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# Functional & rheological properties of wheat-cassava dough & bread with partial substitution of gluten by *T. cordifolia gums*

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**ABSTRACT**
In order to enhance the use of hydrocolloid gum of *Triumfetta cordifolia* in breadmaking, a study was carried out for the formulation of a low-gluten bread based on a wheat-cassava flour. A mixture design with minitab 18.1 software was use to generate mix flour with 0 to 10% for *T. cordifolia* powder, 10 to 50% for cassava flour and 40 to 90% wheat flour as constraint. The flour mixtures obtained were characterized on the physicochemical, functional and rheological levels. Then the breads were produced and analyzed on the physical and sensory levels. The results show that The protein contents of the flours (wheat and cassava) were respectively from 3.5 and 10.60%, a starch content which varies from 84.30 to 72.13 g / 100g DM. baking strength which varies between -198 and 133 KJ, a damaged starch content which varies between 15.17 and 20 UCD, respectively for cassava and wheat flour. The absorption capacity of flours mixture increases with the rate of incorporation of the gum while the opposite effect is observed for the solubility of the mixtures. The swelling kinetics of the pasta indicate that the fermentation time varies from formulation to formulation. Regarding the physical or textural parameters, the addition of the gum has a significant influence on the specific volume (1.90 to 4.13 ml / g), the mass yield (86.99 to 90.92%), the elasticity index (0.90 - 1.14mm) and adhesiveness (2.5 - 25.83N / mm), the hardness of the crust (1.18 - 2.02 N) and the color some breads. From a sensory point of view, the bread resulting from the formulation consisting of 20% cassava, 72.5% wheat with 2.5% gum powder was the most accepted by the panelists. In the local context, *Triumfetta cordifolia* gum made it possible to increase the substitution rate of about 10% of wheat compared to the mixture already known.
**Key words:** Hydrocolloid gum, *Triumfetta cordifolia*, techno-functional properties, cassava flour, wheat flour, breadmaking.

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## I. INTRODUCTION

Bread is a food that results from the baking of a dough obtained by kneading a mixture composed of wheat flour, water, salt and subjected to fermentation by yeast (Cauvain and Young, 2002). Bread is the traditional staple food of many cultures and is among the most popular baked goods made from cereals that are consumed by almost all populations around the world (Akpu *and* Okpala 2014). In Cameroon, a Cameroonian eats bread on average three times a day. This bread is obtained mainly from wheat flour, because of the gluten it contains and which is responsible for the elasticity and extensibility allowing the dough to rise during fermentation. In view of the high frequency of bread consumption, most African countries and in particular Cameroon, to meet the demand for wheat is obliged to import this cereal from producing countries (Russia, France, Canada, USA, etc.). Between 2013 and 2019, imports by local leaders increased from 350,000 to 900,000 tonnes of wheat, which represents an outflow of currencies to the tune of around FCfa 150 billion. It is for this reason that in recent years, the partial or total substitution of wheat flour, by other local flours in the manufacture of breads has aroused the interest of researchers, with the aim of reducing very imports. costs of wheat and increase the use of local commodities (Ikpeme et al., 2010). This is the case of Cassava (Manihot esculenta Crantz) is a perennial shrub that is widely cultivated in all regions of Cameroon. In view of several studies on the use of cassava flour in breadmaking, this tuber, thanks to the quality of its starch, appears to be a potential partial or total substitute for wheat.

The new recipes included wheat–cassava composite bread (20% cassava flour and 80% wheat flour) (Shittu *et al.*, 2007). However, a study by Eriksson et al. (2014) found that increasing the proportion of cassava flour above 20% reduced the specific volume of bread and increased its density and hardness, compared with 100% wheat bread. This was attributed to the fact that cassava flour lacks gluten and is therefore unable to form the cohesive viscoelastic, open foam structure that is typical of wheat bread. Generally, faced with this type of technological problem, several authors have suggested the use of hydrocolloids in particular, carboxymethylcellulose, hydroxypropylmethylcellulose, carrageenans, guar gum and xanthan for the manufacture of low-fat or gluten-free breads made from rice, maize, sorghum, sweet potato or cassava (Berta et al 2019). Shittu et al. (2009) reported that adding up to 2% xanthan gum resulted in a major hindrance of gluten–starch interaction in the presence of hydrocolloid molecules, thus conferring a significantly higher softness to fresh, composite cassava–wheat bread. They also reported that crumb hardening and moisture loss followed a linear sequence up to the 1% xanthan gum level, which, therefore, was proposed as the optimum concentration to reduce both phenomena, even if the 2% xanthan gum level best estimated the crumb firming rate. This improvement is not the same for french baguette, in fact, results obtained in Benin showed that the use of cassava flour as a 15% substitute for wheat yielded bread loaves and french baguettes of the same quality as those produced using wheat flour only (IITA, 1999). To understand more what happens in the mixture of cassava-wheat flour and gum, some studies show that the Cassava-wheat flour complexed with guar gum have increased dough tenacity and elasticity and retarded amylopectin retrogradation of bread during storage (dudu *et al.*, 2020).

The foregoing cited studies suggested the possibility of improving the subtitution level of wheat flour with the cassava flour by using gum. In Cameroon, local vegetable gums have properties potentially capable of replacing or playing the role of gluten, including *Triumfetta cordifolia*, *Bridelia thermifolia* and *Grewia mollis*. The barks of the first two plants are locally used as a thickener in sauces, as a decanting agent and as a flocculation agent in the preparation of traditional beers (Saidou et al., 2013). The aqueous extracts of the gums of these barks have a shear-thinning and viscoelastic behavior of the gel type, non-thixotropic and with a yield point. This justifies their thickening and gelling behavior in aqueous solution. The incorporation of extracts of *T. cordifolia* and *B. thermifolia* in corn or sorghum flour improves the swelling of corn and sorghum fritters (Saidou et al., 2014). Hence the main objective of this work to process french baguette bread with a mixture of cassava-wheat-*T. cordifolia*, based on the hypothsesis that the vegetable gum will lead to improvement of cassava proportion in the composite flour.

