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Functional properties of the composed flours of three Malagasy cassava (*Manihot esculenta* Crantz) varieties Menarevaka, Mena and Fotsy with wheat flour

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Abstract: The present research work was carried out with the aim to produce the composed flours of the Malagasy cassava varieties Menarevaka, Mena and Fotsy and wheat and to determine the functional properties of the composed flours thus produced. Composed flours having percentages of the flours of these Malagasy cassava varieties and that of wheat from 0/100 to 50/50 have been produced. Five functional properties of these composed flours were determined by appropriates methods. The results obtained show that: their water retention capacities (in g per 100g of dry mater) are respectively between 76.14±0.91 and 99.09±0.65; 78.71±0.56 and 100.43±0.92 and 88.53±1.46 and 100.60±0.92. Their oil retention capacities (in g per 100g of dry mater) are respectively between 87.33±2.74 and 93.49±1.45; 93.89±1.93 and 112.84±1.02; 80.30±0.92 and 89.95±0.92. Their hydrophilic-lipophilic ratios are between 0.87±0.03 and 1.06±0.01; 0.84±0.02 and 0.94±0.01 and 0.98±0.02 and 1.12±0.02. The solubility (in % based on dry mater) are respectively varied from 7.75±0.27 to 8.91±0.41; 8.58±0.20 to 10.79±0.04 and 8.30±0.14 to 9.97±0.10. Their swelling powers (in g per g of dry mater) are respectively oscillated between 8.27±0.04 and 10.33±0.28; 8.90±0.27 and 11.32±0.11 and 8.80±0.26 and 10.71±0.12. The results show that the composed flours of the cassava Menarevaka and wheat; Mena and wheat; Fotsy and wheat have important functional properties. These composed flours can be used to make other food products adapted to these functional properties.

***Keywords* —**Malagasy cassava, wheat, composed flour, functional property, food product, Madagascar.

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I. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a starchy plant with roots. It is consumed by nearly a billion people worldwide **[1]**. It is cultivated throughout the tropics, in Africa, America and Asia **[2]**. It is used for both human and animal food. It is also used as a raw material in the non-food industry **[3]**. In the chemical industry, cassava flour and starch are used in the manufacture of textiles, paper-cardboard, detergents, adhesive glues, solvents or bio-fuels **[4]**. It is also used as an excipient for the manufacture of drugs, such as capsules and tablets in the pharmaceutical industry **[5]**.

Madagascar grows wheat, but the production fails to supply the country in sufficient quantity. Due to insufficient national wheat production, economic operators are forced to import wheat flour **[6]**. In general, Madagascar imports 6000 tons of wheat flour per year. In 2014, for example, 78483 tons of wheat flour was imported **[7]**. The use of the composed flours by incorporating flour from widely available starchy plants, as cassava, in wheat flour is one of the favorable solutions to reduce the massive importation of wheat flour.

The main objective of this work is to contribute to the promotion of edible starch plants available in Madagascar. Its specific objectives are to produce the composed flours of wheat and of three Malagasy cassava varieties Menarevaka, Mena and Fotsy and to determine the functional properties of the composed flours produced. These three cassava varieties are the most cultivated the most consumed and the most available in the Region of DIANA-Madagascar. The results obtained will therefore make it possible to know which Malagasy cassava variety flour is most suitable for the manufacture of a desired food product.

II. MATERIALS AND METHODS

A. Plant materials

In this research work, we used the composed flours of cassava-wheat. Commercial Type 55 wheat flour was used. Cassava flours were obtained by artisanal processing of the roots of the Menarevaka, Mena and Fotsy cassava varieties.

These cassava flours were packaged in tightly closed boxes while waiting analysis. The cassava and wheat flour were mixed according to the proportions (mass in g of cassava flour / mass in g of wheat flour), 5/95, 10/90, 15/85, 20/80, 25/75, 30/70, 35/65, 40/60, 45/55 and 50/50. The mixtures were made a few days before the analysis so that the intermolecular interactions between the cassava flour and that of wheat were linked.

B. Determination of the functional properties of the composed flours

Five parameters were measured by suitable methods to determine the functional characteristics of the composed flours of cassava-wheat. These are: the water and oil retention capacity according to the method of **Sosulski [8]**, the hydrophilic and lipophilic ratio using the method described by **Njintang Mbofung** and **Waldron [9]**, the swelling and solubility capacity according to the method of **Leach** ***et al.*** **[10]**.

