Wheat Flour + Wheat Flour)	Maize Flour
CONTROL	100 g	0 g
MW 01	90 g	10 g
MW 02	80 g	20 g
MW 03	70 g	30 g
MW 04	60 g	40 g
MW 05	50 g	50 g

*MW- Maize Waffle

Table 2- Characterization of nutritive and functional properties of flour blends

	Nutritional profile					Functional properties		
Samples	**Moisture%**	**Protein%**	**Fat %**	**Ash %**	**Carbohydrate %**	**Oil Absorption Capacity (%)**	**Water Absorption Capacity (%)**	**Bulk density (g/cm^3)**
Control	13.8 ± 0.34^a	14.28 ± 0.27^a	1.59 ± 0.07^a	47.26 ± 1.31^a	20.4 ± 0.73^a	7.72 ± 0.31	6.19 ± 0.58	0.83 ± 1.14^a
MW01	13.2 ± 0.52^b	14.51 ± 0.64^b	$1.65.1\pm0.01^b$	47.14 ± 1.04^b	19.49 ± 0.88^b	8.14 ± 0.89	7.56 ± 1.12	0.70 ± 1.17^b
MW02	13.11 ± 0.51^c	13.32 ± 0.85^c	1.81 ± 0.09^c	46.89 ± 1.72^c	24.18 ± 1.12^c	8.43 ± 0.78	7.71 ± 0.63	0.80 ± 1.12^c
MW03	12.67 ± 0.01^d	11.81 ± 0.31^d	1.84 ± 0.08^d	46.59 ± 1.82^d	25.02 ± 1.09^d	8.74 ± 0.24	8.02 ± 0.86	0.83 ± 0.67^a
MW04	12.33 ± 0.12^d	11.22 ± 1.08^e	2.15 ± 0.01^e	46.17 ± 1.63^e	28.8 ± 0.77^e	9.22 ± 0.85	8.84 ± 0.54	0.89 ± 0.23^d
MW05	12.10 ± 0.56^e	09.14 ± 0.83^f	2.59 ± 0.05^f	45.41 ± 1.11^f	30.27 ± 0.27^f	9.84 ± 1.59	9.19 ± 0.51	0.95 ± 0.11^e

The values are represented in Mean ± Standard deviation derived for triplicate experiments (n=3). The values denoted with differentsuperscripts differ significantly at $p<0.05$ in a column

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Table 3- Characterization of nutritive and functional properties of waffle treatments

Nutritional profile						Functional properties	
Samples	**Moisture%**	**Protein%**	**Fat%**	**Ash%**	**Carbohydrate%**	**Oil Absorption Capacity (%)**	**Water Absorption Capacity (%)**
Control	19.8±0.25[a]	12.25±0.19[a]	3.7±0.01[a]	30.02±1.06[a]	33.95±1.73[a]	13.14±0.67[a]	10.24±1.06[a]
MW01	20±0.52[b]	16.63±0.99[b]	4.1±0.05[b]	28.55±0.81[b]	28.9±1.88[b]	13.93±0.61[b]	10.85±0.46[b]
MW02	20.2±0.41[c]	14.44±0.44[c]	4.3±0.04[c]	28.3±0.44[b]	29.44±2.19[c]	14.31±0.70[c]	11.22±0.77[c]
MW03	20.4±0.88[d]	11.38±0.86[d]	5.2±0.11[d]	27.9±1.02[c]	34.21±2.09[d]	15.49±0.60[c]	11.96±0.47[c]
MW04	21.4±0.41[e]	11.2±0.85[e]	5.58±0.19[e]	27.5±0.89[d]	34.55±1.77[e]	17.76±0.87[d]	13.69±0.59[c]
MW05	22.1±0.47[f]	10.5±0.44[e]	6.78±0.21[f]	26.41±1.68[e]	36.54±1.27[f]	17.94±0.71[e]	13.82±0.95[d]

The values are represented in Mean ± Standard deviation derived for triplicate experiments (n=3). The values denoted with different superscripts differ significantly at $p<0.05$ in a column

Table 4- Effect of different treatments on various sensory attributes of waffles prepared from maize flour

Samples	**Color and appearance**	**Taste**	**Aroma**	**Texture**	**Overall acceptability**
Control	7.33±0.41[a]	7.13±0.22[a]	6.75±0.04[a]	6.98±0.83[a]	7.04±0.03[a]
MW01	6.9±0.52[a]	6.8±0.21[b]	7.2±0.03[b]	7.1±0.9[b]	7±0.04[a]
MW02	7±0.41[b]	7±0.20[b]	6.83±0.30[c]	6.88±0.99[c]	6.92±0.07[b]
MW03	7.44±0.53[b]	7.44±0.53[c]	7.5±0.53[d]	7.5±0.76[c]	7.47±0.01[dc]

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MW04	6.89±0.76[c]	7±0.62[d]	6.65±0.41[e]	6.18±0.06[d]	6.68±0.04[d]
MW05	6.33±0.32[d]	6.19±0.62[d]	6.5±0.51[f]	6±0.19[e]	6.25±0.06[e]

The values are represented in Mean ± Standard deviation derived for triplicate experiments (n =3). The values denoted with different superscripts differ significantly at *p*<0.05 in a column.

Table 5- Shelf life analysis of the optimized waffle

Tests	**0th day**	**3rd day**	**6th day**	**9th day**	**12th day**	**15th day**
HMF(µmoles/g)	2.45±0.03[a]	2.61±0.04[b]	2.71±0.6[c]	4.11±0.08[d]	5.86±0.4[e]	7.18±0.04[f]
TBA (mg malenaldehyde /kg)	2.82±0.04[a]	3.41±0.6[b]	4.01±0.06[c]	5.74±0.5[d]	6.21±0.6[e]	6.45±0.04[f]
FFA (% oleic acid)	6.73±0.28[a]	7.83±0.7[b]	8.30±0.07[c]	9.56±0.06[d]	10.21±0.4[e]	10.78±0.5[f]
Total plate count (cfu/g)	0.00	$3.53*10^{7}$[a]	$3.68*10^{7}$[b]	$4.10*10^{7}$[c]	$7.66*10^{7}$[d]	$9.72*10^{7}$[e]
Moisture	15.7%±0.5[a]	14.3%±0.4[b]	13.9%±0.8[c]	13.2%±0.52[d]	12.8%±0.2[e]	11.4%±0.6[f]

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The values are represented in Mean ± Standard deviation derived for triplicate experiments (n =3). The values denoted with different superscripts differ significantly at *p*<0.05 in a column