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Impact of Using Millet Flour On Burger Bun and Beef Burger Quality

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ABSTRACT

The objective of this study was to evaluate the impact of using millet flour on the quality of both burger bun bread and beef burger patty as a favorite sandwich for a big category of people specially children. For burger bun bread (BB), wheat flour (WF) was substituted by 10 (T1), 20 (T2), 30 (T3), 40 (T4) and 50% (T5) millet flour (MF). Sensory evaluation was achieved in order to choose the most accepted BB samples, then chemical composition, physical properties, alkaline water retention capacity (AWRC), staling rate (SR), crust and crumb color and rheological properties were done on the most accepted BB samples. Likewise, beef burger patties (BP) were formulated by substitute beef meat by 5 (MF5), 10 (MF10) and 15% (MF15) MF. A control samples (C) of BB and BP were done from 100 % of WF and beef meat. Different prepared BP samples were tested for its chemical composition, hardness, cooking properties, color and sensory characteristics. Sensory evaluation of BB showed that the, the most accepted BB samples were C, T1, T2 and T3. Total ash, crude fiber and ether extract were be enhanced in T1, T2 and T3 then C sample. Calorie value was higher for T2 and T3 samples. Weigh of T2 and T3 was found to be the same as C sample, however volume and specific volume of prepared BB samples were decreased as the MF proportion increased. Lower AWRC and SR was reported for C, T1, T2 and T3. Regarding rheological properties, the wheat flour blends with MF had a good behavior in rheological properties, where there was an increment in stability time, dough development time, decrement of dough weakening and mixing tolerance index and R/E values. The crust and crumb color of the BB samples contained MF decreased as the MF proportion increased. With regards to BP samples, the moisture, crude fiber, ether extract and total carbohydrates content were reinforcement, as well as, the BP contain MF exhibit a good hardness, cooking yield, cooking loss, shrinkage, weight after cooking, color properties and an excellent sensory attribute when compared with C sample. Therefore, it could be illustrated that MF could be successfully used in the preparation of burger bun bread with a concentration up to 20% MF and beef burger patty with a concentration up to 15 % of MF.

Keywords: Millet, beef burger patty, burger bun bread, cooking properties, hardness, physical properties, rheological properties

1. Introduction

Rising consumer awareness in wellness, health, and nutrition increased the demand about food items that improves nutritional status and reduce the risk of certain diseases linked to modern lifestyles (Sun, *et al.,* 2002 and Oboh *et al.,* 2007).

Pearl millet (*Pennisetum glaucum*) is an annual, warm season crop belonging to the Poaceae family. It is drought, heat tolerant and has the ability to grow in poor, sandy and saline soils under arid, hot and dry climate, therefor it is resilient to climate change (Jukanti *et al.*, 2016). Millet is a food that supplies a major proportion of calories to large segments of populations in the semi-arid tropical regions of Africa and Asia (O'Kennedy *et al.*, 2006). Millet is a superior cereal with regard to nutritional quality and presents several health benefits (Krishnan *et al.,* 2011), where millet is a gluten free nature (Nada, *et al.,* 2016) and can be used as a staple food substitute for celiac patients who require gluten-free cereal (Shahidi and Chandrasekara, 2013), likewise, utilization of millet flour in different food product improved the nutritional quality by contributing to higher concentration of protein, fiber,

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minerals such as iron and zinc, vitamin B6, also, have a low glycemic index (Shobana *et al.*, 2009). Millet has a several health benefits such as antioxidant, antimicrobial and hypo cholesterolaemic properties (Devi *et al.*, 2011).

A burger consists of cooked burger patty in bun bread, it considered one of the enjoyment foods that consumed for a big category of people today. Moreover, it could be healthy if it prepared with a healthy ingredient and cooked in a healthy way. Beef burger is one of the most popular meat products that is widely used as a ready meal (Heck *et al.*, 2017). The acceptability of the foods developed with millet flour, such as biscuit and breads, is reported to be very good (Saha *et al.*, 2011 and Schoenlechner *et al.*, 2013).

According to above information, millet grains can find a place in the preparation of several health food-products. Therefore, the purpose of this research was evaluating the impact of using millet flour on the quality of burger bun bread and beef burger patty. Sensory evaluation, chemical composition, physical properties, alkaline water retention capacity, staling rate, crust and crumb color and rheological properties for burger bun bread were achieved. As well as, chemical composition, hardness, cooking properties, color and sensory evaluation were done for the beef burger patty.

2. Materials and Methods

2.1. Materials

Millet grains (*pennisetum glaucum*) was obtained from Siwa Oasis station, desert Research Center, Matrouh Governorate, Egypt. Wheat flour (WF), 72% extraction, yeast, butter, sugar, egg, vanilla, salt and baking powder were purchased from the Local market of Cairo, Egypt. Boneless grounded beef meat (lean meat) was purchased from a local butcher shop in the day before the experiment in this investigation was done and stored in a refrigerator at 5±1°C overnight. Spices, white and black pepper, onion powder, garlic powder and salt were obtained from the local market, Giza, Egypt.

2.2. Preparation of millet flour:

Millet grains were cleaned from dust and ground to flour in an electric grinder stainless steel (made in france; LM240 6A06 495 (b)) and sifted through a 60 mesh and finally were packed and stored at –18ºC until analysis and used (Hassan *et al.*, 2020).

2.3. Burger bun bread processing:

The production of Burger bun bread (BB) was carried out at Egyptian Baking Technology, El-Haram, Giza, Egypt, following the procedures outlined by A.A.C.C., (2000). The ingredients for the BB included 100 g mixed flour, 1.5 g instant active dry yeast, 1.0 g salt (sodium chloride), 5 g sugar (sucrose), 5 g shortening, and water (added to reach 500 Brabender Units of consistency). The dry ingredients were manually mixed and added to a mixing bowl. Shortening and water were then added, and the components were thoroughly mixed using an electric mixer. The resulting dough was divided, rounded, allowed to relax, molded, panned, and proofed in a fermentation cabinet. The proofed pieces were then baked in an electric oven, cooled, packed, and subjected to further analysis. BB samples were prepared as follows: (C):100% WF as a control sample; (T1):90% WF + 10% MF; (T2): 80% WF + 20% MF; (T3): 70% WF + 30% MF; (T4): 60 WF + 40% MF and (T5): the WF was replaced by 50% MF.

2.4. Beef burger patties preparation

Beef burger was formulated by 71% lean meat, 10% fat, 1.0 % salt, 0.2% white pepper, 0.2% black pepper, 0.2% garlic powder, 2.0% onion powder and 15.4% cold water. Each blend of beef burger patty (BP) was mixed with all ingredients and formed into beef patties using a burger patty forming machine (Expro. Co., Shanghai, China) with a diameter about 8 to 9 cm. The beef patties were cooked for 20 min in a pre-heated hot-air oven at 180 ± 1°C to an internal temperature of 75°C measured reached to ensure a uniform cooking. Then the beef patties were turned over at 10 min intervals (Shokry, 2016). BP samples were prepared by replacing beef meat by MF as follows: (C):100% minced meat as a control sample; (MF5%): 95 % meat + 5% millet flour; (MF10%): 90% meat + 10% millet flour and (MF15%): 85% meat + 15% millet flour.