III. R ESULTS

A. Water retention capacity

The values of the water retention capacities of the composed flours of the cassava varieties Menarevaka, Mena and Fotsy with that of wheat are respectively between 76.14±0.91 (5%) and 99.09±0.65g/100g of dry mater (50%); 78.71±0.56 (5%) and 106.43±0.92g/100g of dry mater (50%); 78.53±1.46 (5%) and 100.60±0.92g/100g of dry mater (50%). The curves of the variations in water retention capacity as a function of the incorporation rates of cassava flours into that of wheat are shown in figure 1.

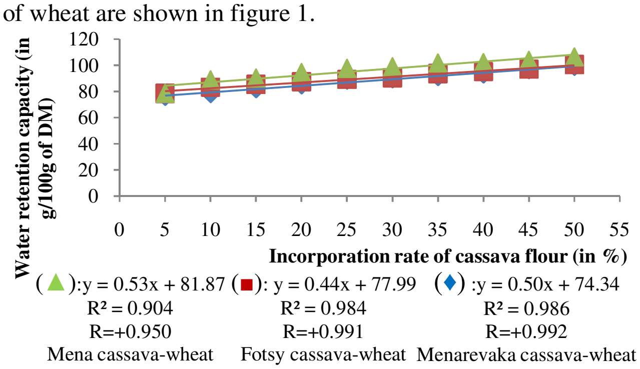

Fig1. *Variations in the water retention capacities of the composed flours as a function of the incorporation rate of cassava flours into that of wheat*

According to the curves, the correlation coefficients R are all positive. This means that the water retention capacities of the composed flours augment proportionally with the increase in the incorporation rate of cassava flours into that of wheat.

B. Oil retention capacity

The oil retention capacities of the composed flours containing flour of the Menarevaka, Mena and Fotsy cassava varieties are respectively between 87.33±2.74 (5%) and 93.49±1.44g/100g of dry mater (50%), 93.89±1.93 (5%) and 112.84± 1.02g/100g of dry mater (50%); 80.30±0.92 (5%) and 89.95±0.92g/100g of dry mater (50%). The curves of the variations in the oil retention capacity as a function of the incorporation rates of cassava flours into that of wheat are shown in figure 2.

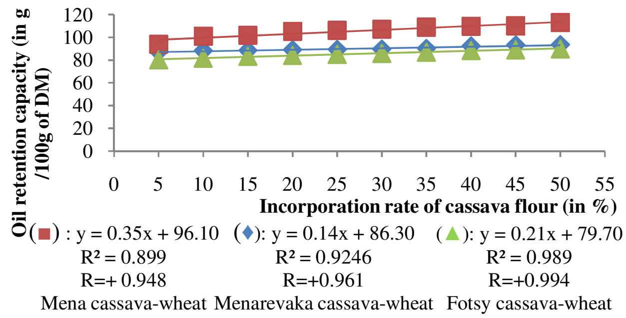

Fig2. *Variations in the oil retention capacities of the composed flours as a function of the incorporation rate of cassava flours into that of wheat*

According to the curves, the correlation coefficients R are all positive. Thus, the oil retention capacities of the composed flours augment as the rate of incorporation of cassava flours into wheat flour increases.

C. Hydrophilic-lipophilic ratio

The values of the hydrophilic and lipophilic ratios of the composed flours containing the flour of the Menarevaka, Mena and Fotsy cassava varieties are respectively between 1.87±0.03 (5%) and 1.06±0.01 (50%); 0.84±0.02 (5%) and 0.94±0.01 (50%); 0.98±0.02 (5%) and 1.12±0.02 (50%). The curves of the variations of the hydrophilic and lipophilic ratios as a function of the incorporation rates of cassava flours into that of wheat are shown in figure 3.

