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Characteristics Estimation of Gluten-Free Cookies Using Quinoa, Millet and Cassava Flours as Functional Food

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ABSTRACT

The present study was carried out to develop a free gluten cookie from quinoa (QF), millet (MF) and cassava (CF) flours which distinguished as a free gluten flour. As a result, quinoa and millet flours (QMF) were blended in a ratio of 1:1, and cassava flour (CF5, CF10, CF15 and CF20) was used to replace 5, 10, 15, and 20% of the QMF. A control cookie sample was done by 100% QMF. Chemical composition of quinoa, millet and cassava flours were analyzed. Flour blends were evaluated for pasting properties. Cookies samples were evaluated for gross chemical composition, baking quality, color, hardness, antioxidant activity and sensory properties. Results revealed that, QF recorded high moisture, crude protein and ether extract contents followed by MF then CF. The highest crude fiber and total carbohydrates recognized with CF followed by MF then QF, where total ash value was 1.7, 1.3 and 0.7 % for QF, CF and MF, respectively. Concerning pasting properties, peak viscosity, final viscosity and breakdown were increased, whilst holding strength and setback were decreased in samples containing CF as compared with CF0 sample. A moisture content and crude fiber decrement, increment in crude protein, ether extract and calorie values were occurred as the CF replacement proportion increased. Total carbohydrates were increased with CF15 and CF20, respectively. Volume, specific volume, thickness, diameter and spread ratio values were gradually increased as the CF replacement proportion increased, but cookies weight started to increase with CF15 and CF20 samples. As the quantity of CF substitution raised, cookies were seen to have a lighter color and a softer texture. Furthermore, cassava flour substituted for QMF shows a considerable increase in antioxidant activity. Regarding sensory properties, the replacement of QMF by different proportion of CF enhanced all sensory attributes as compared to CF0 sample. Finaly, it was concluded that, replacement QMF by CF reinforcement cookies characteristics, therefore, the present investigation supported using cassava flour with quinoa and millet flours as an excellent ingredient in free gluten cookies preparation.

Keywords*:* Gluten-free, quinoa, millet, cassava, cookies, pasting properties, physical properties.

Introduction

Celiac disease or gluten intolerance is a chronic intestinal disease with a long-term autoimmune disorder which affecting the small intestine of people who develop intolerance to gluten protein that present in bakery products contain wheat flour. This disease is associated with poor digestion and poor absorption of nutrients, such as vitamins and minerals in the gastrointestinal tract due to the toxic effect of gluten, which damages the villi of the small intestine (Holtmeier and Caspary, 2006, Alvarez-Jubete, 2010, Dizlek and Ozer, 2016). There is no cure for celiac disease, the most effective treatment to prevent complications caused by celiac disease is to consume free gluten foods. The number of people suffering from gluten intolerance is growing worldwide, and at the same time, the need for foods suitable for a gluten-free diet is increasing (Al-Toma *et al.,* 2019, Šmídová and Rysová, 2022).

Quinoa (*Chenopodium quinoa*) belongs to class Dicotyledoneae, family Chenopodiaceae. It is a broad leaf plant with starchy dicotyledonous seed. It considered as pseudo-cereals crop. Quinoa were called “the mother grain” where it established an excellent nutritional food quality mainly due to its high content of good quality protein (Carciochi *et al.,* 2016). Quinoa holds high protein content with bioavailable essential amino acids e.g. lysine, methionine and histidine, dietary fiber, unsaturated lipids,

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complex carbohydrates and other beneficial bioactive compounds such as minerals and vitamins like vitamin B, vitamin C and vitamin E, polyphenolic compounds resulting in enormous helpful health properties to customers (Ramos-Diaz *et al.,* 2015, Fischer *et al.,* 2017). Starch is the major component of quinoa grain and makes up to 70% of the dry matter and acting a vital role in functional properties of quinoa and associated food products (Zhu and Li, 2018). Quinoa is considered as a gluten-free food suitable for patients with celiac disease and people with wheat allergy (Nowak *et al.,* 2016).The flours obtained from quinoa seeds, can be used for elaborated bread or biscuits with the opportunity to develop a gluten-free cereal based products (Gallagher *et al,* 2004).

Pearl millet (*Pennisetum glaucum*) is belonging to the Poaceae family (Jukanti *et al.,* 2016), assumes a crucial role as a staple nutri-cereal crop in arid and semi-arid regions of Africa and Asia (Singh and Nara 2023). Pearl millet is recognized for its elevated nutritional and caloric characteristics which promoted its high potential as food. It serves as a primary dietary component owing to its high levels of carbohydrates, proteins, fats, vitamins, and essential minerals, phenolic acids, flavonoids, and dietary fiber (Samtiya *et al*. 2023, Triki *et al*. 2022). pearl millet has been integrated into multi-millet flour, utilized in the creation of nutritious products as an alternative to wheat flour, specifically for individuals with celiac disease and gastrointestinal concerns (Arepally *et al*. 2023). Millet grains are reported to have high antioxidant activity, anti-aging, anti-microbial, anti-diabetic, and anticancer properties (Saleh *et al.,* 2013). Millet is gluten-free which make it a good choice to people surfing celiac diseases (Gélinas *et al.,* 2008).

Cassava (*Manihot esculenta*), is a root crop which is grown in the tropical and subtropical areas of the word (Burrell, 2003). Cassava roots have high nutritional value, and they are rich in carbohydrates, fibers, vitamins and minerals. Starch is the major component of the cassava root and its use is primarily determined by its physicochemical properties (Onitilo *et al*. 2007, Adesina and Bolaji, 2013). The traditional method of edible cassava preparation is to remove the skin, chop into pieces, and then remove the cyanogenic glycosides by water immersion, then cooked or sun-dried, ultra-fine grinding and sometimes combined with other cereals. Cassava is suitable for partial or complete replacement of wheat flour, because of its high yield, low cost of production, and the unique functional properties of its flour and starch. (Akingbala *et al.,* 2011, Gyedu-Akoto and Laryea, 2013). Cassava flour is deficient in gluten and causes no allergic effects when consumed by the patients with celiac disease (Dudu *et al.,* 2019).