2.5. Analytically methods

2.5.1. Sensory evaluation of burger bun bread samples

The sensory evaluation of BB samples was performed by a ten member from the Agro-Industrial Unit, Plant Production Department, Desert Research Center, Cairo, Egypt to set the accepted sensory BB samples. The samples for sensory analysis were coded and placed randomly among the panel members to evaluate the sensory characteristics (crumb color, crust color, taste, texture, flavor, mouthfeel and overall acceptability). The analysis is based on a 10-point hedonic (Nongrang and Thakur, 2019). The sensory analysis was carried out after 24 hrs. of baking.

2.5.2. Rheological properties determination

Rheological properties of blended flour that gave the most accepted BB samples were evaluated at Egyptian Baking Technology, El-Haram, Giza, Egypt, using farinograph and extensograph measurements according to A.A.C.C. (2000).

2.5.3. Chemical composition

Moisture content, ash, crude protein, crud fiber and ether extract of WF, MF, for the accepted BB and all BP samples were estimated according to A.O.A.C. (2000) and Total carbohydrates were determined by differences. Calorie values were calculated for WF, MF and accepted BB samples according to Stilinović *et al.* (2020) using the following equation:

$$\text{Calorie value (kcal/100 g)} = (\%\ \text{carbohydrate} \times 4) + (\%\ \text{protein} \times 4) + (\%\ \text{fat} \times 9).$$

2.5.4. Physical properties of accepted burger bun bread samples

After BB samples were cooled for 15 min. the weight, volume and specific volume were determined according to A.A.C.C. (2000).

2.5.5. Alkaline water retention capacity of accepted burger bun bread samples

The alkaline water retention capacity (AWRC) was determined as described by Kitterman and Rubanthaler (1971), as following: After baking, the most accepted BB samples were cooled at room temperature, and then stored at 24 °C in sealed polyethylene bags to prevent moisture loss. At zero, 24, 48 and 72 hrs. of storage at room temperature, BB was cut into small pieces, dried at 50 °C under reduced vacuum oven and then ground on a stein mill to pass through a 60-mesh stainless steel sieve. Five gram of each dried BB sample was placed into a 50 ml dry plastic centrifuge tube. Then, 25 ml of $NaHCO_3$ solution (8.4 sodium bicarbonate dissolved in one-liter distilled water) were added. The tube was stopped and shake until all packed products became wet. Then, the mixture was left for 20 min. with shaking every 5 min. the contents were then centrifuged at 2500 rpm for 15 min. After centrifugation, the supernatant was decanted and the precipitate was left for 10 min. at 45˚ angle to get rid of free water. The AWRC% of different tested BB samples was determined as follows:

$$\text{AWRC \%} = [(\text{Weight of tube with sample after centrifuge} - \text{weight of empty tube}) / \text{Weight of sample}] \times 100.$$

2.5.6. Staling rate of accepted burger bun bread samples

Determination of staling rate after 24, 48 and 72 hrs. of storage for the accepted BB samples, according to Abd El-Khalek *et al.* (2019) by using the following equation:

$$\text{Staling rate (SR \%)} = [(AWRC0 - AWRCn)/ AWRC0] \times 100$$

Where: AWRC0: AWRC at zero time.
AWRCn: AWRC at a specific day of storage.

2.5.7. Color measurement of accepted burger bun bread and beef burger patty samples

Color of both BB and BP samples were measured by using Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer at Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University. Color was expressed using the CIE L*, a*, and b* color system (CIE, 1976). A total of three spectral readings were taken for each sample. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish) and the yellowness (b*) value (yellowish to bluish) were evaluated.

2.5.8. Hardness measurements of beef burger patty samples

Hardness of BP samples was performed at Food Technology Department, National research Center, Cairo, Egypt, using Brookfield, CT3-10 kg, equipped with Fixture TA-MTP. Test method was done as follows: test type compression, trigger load 0.07 N and test speed 1 mm/s.

2.5.9. Cooking measurements of beef burger patty samples

The cooking yield, moisture retention and shrinkage of BP samples have been determined according to El-Magoli *et al.* (1996), while cooking loss of BP samples were calculated consistent with the method mentioned by Jama *et al.* (2008) using the following equation:

$$\text{Cooking loss} = \frac{\text{Weight of raw sample} - \text{Weight of cooked sample}}{\text{Weight of raw sample}} \times 100$$

$$\text{Cooking yield (\%)} = \frac{\text{Cooked weight}}{\text{Raw weight}} \times 100$$

$$\text{Moisture retention (\%)} = \frac{\text{Percent yield x moisture}}{100}$$

$$\text{Shrinkage (\%)} = \frac{\text{Raw burger diameter- Cooked burger diameter}}{\text{Raw burger diameter}} \times 100$$

2.5.10. Sensory evaluation for beef burger patty samples

Sensory evaluation was carried out by ten members at Food Technology Department, National research Center, Cairo, Egypt. The panelists were asked to evaluate color, taste, tenderness, flavor, appearance and overall acceptability as described by Kassem and Emara, (2010), using 20-point scale for grading the quality of samples.

2.6. Statistical Analysis

The collected data were analyzed using the SPSS (Statistical Program for Sociology Scientists) Statistics Version 20 for computing the mean values, LSD, ANOVA ($p < 0.05$) and Duncan Multiple Range test (Armonk, 2011).

3. Results and Discussion

3.1. Chemical composition of wheat and millet flours

Results presented in table (1) clarified the chemical composition of both WF and MF on dry weight basis. The moisture content of WF (12.07%) was found to be higher than moisture content of MF (8.29%). Moreover, MF found to contain a higher amount of ether extract (5.77%), total ash (0.65%), crude fiber (0.18%) and total carbohydrates (78.51%) than WF. Moreover, MF found to contain a considerable amount of crude protein (6.6%), whilst the WF had the highest crude protein content (9.11%). Regarding calorie value, the MF recorded 392.37 Kcal which was higher than the calorie value of WF (356.99 Kcal). The results of total ash, crude protein, crude fiber and fat values of MF was lower than those obtained by Audu *et al.* (2018) who stated that millet flour total ash, crude protein, crude fiber and fat with 2.51, 8.42, 2.51 and 7.94%, respectively. It could be illustrated that the low moisture content indicates a long shelf life for the cereal flours. El-Tanahy *et al.* (2021) observed the same fat content of millet flour (5.88%). Moisture content and ether extract of MF was higher than those found with Hassan *et al.*, (2020), who established that moisture content and fat was 8.43 and 1.89 %, respectively. Meanwhile, the total carbohydrates values of MF were higher than those stated by Audu *et al.* (2018) which was (73.32%) and equal the same value (77.88 %) observed with Hassan *et al.* (2020). Sood *et al.* (2016) reported that millet grains consist of nutrient carbohydrates with a high concentration as compared to other cereal grains. Results for WF were lower than those observed with El-Said *et al.* (2021) for all chemical composition parameters except fat content (1.4%) was in agreement as our result which was (1.47%).