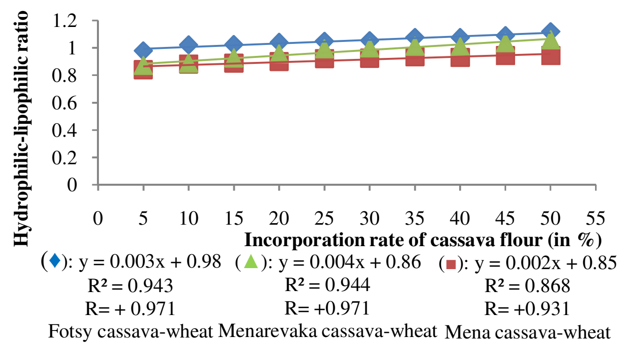

Fig3. *Variations in the hydrophilic and lipophilic ratios of the composed flours as a function of the incorporation rate of cassava flours into that of wheat*

The correlation coefficients R are all positive. Thus, the hydrophilic and lipophilic ratios of the composed flours containing flours of the Menarevaka, Mena and Fotsy cassava varieties augment in proportion with the increase in the rate of incorporation of cassava flours into that of wheat. Of these three curves, the hydrophilic and lipophilic ratios of the composed flours containing flour of the Fotsy cassava variety are greater than one (1).

D. Solubility

The solubility values of the composed flours containing flour of the Menarevaka, Mena and Fotsy cassava varieties are respectively between 7.75±0.27 (5%) and 8.91±0.41% (50%); 8.58±0.20 (5%) and 10.79±0.04% (50%) and 8.30±0.14 (5%) and 9.97±0.10% (50%). The curves of the variations in solubility as a function of the incorporation rates of cassava flours into that of wheat are shown in figure 4.

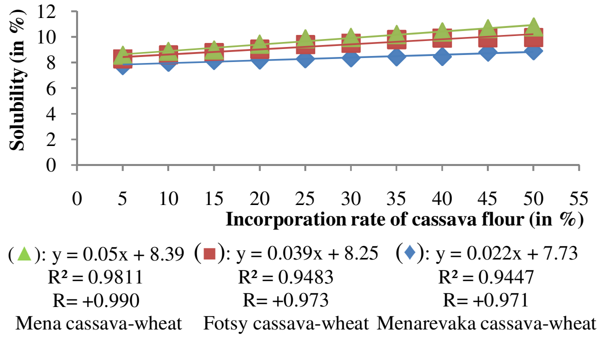

Fig4. *Variations in the solubility of the composed flours as a function of the incorporation rate of cassava flours into that of wheat*

The correlation coefficients R are all positive. Thus, the solubility of compound flours containing flours of the Menarevaka, Mena and Fotsy cassava varieties augment in proportion with the increase in the rate of incorporation of cassava flours into that of wheat.

E. Swelling power

The swelling power values of the composed flours containing flours of the Menarevaka, Mena and Fotsy cassava varieties are respectively between 8.27±0.04 (5%) and 10.33±0.28g/g of dry mater (50%); 8.90±0.27 (5%) and 11.32±0.11g/g of dry mater (50%); 8.80±0.26 (5%) and 10.71±0.12g/g of dry mater (50%). The curves of the variations in swelling power as a function of the incorporation rates of cassava flours into that of wheat are shown in figure 5.

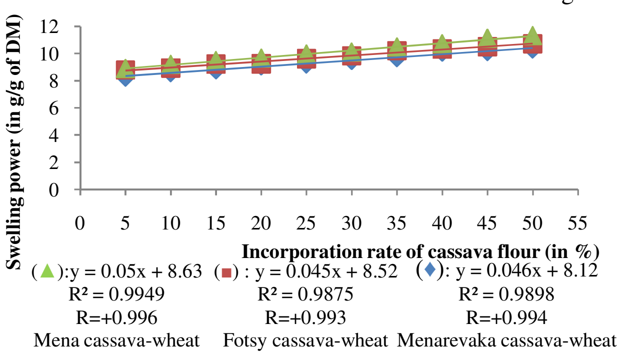

Fig5. *Variations in the swelling powers of the composed flours as a function of the incorporation rate of cassava flours into that of wheat*

The correlation coefficients R are all positive. Indeed, the swelling power values augment proportionally with the increase in the incorporation rate of cassava flours into that of wheat.