Cookies are one of the foods that are highly consumed by local community at various age groups. Cookies are a type of biscuits made from soft dough, crunchy, and when fracture cross-section appears textured less densely. Gluten-free cookies can also be enriched with constituents that play a nutritional role in the human body (Torbica *et al.,* 2012). Therefore, the aim of this study is to estimate the gross chemical characteristics, physical properties, hardness, color, antioxidant activity and sensory properties of a gluten-free cookies made with quinoa, millet and cassava flours blend as a functional food. Also, the flour blends were evaluated for pasting properties.

2. Materials and methods

2.1. Raw Materials

Cassava roots (*Manihot esculenta*) were obtained from center for sustainable development of New Valley Resources- Kharga, New Valley governorate, Cairo, Egypt. Quinoa (*Chinopodium quinoa*) and millet grains (*pennisetum glaucum*) was obtained from New Valley governorate, Cairo, Egypt. Butter, sugar, egg, vanilla, salt and baking powder was purchased from the local market of Cairo, Egypt.

2.2. Methods

2.2.1. Preparation of cassava flour (CF)

Cassava flour was prepared according to Haiqin *et al.* (2020). Cassava root tubers by watching, peeling, grating, drying and grinding it into powder using a high-speed blender mill (25000/min), (WK-1000A; Qing Zhou Machinery Co., Ltd.). Cassava powder was passed through a 100-mesh screen. The obtained cassava flour was then stored in polyethylene bags at 4ºC until process and analysis.

2.2.2. Preparation of quinoa flour (QF)

Quinoa seeds were washed with cold water for several times in order to remove possible saponin residues then dried in an electric oven at 50°C, until it dry. The quinoa seeds were ground into flour using a high-speed blender mill (25000/min), (WK-1000A; Qing Zhou Machinery Co., Ltd.), and then stored in polyethylene bags at 4ºC until process and analysis (Shokry, 2016).

2.2.3. Preparation of millet flour (MF)

Millet grains were cleaned from dust and ground to flour in an electric grinder stainless steel (made in france; LM240 6A06 495 (b)) and sieved through a 60 mesh and finally were packed and stored at 4ºC until process and analysis (Hassan *et al.,* 2020).

2.2.4. Preparation of flour blends and cookies formulation:

A flour blend of QF and MF (QMF) was formed with a ratio 1:1 (w:w). A 5, 10, 15 and 20% of QMF was replaced by CF and coded as CF5, CF10, CF15 and CF20, respectively. A control sample was done by using 100% of QMF and coded as CF0.

2.2.5. Preparation of cookies

Cookies were prepared according to **Chakrabarti *et al.,* (2017).** Weigh All the Ingredients. Beat butter for one minute in a large bowl, then add sugar and beat till it become light and fluffy. Add the eggs and vanilla essence and beat well for 30 seconds, then add flour, salt and baking powder and mix well. Impasto well until we get a non-sticky dough. Roll the dough on a pastry board in uniform thickness, Cut the dough using a cookie cutter and placing them on a butter paper on an oven try. Bake in a preheat oven at 163°C for 13-15 minutes. Remove the tray and cool for 30 minutes at room temperature, then package the cookies in clean plastic container and store at 4°C until analysis.

2.6. Analytical methods

2.6.1. Gross chemical composition

Moisture content, ash, crude protein, crude fiber, ether extract of QF, MF, CF, cookies samples were estimated according A.O.A.C. (2007). Total carbohydrates were calculated by difference. Calorie value was calculated according to Stilinović *et al.* (2020) as follows:

Calorie value (Kcal/100 g) = (Fat × 9 Kcal) + (Protein × 4 Kcal) + (Carbohydrate × 4 Kcal).

2.6.2. Pasting properties of flour blend samples

Pasting properties of flour blends of different cookies samples were determined using a starch cell (Physica Smart, Starch Analyzer-Anton Paar) attached to a CR/CS rheometer (RheoLab QC, Anton Paar, GmbH, Germany) and established methodology (Jayakody *et al.,* 2007). A sample (4% w/w) was equilibrated at 50°C for 1 min, then heated from 50 to 95°C at 6°C/min, held at 95°C for 5 min, cooled to 50°C at 6°C/min, and held at 50°C for 2 min. The speed was 960 rpm for the first 10s, then 160 rpm for the reminder of the experiment. The pasting properties of each sample were inferred from acquired diagrams including the peak time, peak viscosity, holding strength, setback, and final viscosity.

2.6.3. Baking quality of cookies samples

Diameter (mm), thickness (mm), spread ratio, weight (gm), volume (ml) and specific volume (ml/gm) were determined as described in AACC (2000), whilst the spread factor of biscuits was calculated according to Youssef *et al.* (2016) as the following equations:

Spread factor = (Spread ratio of the sample / Spread ratio of control sample) × 100.

2.6.4. Color of cookies samples

Color was measured by 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). The yellowness (b*) value (yellowish to bluish) was estimated.

2.6.5. Hardness of cookies samples

Hardness of cookies samples were performed at Food Technology Department, National research Center, Cairo, Egypt, using Brookfield, CT3-10 kg, equipped with Fixture TA-MTP, Probe 3R mm. Test method was done as follows: test type compression, trigger load 0.07 N and test speed 1 mm/s.

2.6.6. Sensory properties of cookies samples

Sensory properties were evaluated according to Hussein *et al.* (2019), where each formula was subjected to sensory analysis by 20 panelists. Each panelist was asked to assign scores 0-10 for color, Flavor, taste, texture, appearance and overall acceptability.