## II. MATERIAL AND METHODS.

### 2.1. Source and preparation of samples.

Cassava, *Triumfetta cordifelia,* wheat and the other ingredients (baker's yeast, salt) were acquired from cameroon market. Cassava roots were peeled, washed, roughly cut, dipped in fermentation tank (1kg/5 liters water) for 75h at Between 25 to 30°C, pressed, sun-dried for 72h and milled using a hammer grider. *Triumfetta cordifelia* stem bark were removed, *roughly* cut into small pieces, dried using a ventilated dryer for 72h at 55±2°C and ground. All flours were sieved to a particle size of 200µm and packaged in double density polyethylene bags for further uses and analyses.

### 2.2. Blending wheat, cassava and *Triumfetta cordifelia* flour.

Ten levels of wheat: cassava: *Triumfetta cordifelia* composite flours were prepared by using a «constrained mixture design» (Table 1). The aim was to evaluate the effect of flour

**Table 1**: Low and high constraints for mixture components and experimental design

| Contraints | | | |
|---|---|---|---|
| | **Mixture variables** | **Low constraint** | **High constraint** |
| | Wheat flour (%) | 40 | 90 |
| | Fermented cassava (%) | 10 | 50 |
| | *Triumfetta cordifolia* (%) | 0 | 10 |
| **Experimental matrix** | | | |
| **Formulations codes** | **Wheat flour (%)** | **Fermented cassava (%)** | ***Triumfetta cordifolia* (%)** |
| F1 | 65 | 30 | 5 |

| | | | |
|---|---|---|---|
| F2 | 52,5 | 40 | 7,5 |
| F3 | 80 | 10 | 10 |
| F4 | 50 | 50 | 0 |
| F5 | 90 | 10 | 0 |
| F6 | 57,5 | 40 | 2,5 |
| F7 | 72,5 | 20 | 7,5 |
| F8 | 77,5 | 20 | 2,5 |
| F9 | 40 | 50 | 10 |
| F10 | 80 | 20 | 0 |

proportions (cassava, *Triumfetta cordifolia* and wheat) on the properties of dough and bread. For cassava flour, minimum and maximum levels were established on the objective of using it at a proportion >50%. A mixture design with minitab 18.1 software was use to generate mix flour with 0 to 10% for *T. cordifolia* powder, 10 to 50% for cassava flour and 40 to 90% wheat flour as constraint. Table 1 presents low and high contraints for each component and the expériemental matrix for this constrained mixture design.

**2.3. Bread making.**

Bread was baked according to the straight-dough bread-making method (AACC Method 10-09) (AACCI, 2000). The flour (250 g), 25 g sugar, 3 g salt, 5 g baking fat and 2.5 g baker's yeast were weighed into a mixing bowl. About 150 mL water was added and the mixture was kneaded by hand for 45 min at 30°C and 100% humidity. After proofing, the dough was re-kneaded and divided into 70 g portions (Three portions for each blend), moulded and placed in separate margarine greased baking pans. Following the fermentation, the bread was baked in the oven for 16 min at the temperature range of 178-193°C. The quality characteristics of the bread were determined after cooling at room temperature (20-22°C) overnight.

**2.4. Analysis.**

**2.4.1. Proximate composition**.

Nitrogen content was determined by the AFNOR 1995 method. The crude protein was estimated as %Nx 6.25 for cassava flour while crude protein in wheat flour was estimated as %Nx5.7. The moisture, lipid and fibre contents were determined as described in AOAC (2012) methods 925.10, 929.39 and 962.09, respectively. Starch, amylose, amylopectin and damaged starch were determined by the AFNOR 1993.

**2.4.2. Funtional and physical properties of the different flours.**

The water absorption index (WAI) and water solubility index (WSI) of the wheat flour-dried cassava and *Triumfetta cordifolia* mixtures were determined by slightly modifying the method of Anderson et *al.* (1970). The mixtures were added in a mixer and mixed for 2 min. These mixtures were sieved through a 0.149 mm mesh (Tyler 100, Soyltest Inc., Evanston, IL, USA) to standardize the sample size. The samples (0.65 g) were weighed in centrifuge tubes (15 mL) using an analytical balance (Ohaus Pioneer, Ohaus Corp., China), mixed with 7.8 mL of distilled water and vigorously agitated in a standard laboratory vortex shaker (Classic advanced, Velpscientifica, Usmate, Italy) at 2,400 rpm for 30 s and then placed in a stirred water bath (WNB-14, Memmert GmbH 1 Co. KG, Munich, Germany) for 30 min at 30C. Then, the samples were centrifuged at 5,200 rpm for 10 min at 20°C in a centrifuge (Universal 320- R, Andreas Hettich GmbH & Co. KG, Tuttlingen, Germany). The supernatant liquid was carefully poured into a tared dish and evaporated in a fan oven (UFE-400, Memmert GmbH 1 Co. KG, Munich, Germany) at 105°C overnight. The precipitated gel was weighed and the WAI was calculated from the initial and final weights. As an index of water solubility, the amount of dried solids recovered by evaporating the supernatant was expressed as a percentage of dry solids.