Table 1: Chemical composition of wheat and millet flours (dry weight basis).

Chemical composition (%)	WF	MF
Moisture content	12.070±0.27	8.290±0.27
Total Ash	0.483±0.2	0.65±0.3
Crude protein	9.11±0.3	6.60±0.3
Crude fiber	0.035±0.2	0.180±0.2
Ether extract	1.470±0.3	5.770±0.3
Total carbohydrates*	76.832±0.15	78.510±0.15
Calorie (Kcal/100g)	356.99±0.10	392.37±0.10

WF: Wheat flour, **MF:** Millet flour, Data are mean ± Standard deviation, *Calculated by differences.

On contrary, total ash, crude protein, crude fiber and fat of WF were in agreement with those observed with El-Tanahy *et al.* (2021). Jocelyne *et al.* (2020) stated a lower total carbohydrates content for both wheat and millet flour 73.91 and 71.82 %, but recorded a nearly fat content value 1,73 and 4.58 % for both wheat and millet flour, respectively. With regard to calorie value, the MF recorded a higher calorie value (392.37 Kcal/100g) than WF (356.99 Kcal/100g). Jocelyne *et al.* (2020) found that calorie value of both WF and MF was 308.22 and 319.39 Kcal/100g, respectively, which was lower than our results. Raising in calorie value could be due to the higher content of fat or total carbohydrates (Mansour *et al.*, 2021).

3.2. Evaluation of burger bun bread samples

3.2.1. Sensory evaluation of burger bun bread samples

Effect of substitution WF by 10, 20, 30, 40 and 50% of MF was estimated for sensory parameters. Data in table (2) revealed that, there was no significant ($p \geq 0.05$) difference between C, T1 and T2 samples for all sensory attributes expect the texture, where the T2 sample significantly ($p \leq 0.05$) scored (8.8) lower than both C and T1 samples which scored the same value (9.0). Moreover, both T4 followed by T5 found to had the lowest significant ($p \leq 0.05$) score for all sensory attributes. Concerning the overall acceptability, the C, T1 and T2 samples had scored the highest value followed significantly ($p \leq 0.05$) by T3, T4 and T5 samples, respectively.

Table 2: Sensory evaluation of burger bun bread samples.

Bread Sample	Sensory parameters						
	Crumb color	Crust color	Texture	Flavor	Taste	Mouthfeel	Overall acceptability
C	9.2^{a} ±0.28	9.3^{a} ±0.28	9.3^{a} ±0.28	9.0^{a} ±0.00	9.2^{a} ±0.28	9.5^{a} ±0.00	9.8^{a} ±0.28
T1	9.3^{a} ±0.28	9.4^{a} ±0.36	9.0^{a} ±0.00	9.0^{a} ±0.00	9.3^{a} ±0.28	9.5^{a} ±0.00	9.7^{a} ±0.28
T2	9.1^{a} ±0.32	9.0^{a} ±0.15	8.8^{b} ±0.26	8.8^{a} ±0.26	9.0^{a} ±0.05	9.1^{a} ±0.11	9.3^{a} ±0.28
T3	8.7^{b} ±0.28	8.5^{b} ±0.00	8.6^{c} ±0.17	8.4^{b} ±0.17	8.8^{b} ±0.26	8.5^{b} ±0.00	8.3^{b} ±0.28
T4	7.3^{c} ±0.30	7.7^{c} ±0.28	7.6^{d} ±0.23	7.7^{c} ±0.28	7.3^{c} ±0.28	7.6^{c} ±0.28	7.2^{c} ±0.28
T5	6.5^{d} ±0.50	7.0^{d} ±0.00	6.5^{e} ±0.00	7.0^{d} ±0.00	6.2^{d} ±0.28	6.6^{d} ±0.28	6.2^{d} ±0.28

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.
Mean value ± Standard deviation of replicates, means sharing the same small letter in a column are not significantly different at $p \geq 0.05$.

The panelist comment on the T4 and T5 samples that they had unaccepted texture, taste and they had after taste. So, there was no significant ($p \geq 0.05$) changes between the 100% WF up to 20% MF and 30% MF which like moderately. The decrement in sensory attributes scores were due to the increment of substitution proportion of WF by MF. Hassan *et al.* (2020) reported that, as the millet proportion increase in the prepared gluten free fino bread the overall acceptability scores decrease, also, a control sample made of millet flour found to score a lowest significant (p≤0.05) overall acceptability value.

Similar sensory results were achieved with El-Poraie, *et al.* (2019) who reported that sensory properties of pan bread formulated with millet flour was acceptable even at 30% substitution level. Mansour *et al.* (2021) mention that, as the millet flour level increase in the bread processed blend, a decrement in bread sensory attributes occurred. Therefore, C, T1, T2 and T3 samples were chosen as the most acceptable formulation for BB prepared with MF and will be conduct to the rest analysis to evaluate them.

3.2.2. Rheological properties of blended flour samples

Production of baking products need the most accurate method in quality evaluation, rheological properties is the most effective in processing behavior predicting. Farinograph and extensograph are the most common empirical instruments used for characterizing dough rheology. Therefore, flour blend samples which gave the most accepted BB samples were predicting for farinograph and extensograph estimation and data showed in table (3) and table (4), respectively.

Water absorption (%) is the measure of the water amount which be added to the flour in order to form good dough at 500 brabender units (Abo Raya *et al.*, 2022). The water absorption values went on decreasing as the level of MF increased from 10 to 30%, the great increment was illustrated with the C sample (57.4%), followed by T1, T2 and T3 samples with values 56.4, 55.5 and 54.0 %, respectively, and thus it could be concluded that as the millet substitution proportion increased the water absorption percent decreased. Our results were in the same line with El-Poraie *et al.* (2019) and Mansour *et al.* (2021) who mentioned that the water absorption decreased as the MF substitution proportion increased. Carson and Sun (2000) noticed that the water absorption of the composite flour decreased significantly (p≤0.05) with the increase in the level of sorghum. Differences in water absorption are mainly caused by the greater number of hydroxyl groups in the fiber structure which allow more water interaction through the hydrogen bond (Sudha *et al.*, 2007).

The dough development (Mixing time) is a time necessary to reach 500 BU of dough consistency and found to be the highest with T3 sample, whilst the T1, T2 and C samples recorded the same arrival time. The development dough time start to raise up with the T3 sample (30% MF). Same trend of dough development was detected with El-Poraie *et al.,* (2019) who noticed that there was no significant (p≥0.05) change in dough development values up to 20% replacement of wheat by millet flour. Tomic *et al.,* (2015) marked that reported difference in dough development time values depend on levels of gluten structure built-in. Higher dough development time considered to an indication for a strong flour, moreover, the lower values of dough development time usually related to weaker gluten (El-Sisy *et al.*, 2014).