2.7. 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. Gross chemical composition of quinoa, millet and cassava flours

The gross chemical composition of QF, MF and CF was presented in table (1). QF found to be higher in moisture, crude protein and ether extract content followed by MF and CF, respectively. Moisture content of CF was the lowest (3.07%) with regard to MF (8.30%) and QF (9.40%). Regrded to total ash, QF detected high total ash followed by CF then MF. Conversely, CF exhibit a higher total carbohydrates content (83.1%) followed by MF then QF (77.90 and 67.64 %), respectively. For crude fiber, CF, QF and MF detected crude fiber content 5.11%, 3.88% and 0.2%, respectively. The calorie value of MF (392.7 Kcal/100g) was higher than QF (374.58 Kcal/100g), whilst CF recorded the lowest calorie value (365.76 Kcal/100g). Ismael *et al.* (2019) reported that quinoa and millet flour contains (2.97, 4.86%), (15.10, 12.50%), (6.55, 7.90%), (3.96, 4.24%) and (69.95, 69.84%) for total ash, crude protein, fat, crude fiber and total carbohydrates content, respectively. The crude protein content for QF was align with Dhondiram *et al.* (2023) who reported that quinoa flour contains 11.32% crude protein. Ether extract and crude fiber of QF were closed to those observed with Abdellatif, (2018) who cleared that ether extract and crude fiber of quinoa flour were 6.51 and 4.15%, respectively. Moreover, Romano *et al.* (2019) stated that total ash, crude protein and ether extract of quinoa flour were 1.6, 13.72 and 6.54%, respectively. Bashir *et al.* (2020) stated a lower fat (4.5%) and carbohydrate (71.5%) values for millet flour. Brites *et al.* (2019) reported total ash content of millet flour was 0.8%. Data of CF was higher than those observed with Lu *et al.* (2020) who reported cassava flour with 2.8, 0.6 and 2.0% for crude protein, fat and crude fiber content, respectively. Oyeyinka *et al.* (2018) reported lower protein content (4.25%), crude fiber (2.91%) and total carbohydrates (81.60%), nearly total ash content (1.40%) for cassava flour. Imoisi *et al.* (2024) displayed cassava flour with same total ash content (1.33%) but lower in crude protein (2.74%), crude fiber (1.75%), total carbohydrates (80.88%) and higher in moisture content (12.35%), also detected higher crude protein, crude fiber but lower fat and total carbohydrates content for millet flour. Bala *et al.* (2015) cited that cassava flour had moisture, total ash, crude protein, crude fiber, fat and total carbohydrates contents with 10, 2.84, 2.3, 5, 0.56 and 78.76%, respectively.

Table 1: Gross chemical composition of quinoa, millet and cassava flours (on wet weight basis).

Chemical composition (%)	QF	MF	CF
Moisture content	9.40±0.20	8.30±0.27	3.07±0.22
Total Ash	1.70±0.20	0.70±0.30	1.33±0.12
Crude protein	13.48±0.30	7.00±0.30	6.63±0.28
Crude fiber	3.88±0.21	0.20±0.20	5.11±0.10
Ether extract	6.90±0.30	5.90±0.30	0.76±0.11
Total carbohydrates*	64.64±0.15	77.90±0.15	83.1±0.10
Calorie value (Kcal/100g)	374.58±0.10	392.70±0.10	365.76±0.20

(QF): quinoa flour, (MF): millet flour, (CF): cassava flour, Data are mean ± Standard deviation, *Calculated by differences.

3.2. Pasting properties of flour blends

The starch-based foods that exposed to thermo-treatment in the presence of water, a series of changes occur known as gelatinization properties which influence the starch nature (Babajide and Olowe, 2013). Pasting properties is a reliable predictor of flour quality and used in predicting the pasting behavior and ability of the flour samples.

Peak Viscosity (PV), reflecting the water-binding capacity of the starch or mixture which affect the final product quality, it is also an indication of the ability of the products to swell freely before their physical breakdown (Ingbian and Adegoke, 2007). The peak viscosity is the maximum viscosity developed during or soon after the heating portion of the samples (Eke-Ejiofor and Oparaodu, 2019). The higher the peak viscosity the higher the swelling index, while low peak viscosity is indicative of higher solubility as a result of starch degradation or dextrinization (Imoisi *et al.,* 2020). The pasting properties of flour blend samples were analyzed and the results were summarized in table (2).

It could be noticed that there was an increment PV value in flour blends samples. The maximum PV was found with the CF15 sample followed by CF20 then CF10 samples with values 298.3, 279.4 and 275.7 cp, respectively, while the PV of both CF0 and CF5 samples recorded the lowest PV value with almost same value (270.5 and 270.8 cP). So, the PV increased with increasing in cassava flour proportion in the flour blends.

Final viscosity (FV) gives an idea of the ability of a material to gel after cooking as well as the resistance of the paste to shear stress during stirring. The highest FV value was recorded by CF15 sample (455.8 cP) followed by CF10 sample (453.9 cP) then CF5 sample (449.8 cP) and CF20 sample (437.3 cP), where the CF0 sample recorded the lowest FV value (412.8 cP). The FV value of all flour blend samples contain cassava flour was higher than the control sample which mean that cassava flour affected the FV. A similar trend was reported with Hussain *et al.* (2019) who clarified that as the proportion of millet flour decreased in a wheat-millet flour blend, the peak viscosity and final viscosity increased. Imoisi *et al.* (2020) mentioned that increment in PV value could be due to the high starch content of the cassava flour causing a high gelatinization and swelling index. High final viscosity gives an indication of the strength of the flour used to form a viscous paste or firm gel after cooking and cooling, and also paste or gel resistance to shear force during stirring (Obomeghei and Ebabhamiegbebho, 2020 and Olaleye *et al.,* 2020).