**2.4.3. Measurement of dough volume.**

The dough volume was measured on fresh dough with the method of Havet et *al*. (2000). 100 g of each sample were put in fermentometers for proofing at 28°C for 280 min. This long duration takes into account the time necessary for stabilisation of the dough temperature and for rupture of the gluten network (dough open porosity point). The dough volume was measured separately from dough pieces coming from the same batch using a sterilised flask (diameter: 5 cm) with a cursor applied onto the dough. The vertical displacement of the cursor is related to the increase in the dough volume. Triplicate samples of each dough pieces were used.

**2.4.4. Pasting properties.**

The samples ground to a flour (particle size=300 µm) were used to determine pasting properties to the method reported by Sanchez et al. (2009) using a Rapid Visco Analyser (RVA-4 model Thermocline Windows Control and analysis software, Newport Scientific, Switzerland). Indeed, (2.5 g) of dry matter from each flour were dispersed in distilled water (25 ml° to obtain a 10% suspension. The viscosity was recorded according to the following temperature profile: holding at 50°C for 1 min, heating from 50°C to 95°C at a rate of 6°C/min, holding at 95°C for 5 min, cooling at a rate 12°C/min to 50°C, and finally holding at 50°C for 2 min. the first agitation at 960 rpm was applied for the first 10 s, then at 160 rpm for the remaining time of the experiment. The average over 2 replicas was calculated. Six parameters were measured on the visco-amylogram: emptying temperature (PT), peak viscosity (PV: first peak viscosity following the pasting) holding strength (HS) and finally final viscosity (FV). Two additional parameters were then calculated: the breakdown (BD) estimated by (PV-HS), the set-back (SB) estimated by (FV-HS).

**2.4.5. Bread volume.**

The dough was proofed 1 h at 28°C, 75% RH prior to baking. Baking of non-cut samples and fresh dough were then carried out in an oven (Sofinor, Perenchies France) at a temperature of 220°C for 20 min. After a one hour post-baking period, the bread volume was measured using the method of rapeseed displacement. The specific volume of bread was obtained by dividing the weight of seeds by the bread volume.

**2.4.6. Hedonic analysis of breads.**

The bread samples were evaluated for colour, taste, odour and texture by twenty trained panellists as described Singh-Ackbarali, D. and Maharaj, R. (2014). The panellists were randomly selected from staff and students of the Department of Food Science and Nutrition, ENSAI, University of Nagoundere Cameroon based on their familiarity with bread. Then, the bread samples were presented in 3-digit coded white plastic plates at 29±3°C. The samples were evaluated on a 9 point Hedonic scale where 1 = disliked extremely and 9= like extremely. The order of presentation of the samples to the panellists was randomized. The panellists were provided with bottled water to rinse their mouths in between evaluations. The sensory evaluation was carried out at midmorning (10 am) in the sensory evaluation laboratory under adequate lighting and ventilation. The 100% wheat flour served as a control.

**2.4.7. Statistical analysis**

Triplicate data were evaluated using one-way ANOVA. Pearson's correlation and multivariate principal component analysis (PCA) were done using Xlstat and mean differences were determined using Fisher's Least Significance Difference (LSD) test at a 5% significant level ($p < 0.05$).

## III. RESULTS AND DISCUSSIONS

**3.1.Physico-chemical characterizatics of individual flours**

Table 2 shows the ash, protein, lipid, starch, amylose and amylopectin contents of the individual flours. The water content of the wheat flour is 13.2% and that of cassava is of 10, 4%. This value of the water content of cassava is slightly lower than the Algerian standard (NA 11-32-1991) 16% for storage and good preservation of flour. The water content is a crucial parameter in the storage of flour. Indeed, a water content of flour greater than 16% promotes the development of microorganisms. In this study, the water content of less than 16% could thus allow good resistance during storage.

The ash contents of wheat and cassava are 0.7% and 0.63% respectively. These values are close to the values which are in the interval (0.45-0.60) recommended by the Algerian standard (NA733) on bread wheat flour. However, it is within the range of values acceptable by the Codex standard. Research has recommended a maximum value of 3% for edible cassava flour (Oboh and Elusiyan, 2007). The presence of minerals and possibly divalent types in the flour mixture will play a technological role in the measure where they can form divalent bridges in the structure of Triumfetta cordifolia gums and allowing to strengthen the three-dimensional network formed in the dough.

The starch contents of wheat and cassava flours are 72.13 and 88.59%, respectively. The starch content of fermented cassava flour is close to that obtained by Erikson et al., (2014) on a variety of *Afisiafi* cassava (89.2%).

The amylose contents for cassava and wheat flour are respectively 15.72% and 14.47% (Table 2). The amylose content is an indicator of the functionality of the starch. The higher the amylose content (or amylose /amylopectin ratio), the lower the swellability of the starch will be (Vamadevan and E. Bertoft, 2020). This can make it possible to predict the aptitude of the different flours for leavening during baking. In view of the results obtained, the cassava flour will be more suitable for leavening than wheat flour. The more a flour content amylose the more this flour would retrograde these flour will produce a stalling bread (Hug iten et al., 2003).

The protein content of wheat flour is 10.6% and that of cassava is 3.5%. The high protein content of wheat shows that wheat is more workable than cassava. The low protein content of cassava flour compared to that of wheat is due to the absence of gluten in cassava flour. The protein content of wheat flour is within the range of values established by Ocheme et al. (2017) on bread wheat flour. The protein content by its technological and nutritional value, It is an element of value for the use of flour. According to Wim and Delcour (2002), proteins are known to be the only component of wheat responsible for its baking quality, which is the ability of a wheat or a flour to give beautiful and good bread in working conditions and performance in harmony with normal manufacturing.