With concern to stability time, it was higher with both T2 and T3 samples with a same value (6.5 min.), whereas the T1 sample found to be with a low value (4.0 min.). There was a raising trend in the stability time values as the MF substitution proportion increased. The lowest stability time value was observed with C sample (2.0 min.) and raised to 6.5 with both T2 and T3 samples. The higher value of stability time, which estimate the protein quality, means the higher dough strength (Wang *et al.,* 2002). Regards dough weakening index, it was affected negatively by the increment of MF substitution proportion, where the maximum values stated by C sample while the T1, T2 and T3 samples exhibit a same minimum degree of dough weakening index value. Lower in dough weakening index values could be due to decreased wheat gluten content (Rao and Rao, 1997). Results were not in accordance with, Thorat and Ramachandran, (2016) who informed that there was an increment in development dough time and a decrement in water absorption, stability time and dough weakening values started from 5% substitution with millet flour. Moreover, Mansour *et al.* (2021) have reported that the development dough and stability time decreased as MF substitution proportion increased. As well, the mixing tolerance index scored a highest value with T1 sample (120 BU), then a high reduction occurred with the T2 and T3 samples with a value 50 and 30 BU, respectively. Similar result was observed with Abo Raya *et al.* (2022). El-Sisy *et al.* (2014) notify that higher mixing tolerance index value, weaker is the flour.

Table 3: Farinograph properties of blended flour samples.

Blended flour samples	Water absorption (%)	Dough development (min.)	Stability time (min.)	Dough weakening index (BU)	Mixing Tolerance index (BU)
C	57.4	1.0	2.0	130	100
T1	56.4	1.0	4.0	90	120
T2	55.5	1.0	6.5	90	50
T3	54.0	1.5	6.5	90	30

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.

Extensograph data reveals an information about the viscoelastic behavior of the dough. Resistance to extension, extensibility, R/E and energy of flour blend samples were estimated. Resistance of extension (R) mean the dough strength to extension and measured by the maximum height of the curve. Extensibility (E) means the deformation of the dough during extension and before it breaking and measured by the length of the curve, where the higher extensibility value means the more dough extended before it breaking (Wang *et al.,* 2003). The dough energy (DE) value which is mean the area under the curve and indicate the dough strength (Miś and Dziki, 2013). R/E ratio mean the extent to which the dough can stretch before breaking from data in table (4), It was noticed that the R, E and DE values decreased as the MF substitution proportion increased in the flour blend samples. For the R/E, it was observed that all samples contain MF proportion detect a R/E value higher than C sample. The highest value was scored by T2 and T1 samples (2.9 and 2.8), respectively, followed by T3 sample with 2.4 R/E value. Similar result was demonstrated with Thorat and Ramachandran, (2016) who declared a decrease in resistance to extension, extensibility and dough energy values, and increment in R/E values as millet flour level increase. As well, El-Poraie *et al.* (2019) and Mansour *et al.,* (2021) cleared a decrement in both R, E and energy values as the millet flour replacement increased in the pan bread formulation. Finaly, in spite of low gluten content in the flour blends that contain MF different proportion, except of, there was an increment in stability time, dough development time, decrement of dough weakening, mixing tolerance index and R/E values, which make the flour blends with MF had a good behavior in bun bread process.

Table 4: Extensograph properties of blended flour samples.

Blended flour samples	Resistance to extension (BU)	Extensibility (mm)	R/E	Energy (cm^2)
C	300	140	2.1	51
T1	340	120	2.8	35
T2	320	110	2.9	66
T3	240	100	2.4	55

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.

3.2.3. Chemical composition of accepted burger bun bread samples

Chemical composition of accepted BB samples was determined and presented in table (5). The lowest moisture content mean value was put in place with T3 sample (29.58 %) followed by T2 sample (30.31 %) then C sample (31.13 %), while the T1 sample recorded the highest moisture content mean value (31.67 %). Mean value of both total ash and crude fiber were increased with the T1 (3.09 and 0.07 %), T2 (3.09 and 0.08 %) and T3 samples (2.09 and 0.07 %) when compared with C sample (1.83 and 0.06 %), respectively. Therefore, total ash and crude fiber content of BB samples contain MF was found to be significantly ($p \leq 0.05$) differ than the C sample (100 %WF) and this due to the MF higher content of total ash and crude fiber than WF. Crude protein content of BB samples was gradually decreased as the substitution proportion of MF increased, this may be due to the MF lower content of crude protein than WF. The lowest decrement rate in crude protein mean value was noticed with T1 sample (13.22%), whereas the highest decrement rate in crude protein mean value was obtained with

T3 sample (12.62%). As for total carbohydrates, the highest mean value was recorded with T2 and T3 samples, whilst the lowest mean value was listed with T1 sample. Concerning ether extract, the T1, T2 and T3 samples registered a highly ether extract mean value (9.46, 9.84 and 9.03%) more than C sample (8.79%), these could be due to higher ether extract content in MF than WF. Arora and Saini, (2016) mentioned that decrement in moisture content helps improve the storage of bakery products at ambient temperature. Our crude protein, total ash and crude fiber results trend were in line with Devani *et al.* (2016) who recorded a decrement in crude protein content and an increment in both total ash and crude fiber as the wheat flour replacement proportion with millet flour increased in processed white bread. Rajiv *et al.* (2011) notified that, as the addition of millet flour increased, the ash content increased and the protein content decreased in muffins. Zidan, (2021) demonstrated an improvement in both ash and crude fiber content in toast bread as the millet flour proportion increased, whilst the protein, fat and total carbohydrate decreased.

Table 5: Chemical composition of accepted burger bun bread samples (dry weight basis).

Chemical composition (%)	BB samples			
	C	T1	T2	T3
Moisture content	31.13^{b}±0.02	31.67^{a}±0.00	30.31^{c}±0.00	29.58^{d}±0.70
Total Ash	1.83^{c}±0.05	3.09^{a}±0.00	3.09^{a}±0.00	2.90^{b}±0.17
Crude protein	13.53^{a}±0.03	13.22^{b}±0.00	12.83^{c}±0.05	12.62^{d}±0.02
Crude fiber	0.06^{b}±0.01	0.07^{a}±0.01	0.08^{a}±0.01	0.07^{a}±0.01
Ether extract	8.79^{d}±0.01	9.46^{b}±0.00	9.84^{a}±0.00	9.03^{c}±0.05
Total carbohydrates*	44.66^{b}±0.01	42.49^{d}±0.28	43.85^{c}±0.70	45.80^{a}±0.21
Calorie (Kcal/100g)	311.87^{b}±0.12	307.98^{c}±0.10	315.28^{a}±0.20	314.95^{a}±0.20

C: Control burger bun bread, **T1:** burger bun bread with 10 % millet flour, **T2:** burger bun bread with 20 % millet flour, **T3:** burger bun bread with 30 % millet flour.
Mean value ± Standard deviation of three replicates, means sharing the same small letter in a raw are not significantly different at $p \geq 0.05$.
*Calculated by differences.