Table 2: Pasting properties of flour blends samples.

Pasting properties	Flour blend samples				
	CF0	**CF5**	**CF10**	**CF15**	**CF20**
Peak viscosity (cP)	270.5	270.8	275.7	289.3	279.4
Peak time (min.)	14.2	11.6	11.2	11.2	11.0
Peak temperature (°C)	95	94.90	94.8	94.8	94.80
Holding strength (cP)	259.6	229.5	210.5	210.6	185.3
Breakdown (cP)	10.87	41.23	65.16	78.73	94.1
Final viscosity (cP)	412.8	449.8	453.9	455.8	437.3
Setback (cP)	401.9	408.6	388.7	377	343.2

(CF0) control sample 100% QMF blend, (CF5) 95% QMF blend with 5 % cassava flour, (CF10) 90% QMF blend with 10 % cassava flour, (CF15) 85% QMF blend with 15 % cassava flour. (CF20) 80% QMF blend with 20 % cassava flour.

Concerning peak time (PKT), a decrement in mean PKT values were happened as the cassava flour increased in the flour blend samples where the highest mean value was recorded with CF0 sample (14.2 mins.). Low peak time is indicative of its ability cook fast (Imoisi *et al.,* 2020).

The lowest mean breakdown value was recorded with CF0 sample (10.87 cP). The breakdown values increased from 41.23 to 94.1 cP by increasing of cassava flour proportion from 5 to 20% in the flour blend samples. Imoisi *et al.* (2020), pointed out that the increment in breakdown viscosity mean that the flour blend samples are stable under thermal treatment, therefore it could be suitable for foods processed by heating at high temperatures.

Holding strength (HS) value found to decrease as the cassava flour proportion increased in the flour blend samples. The highest HS value reported with the CF0 sample (259.6 cP), whilst the lowest mean value found with the CF20 sample (185.3cP).

Setback values is the tendency indicator of starch to associate and re-ordering on cooling. A significant decrement occurred in the setback values as the cassava flour proportion increased in the flour blend samples. The setback values ranged from 401.9 cP with CF0 sample to 343.2 cP with CF20 sample and the highly rate of decrement in setback values started from the CF10 sample (388.7 cP). Thus, the setback value decrease as the cassava flour increased in the flour blend samples. The setback higher value in a flour blend may be due to the additive of different types of flour which have different types of starch and a variable amount of amylose content (Shafi *et al.,* 2016).

This finding was disagreed with those observed with Imoisi *et al.* (2020) who established that the peak viscosity, trough value, final viscosity, breakdown and setback values increased as the cassava flour in the cassava-citrus fiber blend increased. Also, Osungbaro *et al.* (2010) illustrated that the peak viscosity, final viscosity, breakdown and setback values increased with the increment of cassava flour percentage in the cassava-sorghum flour blends. Peroni *et al*. (2006) informed that the flour with low setback value have low values of amylase which have high molecular weight.

3.3. Gross chemical composition of cookies samples

The evaluation of cookies gross chemical composition is shown in table (3). It was noticed that there was a significant ($p \leq 0.05$) decrement in moisture content values as the CF replacement proportion increased. The highest moisture content was cited with CF0 sample (8.80%), whilst the lowest moisture content mean value recognized with CF20 and CF15 samples (5.00 and 4.03%), respectively. Ash content is an indication of the mineral content of food products. Total ash content slightly decreased as the CF replacement proportion increased with no significant ($p \geq 0.05$) differences. The crude fiber decreased as CF replacement proportion increased. The highest mean crude fiber value observed with CFO sample whilst the smallest value found with CF20 sample.

Recognizing ether extract, the maximum ether extract value stated with CF20 (19.1%) followed by CF15 sample (18.88%) with no significant ($p \geq 0.05$) differences. Total carbohydrates were found to be increased with CF15 and CF20 samples with 64.99 and 63.71%. Adejumo *et al.* (2023) referred the difference in total carbohydrates content of the cassava inclusion cookies might be caused by other ingredients used for the cookie's formulation.

Also, it was found that, the higher CF replacement proportion, the higher calorie value, where CF15 and CF20 samples found to have calorie value (452.36 and 450.74Kcal/100g), respectively. It could be concluded that, substitution of composite QMF by CF could improve cookies crude protein, ether extract, total carbohydrates and calorie values with low moisture content and good total ash content which make these cookies nutritious.

Table 3: Gross chemical composition of cookies samples (on wet weight basis).

Chemical composition (%)	CF0	CF5	CF10	CF15	CF20
Moisture content	$8.80^{a}\pm0.20$	$7.20^{b}\pm0.27$	$7.73^{b}\pm0.22$	$4.03^{c}\pm0.20$	$5.00^{c}\pm0.21$
Total Ash	$2.28^{a}\pm0.01$	$2.20^{a}\pm0.11$	$2.10^{a}\pm0.12$	$1.98^{a}\pm0.01$	$1.99^{a}\pm0.02$
Crude protein	$4.22^{c}\pm0.30$	$5.30^{b}\pm0.30$	$5.39^{b}\pm0.28$	$5.62^{a}\pm0.22$	$6.00^{a}\pm0.28$
Crude fiber	$4.91^{a}\pm0.01$	$4.83^{a}\pm0.01$	$4.82^{a}\pm0.10$	$4.50^{b}\pm0.22$	$4.20^{b}\pm0.20$
Ether extract	$18.50^{b}\pm0.01$	$18.60^{b}\pm0.01$	$18.70^{b}\pm0.03$	$18.88^{a}\pm0.02$	$19.10^{a}\pm0.02$
Total carbohydrates*	$61.29^{d}\pm0.15$	$61.87^{c}\pm0.25$	$61.26^{d}\pm0.28$	$64.99^{a}\pm0.27$	$63.71^{b}\pm0.25$
Calorie value (Kcal/100g)	$428.54^{d}\pm0.10$	$436.08^{c}\pm0.10$	$434.90^{c}\pm0.20$	$452.36^{a}\pm0.20$	$450.74^{b}\pm0.21$

(CF0) control cookies, (CF5) cookies with 5 % cassava flour, (CF10) cookies with 10 % cassava flour, (CF15) cookies with 15 % cassava flour. (CF20) cookies with 20 % cassava flour. Mean value ± Standard deviation of three replicates, means sharing the same small letter in a column are not significantly different at $p \geq 0.05$.