The lipid contents of wheat and cassava are respectively 1.77 ± 126 and 1.3 ± 45 (g / 100G MS). These contents are lower than the reference range of 2 to 3% (Ocheme et al. 2017). The presence of fat influences the mechanical properties of the flour: the more fat a flour contains, the lower its baking strength. They can influence the interaction of flour with water because they are hydrophobic. Endogenous lipids play an important role in the properties of the dough, the behavior during baking as well as the staleness of the bread because their functional properties depend on their bonds or interactions with the other constituents of the flour.

Baker's strength (w) characterizes the strength of a flour, the baking strength of wheat flour and cassava are respectively 133J and -198J. These results show that wheat flour is in the range of breadmaking flours established by Mehak et al (2019) which ranges from 130 to 180, unlike cassava flour. From these results, it emerges that the substitution of wheat flour by cassava flour will reduce the flour's aptitude for breadmaking.

**Table 2**: Physicochemical properties of cassava and wheat flours.

| | Wheat flour | Cassava flour |
|---|---|---|
| Ash content (%) | 0.7 ± 0.02 | 0.63 ± 0.01 |
| Proteins (%) | 10.6± 0.86 | 3.5 ± 0.13 |
| Gluten=14% | 23.5 ± 2.17 | 5.3± 0.69 |
| Lipids(%) | 1.7 ± 0.14 | 1.3 ± 0.17 |
| Starch content (%) | 72.13 ± 0.02 | 84.3 ± 0.02 |
| Amylose (%) | 14.47 ± 0.02 | 15.72 ± 0.02 |
| Amylopectin (%) | 57.66 ± 0.02 | 68.58 ± 0.02 |
| Damaged starch (UCD) | 20 ± 0.02 | 15.17 ± 0.02 |
| Strengh of flour (W) | 133 Joule | -198 Joule |

### 3.2. Functional properties of the different flours.

#### 3.2.1 Water absorption capacity and solubility index

Rehydration is the first step in the use of food powders because the technological aptitude of a flour relates first of all to its behavior with respect to water. Water absorption capacity (WAC) measures the ability of the powder to fix water. The water absorption capacity of different formulations are shown in figure 1 and the Solubility index in figure 2. Formulation F7 has the highest water absorption capacity (415%) compared to formulation F4 which has the lowest actual (23.644%) and apparent (18%) water absorption values. These high values of the water absorption capacity can be explained by the large quantity of wheat (72.5), but also by the presence of a large quantity of the gum of *triumfetta cordifelia* in formulation 7 which are more hydrophilic constituents. In view of the results, it is noted that the incorporation of the gum powder contributes to the increase in the water absorption capacity of the flour mixtures. This behavior can be explained by the hydrophilicity that water-soluble hydrocolloids generally have. This is due to the presence of OH groups which can form hydrogen bonds with water molecules

The low value of the water absorption capacity in F4 is due to the low proportion of wheat flour and the total absence of gum in this formulation. We note the presence of a significant amount of cassava flour which is very rich in starch. Compounds with a high starch content do not always exhibit high water absorption capacity compared to wheat flour. This low absorption can also be explained by the fact that the starch is still in its native state.

#### 3.2.2 Solubility index

The solubility index (SI) of a flour is the percentage of flour dissolved in water, Figure 2 shows the different indices of each formulation. Formulation F4 has the highest value of the solubility index with a high value of 833%, formulation F7 has the lowest value of 605%. Unlike the water absorption capacity, the solubility index increases with decreasing gum.

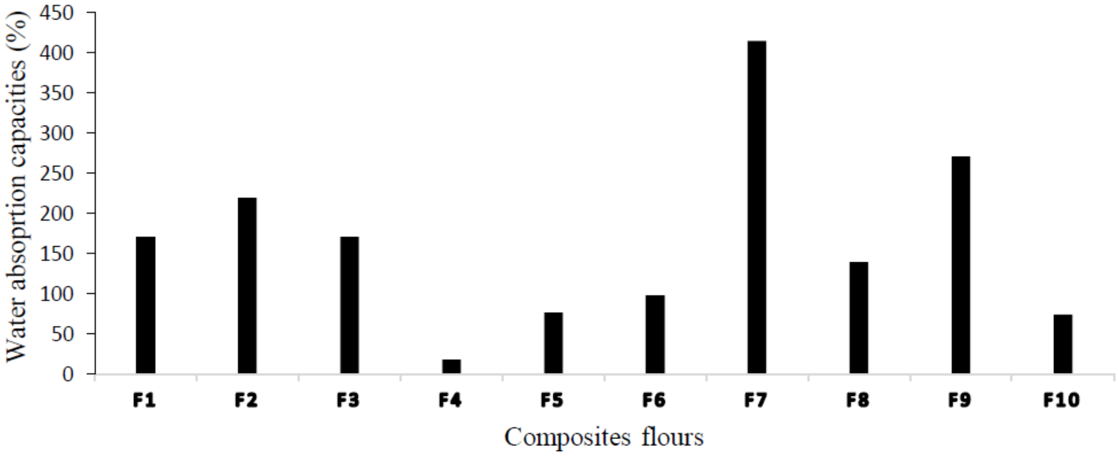


**Figure 1:** Effect of wheat substitution with cassava and *T. cordifolia* on water absorption capacity of composite flours.