3.2.4. Physical properties of accepted burger bun bread samples

The effect of replacement WF by 10, 20, 30 % MF on weight, volume and specific volume of accepted BB samples were presented in table (6). Results showed that, there was no significant ($p \geq 0.05$) difference in weight of BB samples observed between the C sample (60.17 g), T2 sample (61.19 g) and T3 sample (62.27 g), whereas the T1 sample (61.19 g) recorded the lowest significant ($p \leq 0.05$) BB weigh. Thus, replacement of WF with 20 and 30% of MF doesn't affect the BB weight. The volume and specific volume decreased significantly ($p \leq 0.05$) as the replacement proportion of MF increased.

This result was not in accordance with El-Poraie *et al.* (2019) who conclude that the weight of pan bread formulated by more than 10% of MF increased as compared to the control weight sample. Devani *et al.* (2016) registered an increment in white bread weight as the substitution level of millet flour increased and attributed the reason to less retention of carbon dioxide gas in the blended dough resulting in dense bread texture, also a decrement in white bread volume was observed which it could be due to the decrease in the proportion of the gluten content which ensures the increased volume of bread. Horsfall *et al.* (2007) stated that increment in weight could be attributed to increased moisture absorption and decreased air entrapment, resulting in heavy dough.

Results were in accordance with Mudau *et al.* (2021) who found an increment in weigh and decrement in both specific volume and volume as the replacement percentage of finger millet flour in bread formulation increased and mentioned that the decrement in volume and specific volume may be due to decrement of gluten level in the bread dough. Moreover, Arora and Saini, (2016) except a decrement in volume of bun loaf bread as the amount of free gluten de-oiled maize germ flour increase. Also, Bibiana *et al.* (2014) informed that decrease in structure forming protein leads to low bread volume. Banks *et al.* (1997) reported that partial replacement of wheat flour by a gluten free flour resulted in lower baked volume.

Table 6: Physical properties of accepted burger bun bread samples

Bread samples	Physical parameters		
	Weight (g)	**Volume (cm^3)**	**Specific volume (cm^3/g)**
C	$60.17^a \pm 0.37$	$237.5^a \pm 3.54$	$3.95^a \pm 0.04$
T1	$58.27^b \pm 0.38$	$200.0^b \pm 0.00$	$3.44^b \pm 0.02$
T2	$61.19^a \pm 2.06$	$152.5^c \pm 3.54$	$2.49^c \pm 0.03$
T3	$62.27^a \pm 1.12$	$112.5^d \pm 3.54$	$1.81^d \pm 0.02$

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.
Mean value ± Standard deviation of three replicates, means sharing the same small letter in a column are not significantly different at $p \geq 0.05$.

3.2.5. Alkaline water retention capacity (AWRC) and staling rate (SR) of accepted bun bread samples:

Bun bread samples were estimated for AWRC which assess the bread staling and describes the time-dependent loss in bread quality (Obadi *et al.,* 2018). Table (7) displayed the AWRC of BB samples was measured at Zero, 24, 48 and 72 hrs. At zero time, the higher decrement in AWRC was obtained with the T3 sample (322.5%), whilst the higher AWRC mean value was found with C sample (407.0 %). Likewise, data revealed that the AWRC significantly ($p \leq 0.05$) decrease when the storage period increase, taking into consideration that the highest rate of decrement among the storage period was set with the T3 sample where the mean value of AWRC decreased during the first 72 hrs., followed by T2, T1 samples then C sample. Lower in AWRC values mean a higher fraction of starch structure Licciardello *et al.* (2014).

Table 7: Alkaline water retention capacity and staling rate of accepted burger bun bread samples.

Bread samples	AWRC (%)			
	Zero time	**After 24 hrs.**	**After 48 hrs.**	**After 72 hrs.**
C	$407.00^a \pm 5.66$	$378.00^a \pm 4.24$	$356.50^a \pm 6.36$	$319.00^a \pm 1.41$
T1	$389.50^b \pm 2.12$	$355.50^b \pm 2.12$	$322.00^b \pm 1.41$	$292.50^b \pm 3.54$
T2	$369.00^c \pm 2.83$	$329.50^c \pm 3.54$	$291.00^c \pm 1.41$	$248.00^c \pm 2.83$
T3	$322.50^d \pm 4.95$	$281.50^d \pm 3.54$	$233.00^d \pm 5.66$	$202.00^d \pm 1.41$
	SR (%)			
	After 24 hrs.	**After 24 hrs.**	**After 48 hrs.**	**After72 hrs.**
C	-------	$7.13^d \pm 0.25$	$12.42^d \pm 0.35$	$21.62^c \pm 1.44$
T1	-------	$8.73^c \pm 0.04$	$17.33^c \pm 0.08$	$24.91^b \pm 0.50$
T2	-------	$10.71^b \pm 0.28$	$21.14^b \pm 0.22$	$32.79^a \pm 1.28$
T3	-------	$12.71^a \pm 0.24$	$27.76^a \pm 0.64$	$37.35^a \pm 1.40$

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.
Mean value ± Standard deviation of three replicates, means sharing the same small letter in a column are not significantly different at $p \geq 0.05$.

Staling decides the shelf-life of bakery products is mainly limited by staling. Staling is a chemical and physical changes affect the quality of bread, these changes include starch retrogradation and increase in firmness (Amigo *et al.*, 2016). Abd El-Khalek *et al.* (2019) announced that there is an inverse relationship between AWRC and SR, whereas the AWRC values decreased, the SR values will be increased, for that, SR was estimated after 24, 48 and 72 hrs. Table (7) displayed the staling rate of BB samples. The SR of BB are highly impacted with the replacement ratio of WF by MF. The lowest significant ($p \leq 0.05$) SR value was stated with C samples followed by T1 and T2 samples, respectively, among the 72 hrs., whilst the T3 samples recorded the highest SR, which mean that as the replacement percentage of WF by MF increased the SR increased. Therefore, the replacement WF by MF affected the freshness of bun bread.

3.2.6. Color of accepted burger bun bread samples

Crust and crumb color of BB samples were performed, data displayed in table (8). Concerning crust color, a decrement in mean L*, a* and b* parameter values were occurred in the BB samples that contain MF. The highest mean L*, a* and b* values were recorded with C sample (58.89, 11.86 and 26.7), respectively, whilst the lowest mean L*, a* and b* values were exhibit with T3 sample (51.83, 11.48 and 22.10), respectively. With respect to crumb color, both L* and b* manifest a decrement value with the BB samples contained MF than C sample. On contrary, a* value increased in BB contained MF and increased as the MF proportion increased. From above data, it could be deduced that as the MF proportion increased, the lightness and yellowness of the BB crust and crumb color decreased and become darker. Our results not in accordance with El-Poraie *et al.* (2019) who cleared that the pan bread become lighter as the incorporation of millet flour increase, but in agreement with Mannuramath *et al.* (2015) who revealed that as the proportion of millet increased the color contrast of bread decreased.