Results were agreed with Adekunlea and Abimbola, (2014) who revealed that moisture content decreased, crude protein and total carbohydrates increased, as the cassava flour proportion increased in cookies made of wheat, cassava and cowpea flour blend, but also informed that fat and ash content decreased which not in agreement with our results. Adejumo *et al.* (2023) reported a lower moisture content, increment in ash, crude fiber, crude protein content, total carbohydrates and calorie value for cookies made with sorghum (80%) and cassava (20%) flours blend with regard to cookies made of 100% sorghum flour. Leticia *et al.* (2022) recognized an increment in cookies moisture content as the cassava flour proportion increased in a flour blend made of cassava and mung bean and informed that the higher the starch content in cookies flour, the higher the ability to trap water. High moisture content due to the high moisture retention capacity of the flour (Singh *et al.,* 2012).

Also, Rathi *et al.* (2004) reported that millet flour had high moisture retention capacity. Increment in cookies fat content could be due to the addition of visible fat in the cookie's recipe (Kulkarni, *et al.,* 2021) or due to high-fat content of flour used (Abdalla *et al.,* 1998). Results was not in agreement with Omah and Okafor, (2015) who established that moisture content, total ash and crude fiber increased, whilst crude protein and total carbohydrates decreased in cookies, as the cassava flour proportion increased in a wheat-millet-pigeon pea flour blend.

3.4. Baking quality of cookies samples

The baking quality of cookies are important for both consumers and manufacturers point of view because it considered to be a guideline for its quality characteristics. Baking quality of cookies samples were estimated in term of weigh, volume, specific volume, thickness, diameter, spread ratio and spread factor, data was manifested in table (4). The weight value of both CF5 and CF10 samples (36.50 and 36.36 g) were slightly less than CF0 weight sample (37.87 g), but CF15 sample recorded a significant ($p \leq 0.05$) higher weight value (38.49 g) followed by CF20 sample (41.12 g). Among all samples, the volume, specific volume, thickness, diameter, spread ratio and spread factor values were significantly ($p \leq 0.05$) gradually increased as the CF proportion increased. Maximum volume, specific volume, thickness, diameter, spread ratio and spread factor values were maintained with CF15 and CF20 with no significant differences ($p \geq 0.05$).

Bala *et al.* (2015) displayed an increment trend in spread ratio, thickness, diameter and weight of cookies as the cassava flour proportion increased in cassava, water chestnut and wheat flour blends and the highest values observed with 50% cassava flour and 50% water chestnut flour. Oladunmoye *et al.* (2010) informed that, cassava flour has the highest water absorption capacity. Also, Nisar *et al.* (2018) mentioned that quinoa flour had a higher water absorption capacity and refereed that increment in cookies weight was due to the power of flour to absorb more water and retain it. Kulkarni *et al.* (2021) manifested a decrement in weight, diameter and spread ratio of low gluten free cookies as the millet flour level increased, likewise clarified the increased in diameter of cookies during baking may be due to low fiber content. Moreover, Kulthe *et al.* (2017) cited that replacement of wheat flour by millet flour resulted in reducing cookies diameter, spread ratio and spread factor. Thejasri *et al.* (2017) revealed that gluten free biscuits formulated with quinoa and millet flour, each one separately, had higher weight but lower in diameter, thickness and spread ratio than cookies processed with wheat flour. Leticia *et al.* (2022) found that as the cassava flour proportion increased in a cassava-mung bean flour blend as the cookies spread ratio decreased.

Table 4: Baking quality of cookies samples.

Cookies samples	Baking parameters						
	Weight (g)	Volume (cm^3)	Specific volume (cm^3/g)	Thickness (cm)	Diameter (cm)	Spread ratio (%)	Spread factor (%)
CF0	37.87^c	31.50^c	0.84^b	2.27^c	4.14^d	1.83^c	100.00
CF5	36.50^d	36.50^c	1.00^b	2.35^c	4.44^c	1.89^c	103.28
CF10	36.36^d	46.00^b	1.27^a	2.47^b	4.75^b	1.93^b	105.47
CF15	38.49^b	54.50^a	1.42^a	2.54^a	5.15^a	2.03^a	110.93
CF20	41.12^a	59.00^a	1.43^a	2.61^a	5.26^a	2.01^a	109.83

(CF0): control cookies, (CF5): cookies with 5 % cassava flour, (CF10): cookies with 10 % cassava flour, (CF15): cookies with 15 % cassava flour, (CF20): cookies with 20 % cassava flour. Mean value ± Standard deviation of three replicates, means sharing the same small letter in a column are not significantly different at $p \geq 0.05$.

3.5. Color of cookies samples

Color is one of the important parameters that affect the acceptability of food product. Color of cookies made from quinoa, millet and cassava flour was estimated, figure (1) clarified the crust color of cookies samples. The higher mean L* values were observed with CF20, CF15, CF10, CF5 and CF0 samples, respectively. The higher L* value the more lightness color. Concerning b* parameter, the highest significant b* value was recorded with CF15 followed by CF20 and CF10 samples with a nearly values which was 22.08, 21.63 and 21.11, respectively. The a* mean values of crust color found to had an inverse trend, where the higher mean value was observed with the CF0 sample, whilst the lower mean a* value was recorded with CF15 and CF20 samples with same value followed by CF10 and CF5 samples, respectively. The higher the proportion of CF in cookies samples, the higher the L* and b* values and the lower the a* value of crust cookies color.