Legend:
**F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52.5wheat, 40%cassava, 7.5%*T.cordifolia* **F3**:80 wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57.5%wheat, 40%cassava, 2.5%*T.cordifolia* **F7**:72.5wheat, 20%cassava, 7.5%*T.cordifolia* **F8**:77.5wheat, 20%cassava, 2.5%*T.cordifolia* **F9**:40%wheat, 50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

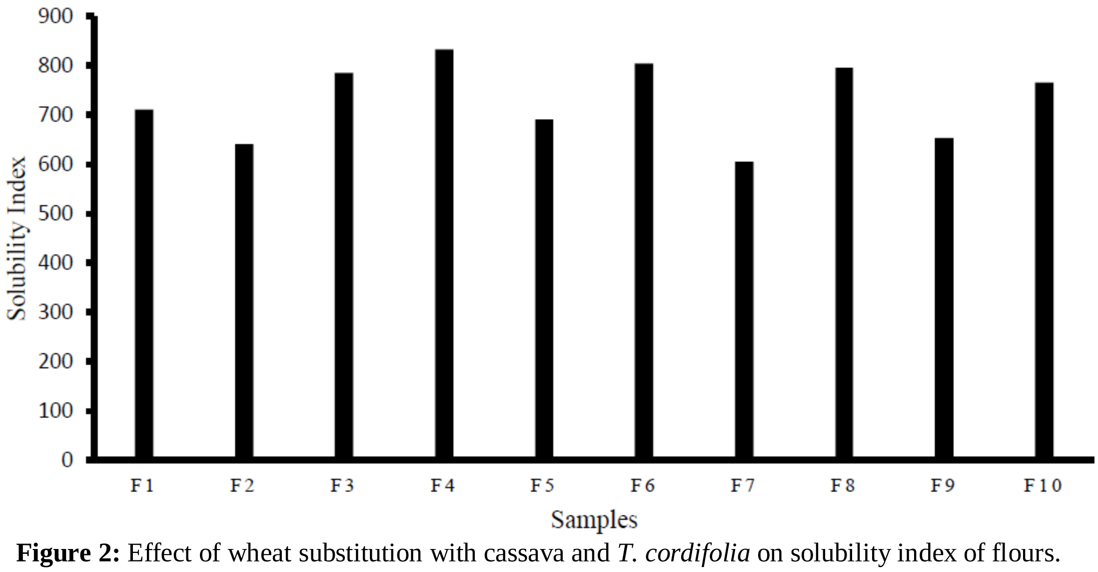


**Figure 2:** Effect of wheat substitution with cassava and *T. cordifolia* on solubility index of flours.

Legend:
**F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52.5wheat, 40%cassava, 7.5%*T.cordifolia* **F3**:80 wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57.5%wheat, 40%cassava, 2.5%*T.cordifolia* **F7**:72.5wheat, 20%cassava, 7.5%*T.cordifolia* **F8**:77.5wheat, 20%cassava, 2.5%*T.cordifolia* **F9**:40%wheat, 50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

**3.3. Pasting properties the mix flour.**

The pasting properties of the mix flou ris show in table 3. The pasting properties of flour predict the behavior of starch granules during hydrothermal treatment (Mehak et al 2019).The maximum viscosity (PV) represents the swelling power of the starch granules, it is also an indicator of the water adsorption capacity of the granules (Singh et al., 2005) Among the formulations, the flours having a high rate of wheat and gum (F9, F5 and F2) exhibit the highest swelling capacities.

This result is justified, on the one hand by the quality of the proteins in our formulations and on the other hand by the hydrophilic nature of the gums incorporated, which improves its swelling capacity and leads to a higher viscosity.

Starch temperature is an index of the minimum energy required to initiate rapid water uptake and swelling of starch granules resulting in increased viscosity (Singh et al., 2005). The starch temperature of our different formulations varies from (90°C) to (90.05°C), the starch content influences the starch temperature so these studies have shown that the starch temperature depends on the origin and starch content (Sonal *et al.*, 2020). These results show that the substitution would have little influence on the gelatinization temperature of the flours.

Once the PV is reached, the starch granules burst and release their internal material, causing a decrease in the viscosity of the medium called a drop in viscosity or breakdown (BD). This parameter provides information on the fragility of the starch granules, the higher its value, the more damaged the starch granule. Flour composed with a high proportion of cassava has a low F4 value (82.00cP) than the one with the least (F8 and F7; 656cP and 894 cP), which reflects its higher damage.

Final viscosity (FV) is associated with the gel capacity after cooling. The formulations made up of high proportions of cassava and low in gum have the highest values of this parameter, this is the case of F4, F8 and F7 (2841cP, 2691cP and 2414cp) than that of the formulations which have a low rate of it. Cassava and more in F5 and F3 gum (1785Cp and 284 Cp). The increase in viscosity after cooling is partly explained by the retrogradation of the starch and the gelling properties of the gums. The phenomenon describing the ability of amylose chains to want to reassociate by hydrogen bonds by expelling water molecules can be quantified by setback (SB). A high setback will therefore be associated with a negative effect on the quality of bread products during storage.

The measured values indicate an important lower SB for the flour with a high level of cassava and low level of gum F4 (2557cP), conversely for the formulations which have the least, F5 (156cP). This result therefore reveals to us that formulations F4, F8 and F7 are more apt to downshift than formulations F5 and F3, this could be due to a higher level of amylose in the flour.

In view of all the viscosity parameters obtained, cassava flour is well suited for breadmaking because of its swelling ability, however it is less stable when hot and has a tendency to high retrogradation. Its association with wheat flours is therefore likely to improve this tendency to downgrade and the incorporation of gum to improve the ability of the dough to rise due to their low viscosity.