Table 8: Color of accepted burger bun bread samples.

Bread samples	Crust color		
	L*	a*	b*
C	58.89^{a}±0.05	11.86^{a}±0.04	26.70^{a}±0.01
T1	54.60^{c}±0.01	11.63^{b}±0.01	23.23^{c}±0.04
T2	55.79^{b}±0.04	11.58^{b}±0.03	25.02^{b}±0.10
T3	51.83^{d}±0.11	11.48^{c}±0.07	22.10^{d}±0.16
		Crumb color	
C	77.33^{a}±0.02	-0.12^{a}±0.04	18.97^{a}±0.03
T1	74.61^{b}±0.00	0.31^{b}±0.01	18.32^{c}±0.03
T2	70.79^{c}±0.01	1.02^{b}±0.03	18.72^{b}±0.03
T3	64.59^{d}±0.05	2.11^{c}±0.07	18.68^{b}±0.09

C: Control burger bun bread, **T1:** Burger bun bread with 10 % millet flour, **T2:** Burger bun bread with 20 % millet flour, **T3:** Burger bun bread with 30 % millet flour.
Mean value ± Standard deviation of three replicates, means sharing the same small letter in a column are not significantly different at p≥0.05.

3.3. Evaluation of beef burger patty samples

3.3.1. Chemical composition of beef burger patty samples

The chemical composition of BP samples was estimated and showed in table (9). It was noticed that, the moisture content was increased as the MF proportion increased. Ether extract, crude fiber and total carbohydrates of MF5, MF10 and MF15 were significantly (p≤0.05) enhanced, whilst total ash and crude protein were significantly (p≤0.05) decreased with regards to control sample. Adzitey *et al.* (2021) clarified that, using millet flour in sausage process did not affect the total ash, fat, protein and carbohydrate contents but reduced the moisture content. Babaoğlu, (2022) revealed that millet flour did not affect moisture, total fat, total ash and protein content values of the burger samples.

Table 9: Chemical composition of beef burger samples (on wet weigh basis).

Chemical composition (%)	BP samples			
	C	MF5	MF10	MF15
Moisture content	51.88^{b}±0.04	54.02^{b}±0.28	56.76^{a}±0.08	58.10^{a}±1.14
Total Ash	3.28^{a}±0.03	3.01^{b}±0.02	2.67^{c}±0.04	2.47^{d}±0.02
Crude protein	36.13^{a}±0.10	28.58^{b}±0.20	21.37^{c}±0.12	16.18^{d}±0.50
Crude fiber	0.46^{c}±0.08	0.50^{b}±0.05	0.55^{b}±0.11	0.71^{a}±0.08
Ether extract	7.56^{d}±0.19	7.97^{c}±0.01	8.37^{b}±0.10	8.77^{a}±0.02
Total carbohydrates*	0.69^{d}±0.01	5.92^{c}±0.16	10.28^{b}±0.08	13.77.8^{a}±0.59

C: Control burger patty, **MF5:** Burger patty with 5 % millet flour, **MF10:** Burger patty with 10 % millet flour, **MF15:** burger patty with 15 % millet flour.
Mean value ± Standard deviation of three replicates, means sharing the same small letter in a raw are not significantly different at p≥0.05.

Mohamed *et al.* (2024) illustrated that the replacement of beef meat by quinoa flour caused a decrement in moisture, protein and fat content, however the total ash and total carbohydrate were increased, as the replacement proportion of beef meat by quinoa flour increased. Biswas *et al.* (2011) mentioned that un meat ingredient with high fiber content are an excellent meat substitutes due to their nutritional effects.

3.3.2. Hardness of beef burger patty samples

Hardness of different prepared BB samples were showed in figure (2). There was a change in hardness values among the BP samples. The C sample exhibit the maximum hardness value (23 N), where the hardness value of MF5, MF10 and MF15 samples was 17.9, 15.8 and 13.4 N, respectively. Same trend of result was observed with Shokry, (2016) who found that all burger patties contained quinoa flour scored a lower hardness value than the control sample. Alrahaife and Abu-Alruz (2023) detected a decrement in hardness value for burger patties contained 5, 10 and 15% untreated lupin flour as compared with control burger patty sample. The results of tested BP samples were not in the same line with Babaoğlu, (2022) who found that the burger patty that contained 5% millet flour was harder than the control sample. Biswas *et al.* (2011) clarified that un meat ingredient with high fiber content could have no or fewer changes on textural parameters of meat products by enhancing water binding capacity.

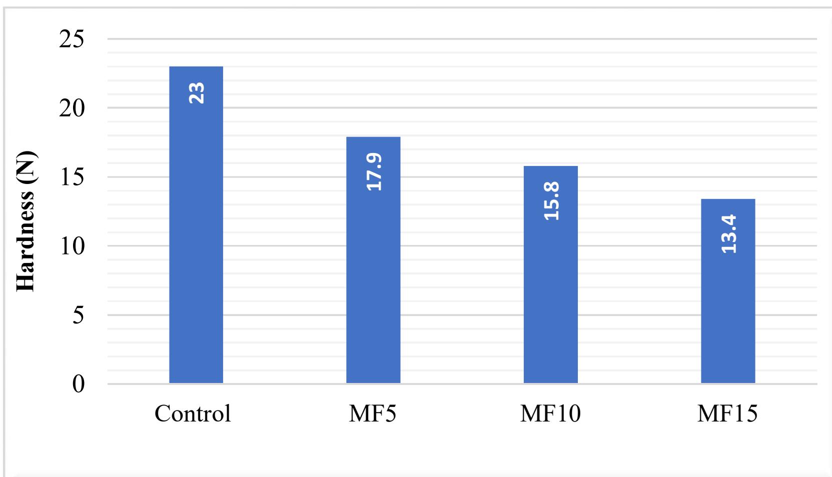

Fig. 1: Hardness of beef burger patty samples.

3.3.3. Cooking properties of beef burger patty samples

Beef burger patty samples processed by replacement beef meat by 5, 10 and 15 % MF have been investigated for its physical properties. Cooking properties are some of the most important factors for that predict the behavior of meat products during cooking. Weight of cooked and uncooked BP samples was demonstrated in figure (2). It was noticed that, replacement of beef meat by MF with different proportion enhanced the weight of BP samples after cooking when compared with the control BP sample, where the lowest weight of cooked BP samples was significant ($p \leq 0.05$) appeared with the control BP sample.

Decrement rate in weight of BP samples decrease by the increment in MF proportion, where the lowest decrement rate in weight value was exhibit with the MF15 sample (68.98g) followed by MF10 and MF5 samples with value (65.07g and 58.57g), respectively. Cooking yield mean value found to be higher with all BP samples that contain MF, whereas the C sample scored the lowest cooking yield mean value. An inverse result observed with the cooking loss, which mean that substitute beef meat by MF reinforcement the cooking yield properties and decreased the cooking loss. Biswas *et al.* (2011) informed that, un meat ingredient with high fiber content are an excellent meat substitutes because it has the ability to prevent cooking loss in meat products.