Figure (2), clarified the crumb cookies color. The highly mean L* values for crumb cookies color were set up with CF20 and CF10 samples followed by CF5 then CF15 samples, where the lowest L* value was found with CF0 sample. On the other hand, the higher mean b* value for crumb cookies samples recorded with CF15 sample (26.43) and CF0 sample (26.26) followed by CF10 (25.64), CF20 (24.92) and CF5 (24.37). there was a significant difference between b* mean values but finally it set in nearly range. With regard to a* value, it was noticed that, the CF0 sample stated the highest mean a* value, meanwhile a decrement in mean a* value occurred with the CF5, CF10, CF15 and CF20 samples, respectively.

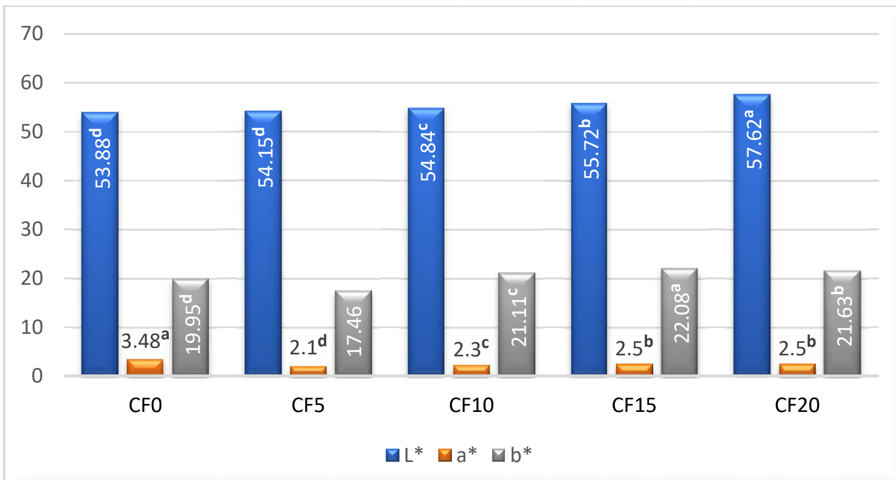

Fig.1: Crust color of cookies samples.

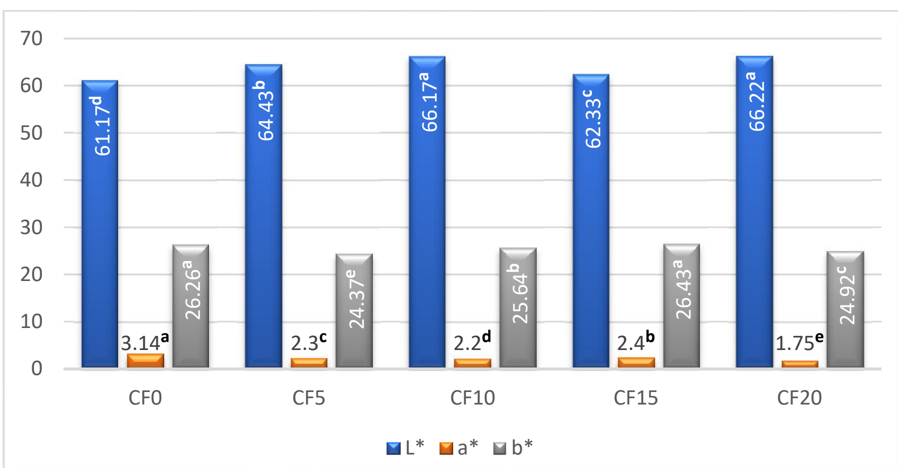

Fig. 2: Crumb color of cookies samples.

From above crumb cookies color data, it was noticed that the CFO sample had the darker crumb color due to the lowest L* value and highest a* value. Increment in L* values and decrement in a* values for the other cookies samples make it more white in color. Oyeyinka *et al.* (2018) pointed out that the wheat cookies were darker than cassava cookies because of the high protein content in and also informed that the darker color of cookies may be due to the sugar content which play a part in Millard reaction. Bala *et al.* (2015) found that cookies contain different proportion of cassava, water chestnut and wheat flours blend were slightly darker than cookie made of 100% wheat flour and the lowest L*, a and b values was scored with cookie made of 50% cassava flour and 50% water chestnut flour.

3.6. Hardness of cookies samples

Hardness is an important quality parameter which mean the maximum force needed to achieved after the increase in the trigger force until the cracking of cookies into two pieces (**Bashir *et al.,* 2020**). Lower in hardness value mean a lower force required to break the cookies (**Leticia *et al.,* 2022)**. Hardness of cookies related to development of gluten network by attracting water molecules (**Aslam *et al.,* 2014**) or water–starch–protein interactions as a function of the composition of flours and interplay among ingredients (**Fustier *et al.,* 2008**).

Data presented in figure (3) clarified a significant ($p \leq 0.05$) decrement trend occurred in hardness values as the CF proportion increased in concern with control sample. The lowest significant ($p \leq 0.05$) decrement hardness value was taking place with CF15 and CF20 samples, 3.49 and 3.63 N, respectively. However, the highest hardness value was observed with CF5 sample (7.47 N), as compared to CF0 sample which recorded (6.00 N) hardness value. So, the higher proportion of QMF and lower CF proportion, the harder cookies observed.