**3.4. Dough volume**

Figure 3 shows the fermentation kinetics expressed by the rise in dough pieces over time. It is observed in this figure that the formulations F8 and F10 exhibit a high value of the volume thrust after baking. This result shows, on the one hand, that the quantity and quality of the proteins in wheat flour promote the development of breads by forming a stable three-dimensional network. This protein network is capable of retaining carbon dioxide ($CO_2$) which is formed during the fermentation of the dough and of forming a fairly regular alveolar structure after the expansion of the gases during cooking. On the other hand, cassava flour contains a lot of starch. This starch will be hydrolyzed by enzymes such as α- and β-amylase of baker's yeast into simple sugars. The latter undergo fermentation and produce $CO_2$ (Havet et al. 2000). This $CO_2$ thus produced will seek to escape and will be trapped by the three-dimensional network of gluten. The addition of hydrocolloids to these formulations induced a significant improvement in the volume thrust. This could probably be explained by the ability of the hydrocolloids of *triumfetta cordifolia* to form a network similar to that of wheat, capable of retaining the gases produced during fermentation. The formation of this network can give the dough a flexibility which allows it to expand sufficiently well, which is also favorable to the retention of gas and water vapor during leavening. These results are in agreement with the work of Rossel et al. (2001) and Tavakolipour and Kalbasi-Ashtari (2007) who showed that the incorporation of hydroxypropylmethylcellulose (HPMC) and Carboxymethylcellulose (CMC) in flour wheat improves the swelling of the dough during fermentation and this action depends on the nature of the gum and within a limiting range of concentrations.

In contrast, the formulations F6 and F4 exhibit the lowest values of the volume thrust after steaming. These results are due on the one hand to the low quantity of wheat flour in these samples and on the other hand to the low or non-presence of the gum in these formulations, which explains the high permeability of its dough with respect to $CO_2$ which is given off during fermentation because of a small amount of gluten in this mixture.

| Samples | PV (cP) | HS (cP) | FV (cP) | PT(cP)(cP) | TPV (cP) | BD (cP) | SB (cP) |
|---|---|---|---|---|---|---|---|
| F1 | 1818 | 1603 | 2219 | 95,05 | 6,4 | 215 | 616 |
| F2 | 2155 | 1414 | 2227 | 95 | 5,87 | 741 | 813 |
| F3 | 1362 | 935 | 284 | 95,05 | 5,73 | 427 | -651 |
| F4 | 366 | 284 | 2841 | 95,5 | 6,33 | 82 | 2557 |
| F5 | 2294 | 1629 | 1785 | 95 | 6,33 | 665 | 156 |
| F6 | 1902 | 1358 | 2008 | 95,05 | 6,4 | 544 | 650 |
| F7 | 2119 | 1228 | 2414 | 95,05 | 6,47 | 891 | 1186 |
| F8 | 2271 | 1615 | 2691 | 95,05 | 6 | 656 | 1076 |
| F9 | 2210 | 1249 | 2111 | 95,05 | 4,87 | 961 | 862 |
| F10 | 1953 | 1375 | 2308 | 95 | 6,4 | 578 | 933 |

**Table 3:** Effect of wheat replacement with cassava and *T. cordifolia* on pasting porperties.

Legend: **F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52,5wheat, 40%cassava, 7,5%*T.cordifolia* **F3**:80%wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57,5%wheat, 40%cassava, 2,5%*T.cordifolia* **F7**:72,5wheat, 20%cassava, 2,5%*T.cordifolia* **F8**:77,5wheat, 20%cassava, 2,5%*T.cordifolia* **F9**:40%wheat ,50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

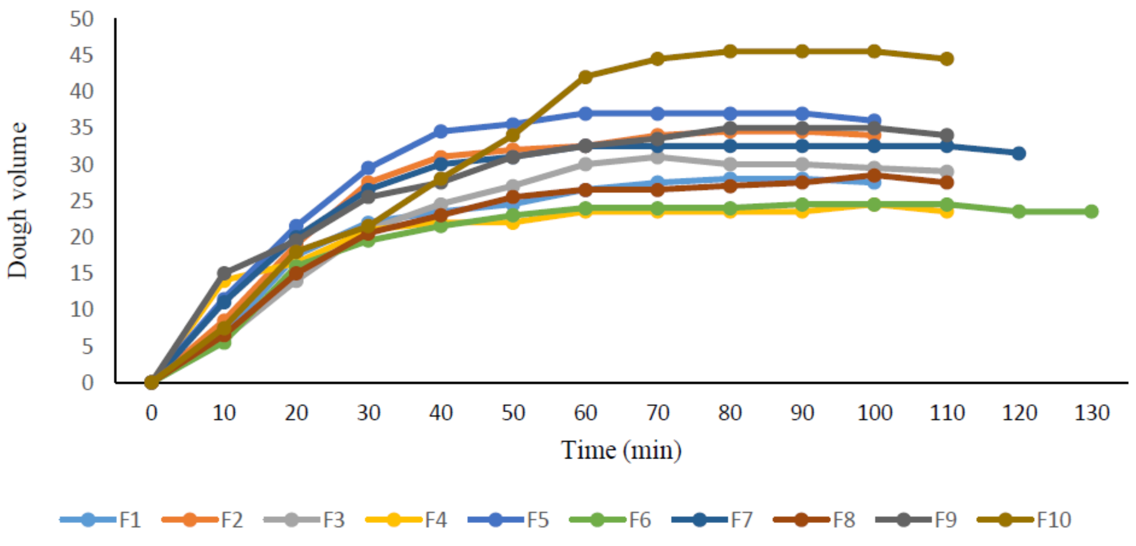


**Figure 3:** Effect of wheat replacement with cassava flour and *T. cordifolia* on dough volume.
Legend:
**F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52.5wheat, 40%cassava, 7.5%*T.cordifolia* **F3**:80 wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57.5%wheat, 40%cassava, 2.5%*T.cordifolia* **F7**:72.5wheat, 20%cassava, 7.5%*T.cordifolia* **F8**:77.5wheat, 20%cassava, 2.5%*T.cordifolia* **F9**:40%wheat, 50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