Regarding, cooking shrinkage was an indicator to protein denaturation and releasing of fat and water from beef burger samples (Drummond and Sun, 2005). It could be noticed from data in figure (2), the MF5, MF10 and MF15 samples scored a lower mean shrinkage values than the C sample

(32.11%). The lowest mean shrinkage value was recorded with MF15 sample (10.72%) followed by MF10 sample (16.23%) and MF5 sample (21.69%). Concerning moisture retention, it was concluded that, the maximum mean value deduced with MF15 (55.95%) while the lowest mean value was found with C sample (25.47%).

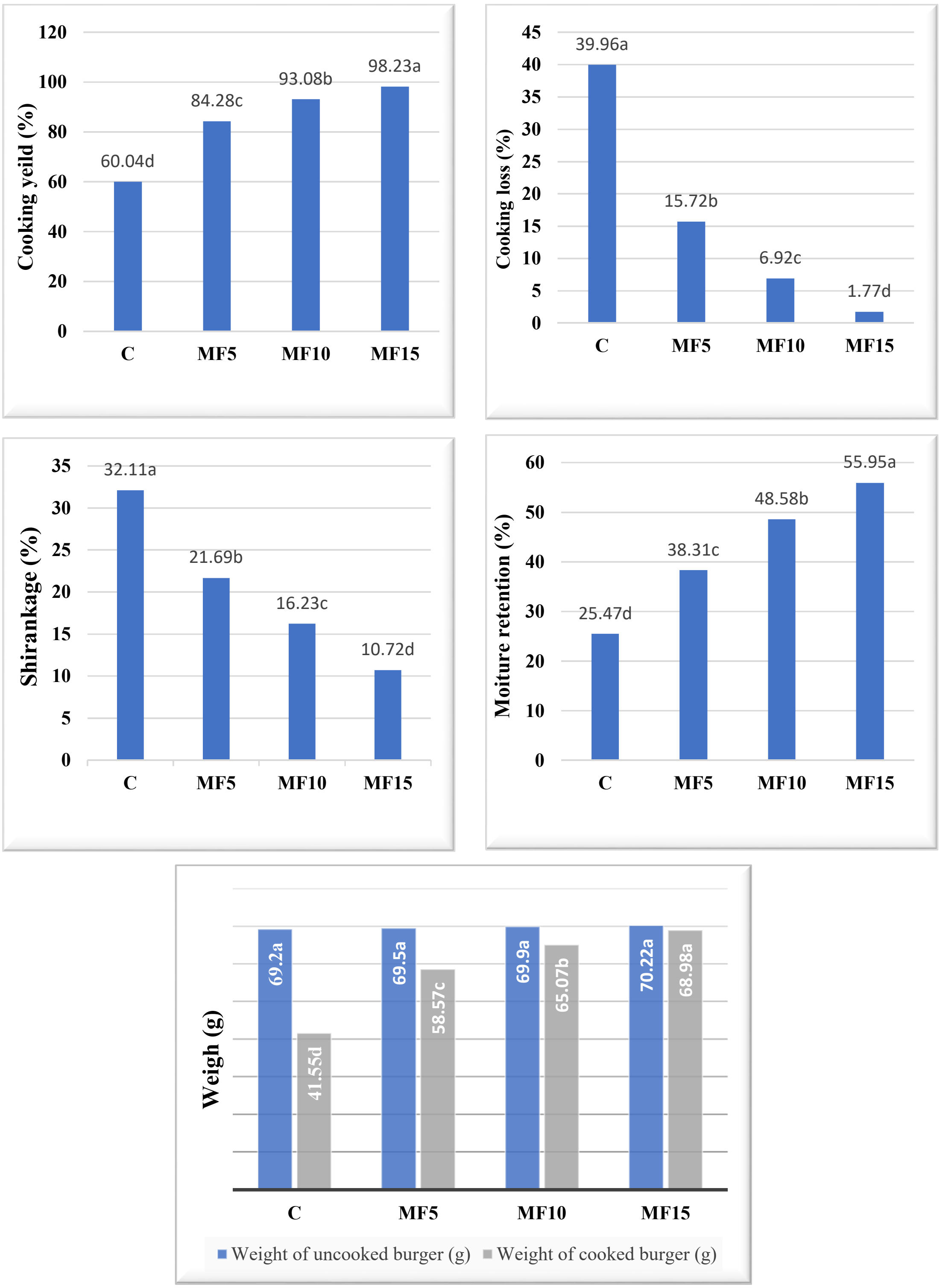

Fig. 2: Cooking properties of beef burger patty samples.

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Selani *et al.* (2015) advertised that high moisture retention positively influenced texture and juiciness of meat products. Ammar, (2012) reported that moisture retention values of beef burger samples increased when mustard flour used instead of soy flour. Kurt and Kilinççeker (2012) stated that, utilization of cereal flours increased the moisture retention of cooked meat patties. Increment in moisture retention may be due to the swelling of the starch and fiber as mentioned by Modi *et al.* (2004).

The results of tested BP samples were in full line with Aly *et al.* (2021), who cleared that both cooking yield and moisture retention increased by increasing the level of millet flour. Moreover, ELKatry and Elsawy, (2021) and Shokry, (2016) who notified that using quinoa flour with a proportion ranged from 2.5% to 15% as a substitution percent with meat increased moisture retention, cooking yield and decreased cooking loss and mentioned that higher moisture retention of powdered quinoa seeds may be attributed to its binding and stabilizing effect. Babaoğlu, (2022) informed that free-gluten flour improved the cooking yield and shrinkage of meatballs and mentioned that the improvement in cooking yield by adding gluten-free starch-based flour to meatballs is mainly related to water retention. Salcedo-Sandoval *et al.* (2014) reported that cooking properties of meat products were affected by the ability to bind water and fat during cooking process. So, usage of MF enhanced the cooking properties of BP processed.

3.3.4. Color of cooked beef burger patty samples

Color of BP samples were determined after cooking and results showed in figure (3). Usage of MF in 5, 10 and 15% substitution proportion resulted in significant ($p \leq 0.05$) increase in L*, a* and b* parameters value. The lowest mean values for color parameters reported with C sample and increased as the substitution MF proportion increased. ELKatry and Elsawy, (2021) and Shokry, (2016) found an increment in L* and b* values but a* value was decreased in all burger patties contain quinoa flour. Ratio of a*/b* value is an index to the quality of color (brightness of red color). There was a decrement trend in the a*/b*, the values were 1.56, 1.18, 1.11, 1.0% for C, MF5, MF10 and MF15 samples, respectively, which mean that MF substitution proportion had an effect on the BP color quality as mentioned by Al-Juhaim *et al.* (2015).