Our hardness finding was agree with **Oyeyinka *et al.* (2018)** reported a lower hardness for 100% cassava flour cookies as a free gluten cookie when compared with cookies made by 100% wheat flour. **Bala *et al.* (2015)** informed that cookies hardness decreased as the proportion of cassava flour increased in a wheat, cassava and water chestnut flours blend as concern with cookie made of 100% wheat flour, also notified that cookie made of 50% cassava flour and 50% water chestnut flour recorded the lowest hardness value. **Brites *et al.* (2019)** indicated a harder cookie as the millet proportion increased and buckwheat decreased in free gluten cookies made of buckwheat and millet flour, moreover, revealed. Findings was not on the same line with **Leticia *et al.* 2022** who announced that, the higher cassava flour proportion in a cassava-mung bean flour blend, the higher hardness value and so harder cookies. Also, **Chakrabarti *et al.* (2017)** concluded that hardness of free gluten cookies made of cassava and soyabean flour increased as the cassava flour proportion increased.

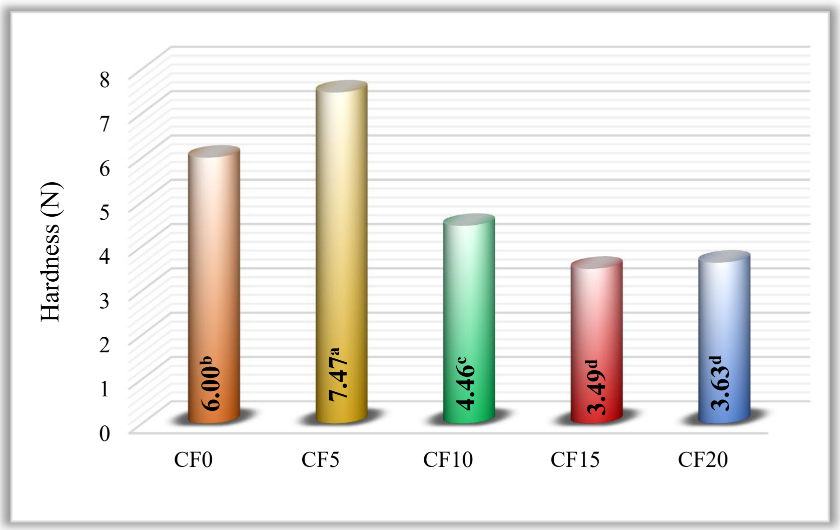

Fig. 3: Hardness of cookies samples.

3.7. Antioxidant activity of cookies samples

Antioxidant activity was estimated by the determination of DPPH radical scavenging assay. DPPH values of cookies samples were presented in figure (4). It was cleared that, replacement of QMF by CF had an effect on DPPH values. The highest DPPH value was 89.76, 89.04, 87.00 and 86.00 % with CF5, CF20, CF15 and CF10 samples, respectively. Khasanah *et al.* (2023) illustrated that cassava flour had

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an excellent antioxidant activity related to total phenolic content. Kareem *et al.* (2023) explained that cassava flour had a strongest DPPH scavenging capacity and could be serve as important sources of antioxidants. Indrianingsih *et al.* (2019) reported that crackers processed from pumpkin-cassava blended flour with different proportion of cassava flour found to have higher DPPH values with regard to crackers processed from 100% cassava flour, meanwhile, this action might be attributed to the different amount of the content of the active compounds.

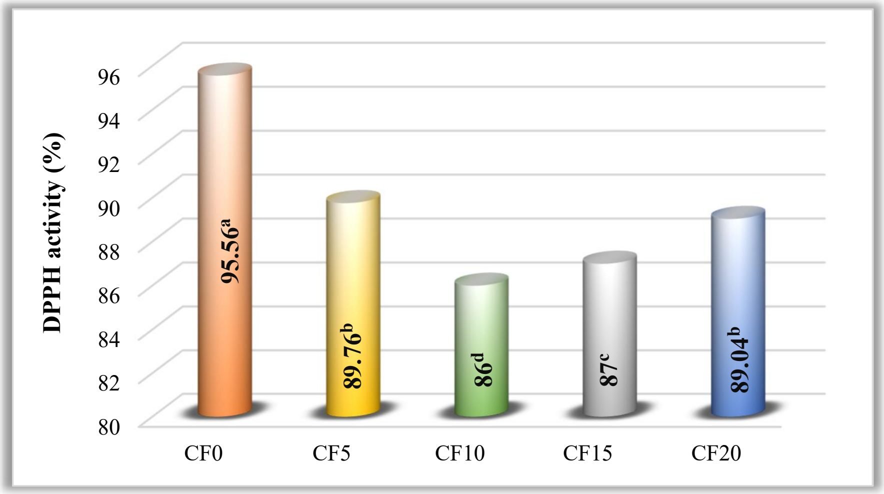

Fig. 4: Antioxidant activity of cookies samples.