**3.5. Physical properties of bread**

The yield is obtained by making the ratio of the masses of the loaves produced to that of the dough pieces multiplied by one hundred (100). The results reported in Figure 4A show a a possible relationship between the volume of the bread, the rate of incorporation of flours and gums. The results show that the formulations with high substitution have a low yield (F4, 86.99) compared to the less substituted (F5, 90.73). However, it is observed that the degree of incorporation of the gums could impart or improve the viscoelastic properties of the dough in order to obtain a larger volume and yield from the breads makes it possible to improve the viscoelastic properties of the dough in order to obtain a greater volume and yield (F3, 90.92). This is to the extent that according to the work of Saidou et al. (2014), *Triumfetta cordifolia* gums have a viscoelastic behavior in aqueous solution.

The specific volume is the ratio of two properties namely, the volume of the bread over its mass. It is adopted in the literature as a more reliable measure of bread size (Shittu et al., 2007). It can be presented as a determining key criterion for the quality and acceptability of a bread (Hager, Elke, & Arendt, 2013)

With regard to Figure 4B, it is noted that the incorporation of the gum powder improves the specific volume of the wheat-cassava flour mixtures because the mixtures comprising the gums with little cassava have a high specific volume and those without the gum have practically a lower specific volume. Thus, it was realized that the higher level of compound flour substitution had a negative effect on the bread volume. This finding is in agreement with that reported by Lazaridou et al (2007), who found lower volumes associated with compound flour in baked products versus pure wheat flour products.

However, the proportion of wheat plays an important role in the expansion of bread with a greater effect than cassava flour. Indeed, the results reported in Figure 4B show that when the proportion of cassava decreases and that of wheat and especially of gum increases, the specific volume increases. Consequently, the formulations allowing to obtain an optimal specific volume will have to integrate high contents of gum, wheat and lower cassava.

One of the important parameters of bread is its texture (Hager and Harendt, 2013). Consumers can describe this texture as soft or flexible (described by low hardness) in general. The texture profile of the composite breads is shown in figure 4C. A gradual increase in hardness is observed with the rate of incorporation of cassava in the formulations F4 and F8 respectively of 1.62 and 1.76 which is greater than the reference value for wheat was 0.07 N. Indeed, the addition of ingredients other than wheat flour results in an increase in the hardness of the bread on the one hand and on the other hand, the addition of gums reduces the hardness of the compound breads thanks to their gelling properties (Panyoo, 2014).

The same phenomenon is observed on the elasticity of breads, which is a property that certain bodies have in recovering their shape or volume when the force which deformed them has ceased to act. The elasticity of the loaves is higher (F1, F2, F7) depending on whether the level of gum incorporated is high and the opposite effect is observed in the formulations without or with little gum.

Adhesiveness expresses the sticky aspect, which is linked to the viscosity of the dough. There is a decrease in this with the increase in cassava flour on the one hand (F4, 2.5 Ns) and on the other hand an increase according to the rate of incorporation of gum in all the samples F8 (25.83 Ns) its results could be explained by the quantity of proteins in the formulations and the viscoelastic properties of gum. Studies have shown that there is a notable influence of the rate of substitution of wheat flour by sweet potato flour on the stickiness of bread (Ndangui, 2015). However, the incorporation of gums at high levels has the opposite effect, this is the case observed in F9 and F3 respectively of 9.66 Ns and 4.66 Ns which have high proportions of gum (10%)

**3.6. Sensory properties of the breads.**

It emerges from the figure 5 that the descriptors hardness, odor and flavor were the least appreciated and the texture of the crumb would have been moderately of the different formulations of breads. Indeed, according to the judges, the breads would be quite heavy with attributes such as the smell, the flavor very different from conventional bread and a dense and not very airy crumb. However, we would observe the color of the crust, the texture of the crust and the crumb close to that of conventional bread, appreciable and a taste close to normal bread.

In general, we observe 02 classes of breads, on the one hand those of the formulations F3; F5, F8 and F10 which are the most appreciated by the judges because they are potentially acceptable breads at the sensory level with characteristics that could recall those of classic breads and the most accepted samples with respect to the set of parameters are samples F5 and F10 because they are in the center with respect to the general acceptability and are the loaves closest to the set of attributes evaluated. However samples 3 and 8 are accepted; but much more according to the texture of the crust and the taste respectively. On the other hand, the breads resulting from formulations 1, 2,4,6,7,9 representing all the defects noted on all the formulations.