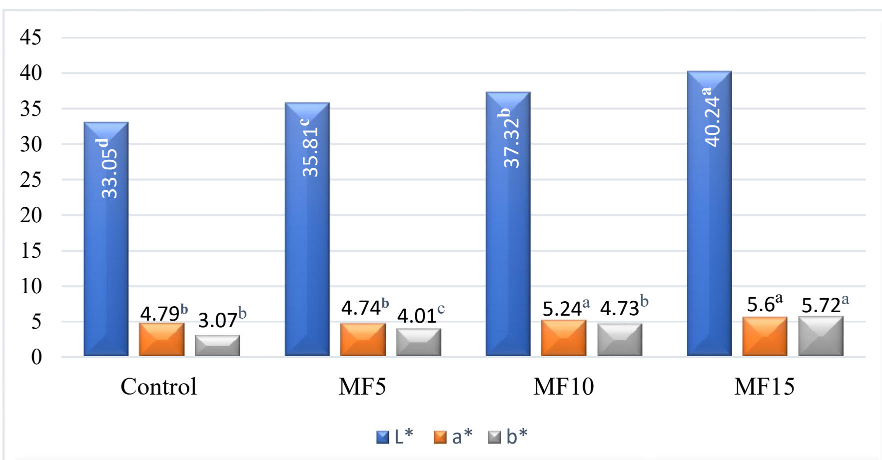

Fig. 3: Color properties of beef burger patty samples.

3.3.5. Sensory evaluation of cooked beef burger patty samples

Sensory evaluation of BP samples was estimated in terms of color, flavor, taste, tenderness, appearance and overall acceptability and data presented in figure (4). According to the mean value scored by the panelist for the BP samples, the sensory parameters scores found to be varied. All BP samples contain MF scored a high value when compared with C sample in all sensory term's parameters. The higher mean overall acceptability value was found with the MF15 followed by MF10 and MF5, respectively, whilst the C sample scored the lower mean overall acceptability value. This mean that all substitute beef meat with 5, 10 and 15% of MF manifest a burger patty with an excellent color, taste, tenderness and appearance without any negative effect on flavor.

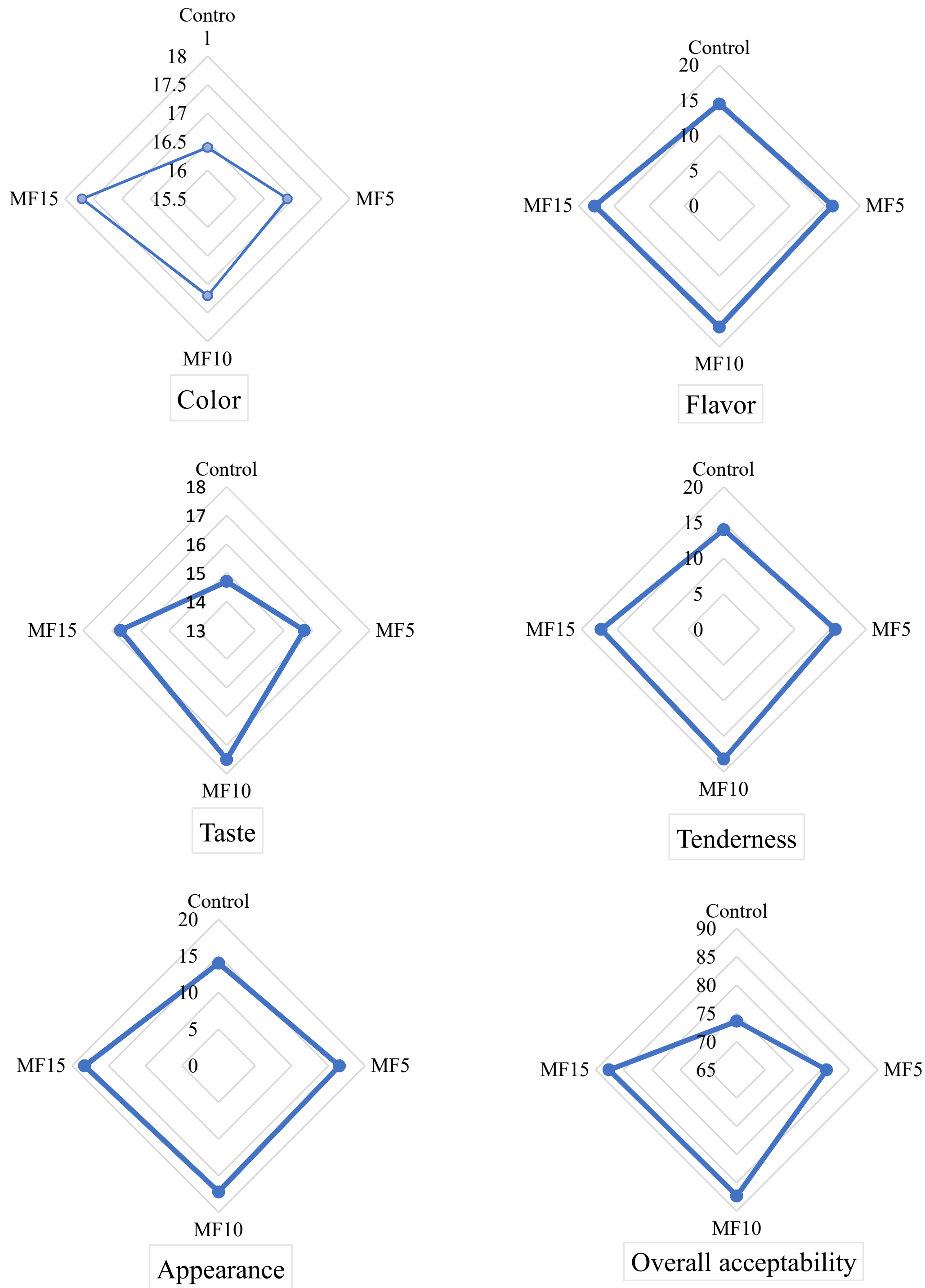

Fig. 4: Sensory properties of beef burger patty samples.

Our sensory results were not in the same line with ELKatry and Elsawy, (2021) who reported that the overall acceptability of burger control patty scored a higher value than burger patties samples contain quinoa flour. Shokry, (2016) illustrated that usage of quinoa flour improved the sensory properties of beef burger. Moreover, Ammar, (2012) informed that the incorporation of mustard flour into beef burger patties instead of soybean flour had no negative effect on sensory properties of beef burger. Al-Juhaim *et al.* (2015) declared that the sensory characteristics of cooked beef patties formulated with moringa seed flour have acceptable sensory scores. Therefore, MF could be used in beef burger manufacture process.

Conclusion

From this study, it could be concluded that millet flour was a powerful ingredient that preserve to be used in the preparation of both burger bun bread and beef burger patties. Millet flour enable to be substitute with wheat flour with a proportion up to 20% in burger bun bread with a good chemical composition, physical and rheological properties, staling rate, crumb and crust color and more accepted sensory characteristics. Also, the substitution of beef meat by 5, 10 and 15 % of millet flour had exhibit an excellent hardness, color, cooking properties and sensory attributes of prepared beef burger patty samples. Therefore, millet flour become a strong choice for the process of both burger bun bread and beef burger patty with a perfect properties.

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