3.8. Sensory properties of cookies samples

Sensory properties are focal in form the opinion about how the product is suitable for consumer. Therefore, color, taste, texture, odor and overall acceptability were estimated and data have been manifested in figure (5). There was a significant ($p \leq 0.05$) difference in sensory parameters between cookies samples. The highest color and odor values were scored with the cookie's samples containing CF with no significant ($p \geq 0.05$) difference, whilst the CF0 sample the lowest significant ($p \leq 0.05$) value for both color and odor parameters. Regarding taste values, the CF20 and CF15 samples recorded the highest significant ($p \leq 0.05$) value followed by CF10 sample, however CF5 and CF0 samples recognized the lowest taste value with no significant ($p \geq 0.05$) difference. Furthermore, the texture values were found to be varied significantly ($p \leq 0.05$), whereas maximum texture value was significantly ($p \leq 0.05$) scored with CF0 cookies sample, where the minimum texture value was scored with CF20 sample. Moreover, CF20 and CF15 samples were significantly differ in texture values with regard to CF10 and CF5 samples, respectively. The texture of the cassava cookies is in agreement with the hardness values. The CF20, CF15, CF10 and CF5 samples submitted a highest overall acceptability, respectively, with no significant ($p \geq 0.05$) difference, and followed significantly ($p \leq 0.05$) by CF0 sample. Take note that, as the CF replacement proportion increased all sensory parameters were enhanced. Leticia *et al.* (2022) detected that the proportion 70:30 of cassava to mung bean flour showed the finest treatment and scored significant preference level for color, texture and taste. Oyeyinka *et al.,* (2018) cleared that sensory attributes of the 100% cassava cookies were not significantly differed than wheat cookies, putted on view that, cassava cookies texture was in accordance with hardness results. Praise *et al.* (2022) confirmed that cookies prepared from cassava flour was sensory preferred than cookies prepared from wheat flour. Bala *et al.* (2015) established that cookie made of 50% cassava flour and 50% water chestnut flour was more acceptable than cookies made of 100% wheat flour or other formulation. Adejumo *et al.* (2023) announced that acceptable cookies could be produce from sorghum-cassava flour blend especially at 20 % cassava flour inclusion.

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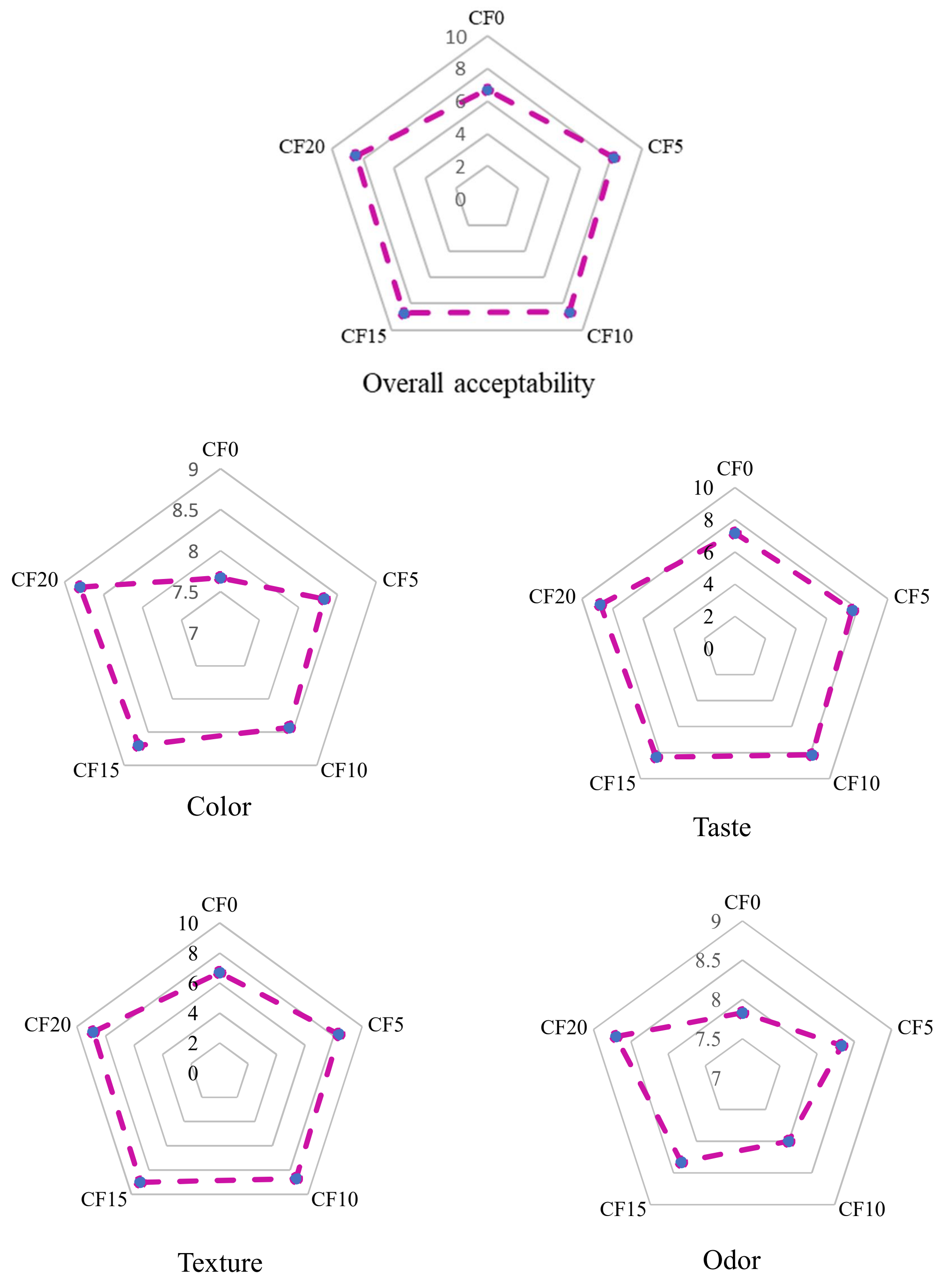

Fig. 5: Sensory properties of cookies samples.

4. Conclusion

Results of the study revealed that pasting properties of the flour blends contain cassava flour was enhanced as the cassava flour replacement proportion increased with concern to quinoa-millet flour blend. As well as, replacement quinoa-millet flour blend by 5, 10, 15 and 20 % of cassava flour enhanced cookie crude protein, ether extract, total carbohydrates and calorie value with an excellent baking quality, color, hardness, an appropriate antioxidant activity and sensory properties. Therefore, cassava flour could be successfully used with quinoa and millet flours in the preparation of free gluten cookies, moreover, it could be recommended for the usage in making free-gluten bakery products.

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