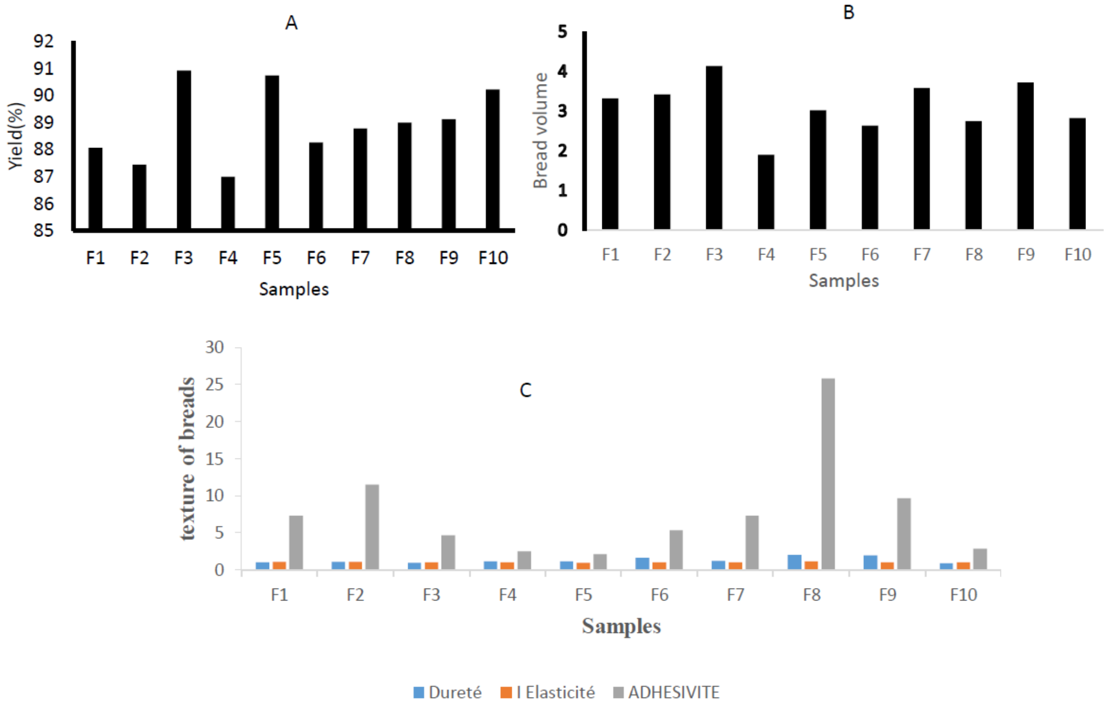


**Figure 4:** Effect of wheat replacement with cassava flour and *T. cordifolia* on physical properties of bread.

**F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52.5wheat, 40%cassava, 7.5%*T.cordifolia* **F3**:80 wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57.5%wheat, 40%cassava, 2.5%*T.cordifolia* **F7**:72.5wheat, 20%cassava, 7.5%*T.cordifolia* **F8**:77.5%wheat, 20%cassava, 2.5%*T.cordifolia* **F9**:40%wheat, 50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

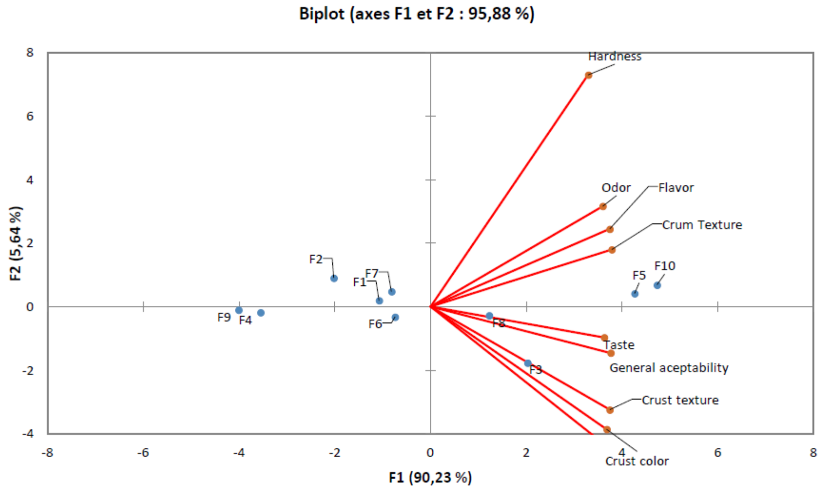


**Figure 5:** Effect of wheat replacement with cassava flour and *T. cordifolia* on sensory properties of bread.

Legend:

**F1**:65%wheat, 30%cassava, 5%*T.cordifolia* **F2**:52.5wheat, 40%cassava, 7.5%*T.cordifolia* **F3**:80 wheat, 10%cassava, 10%*T.cordifolia* **F4**:50%wheat, 50%cassava 0%*T.cordifolia* **F5**:90%wheat, 10%cassava, 0%*T.cordifolia* **F6**:57.5%wheat, 40%cassava, 2.5%*T.cordifolia* **F7**:72.5wheat, 20%cassava, 7.5%*T.cordifolia* **F8**:77.5wheat, 20%cassava, 2.5%*T.cordifolia* **F9**:40%wheat, 50%cassava, 10%*T.cordifolia* **F10**:80%wheat, 20%cassava, 0%*T.cordifolia*.

## IV. CONCLUSION

The functional properties of wheat-cassava compound flours, and the physical and rheological characteristics of the resulting pasta and breads are influenced by the incorporation of Triumfetta cordifolia gum into the flour mixture. This gum powder having a highly hydrophilic character improves the water absorption capacity of compound flour, making them more suitable for baking. It emerges from the physico-chemical and functional characterization that the gum of *T. cordifolia* has a great affinity with water, which improves the water absorption capacity of the compound flours, thus making them more suitable for bread-making. Regarding the physical characterization of the loaves obtained, *T. cordifolia* gum increases the swelling capacity of the dough, thus making the crumb airier with a more developed open crumb structure, which would justify the increase in the rising rate and the specific volume of the bread. The *T. cordifolia* gum at 2.5%, increase the percentage of wheat flour replacement by cassava in breadmaking up to 20%.

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