IV. DISCUSSION

The water retention capacities of the composed flours found during this study are similar to those reported by **Agunbiade *et al.* [11]** on the composed flours at 0%, 10%, 20%, 25% and 30% incorporation rates of cassava flour. They increase with the increase in the incorporation rate of cassava flour. This phenomenon can be explained by the increase in the amount of carbohydrates and starch, compounds with hydrophilic groups, in the composed flour. Note that cassava flour is rich in these compounds. Indeed, when the incorporation rate of cassava flour increases, the amount of starch and that of other carbohydrates in the mixtures increases **[12], [13]**. The increase in the level of these compounds in the flour mixture therefore promotes the increase in the water retention capacity of the composed flour.

The oil retention capacities of the composed flours containing the flours of three cassava varieties studied are consistent with those found by **Agunbiade *et al.* [11]** on the composed flours at 0%, 10%, 20%, 25% and 30% incorporation rates of cassava flour. We have found that the oil retention capacity increases as the incorporation rate of cassava flour increases. This indicates that the amount of hydrophilic compounds increases as the incorporation rate of cassava flour increases.

Composed flours containing flour of the Fotsy cassava variety have a greater affinity for water than for oil, as the hydrophilic and lipophilic ratios of these composed flours are all greater than one (1). In contrast, the composed flours containing flour of the Mena cassava variety have a higher affinity for oil than for water, as the hydrophilic and lipophilic ratios of these compound flours are all less than one (1). This indicates that in the composed flours containing flour of Fotsy cassava variety, the content of hydrophilic compounds is higher than that of lipophilic compounds. While in the composed flours containing Mena cassava variety flour, the content of lipophilic compounds is higher than that of hydrophilic compounds.

The solubility of the composed flours increases proportionally with the increase in the incorporation rate of cassava flours. These values are consistent with those of the work by **Eriksson *et al.* [14]** by incorporating 10%, 20%, 30% and 100% of the flours of three cassava varieties *Afisiafi, Bankye hemmaa* and *Doku duade* in wheat flour. The solubility of the composed flours increases with increasing incorporation rate of cassava flours. The increased solubility's of the composed flours have been explained by **Chanapamokkhot** and **Thongngam [15].** According to these researchers, a high solubility of the flours indicates a great tendency for the diffusion of amylose in aqueous media. The increase in the incorporation rate of cassava flour therefore leads to an increase in the content of soluble amylose in aqueous media. A high solubility of the flours also indicates a great tendency for the diffusion of water-soluble substances in aqueous media. As the incorporation rate of cassava flour increases, the amount of amylose and water soluble substances in the mixtures is also increased. In flour, amylose is soluble under the action of stirring and temperature **[16]**. The hydrolysis products of amylose are glucose, maltose and dextrin, polymers of D-glucose **[17]**. During this study, we found that the composed flours containing Mena cassava flour have the highest solubility rates. The flour of this cassava variety is therefore richer in water-soluble substances than those of the other two cassava varieties, such as Menarevaka and Fotsy.

The swelling powers of the composed flours studied are consistent with those of the work carried out by **Eriksson *et al.* [14]** by incorporating 10%, 20%, 30% and 100% of the flours of three cassava varieties *Afisiafi, Bankye hemmae* and *Boku duade* in wheat flour. Amylopectin is the molecule responsible for the swelling of flour by incorporating the water molecule into its helical structure **[18], [19], [20]**. The water is therefore trapped in the helical structure and in the branch of the amylopectin. As the incorporation rate of cassava flour into wheat flour increases, the amount of amylopectin increases, which also causes increased swelling power. In these three flours of the cassava varieties studied, the composed flours containing Mena cassava flour have the greatest swelling powers. Moreover, Mena cassava flour is richer in amylopectin (88.78%) than Menarevaka cassava flour (88.70%) and Fotsy cassava (87.59%).

V. CONCLUSION

In conclusion, the composed flours containing Mena cassava flour and wheat flour have very high water and oil retention capacities. These flours require a large amount of water and oil during the preparation of food products. The use of flour as a food ingredient depends to a large extent on its interaction with water and oil. In addition, the high oil retention capacity is important over a long shelf life of foods, especially in baked goods and meat products. The composed flours containing Fotsy cassava and wheat flours have a greater affinity for water than for oil with the hydrophilic and lipophilic ratios all greater than 1. These values mean that these flours give an indication of the capacity, retention of flavor. They are therefore useful for preparing soups, cakes and especially meat-based foods. The composed flours containing Mena cassava flour and wheat flour have the greatest solubility and swelling powers. They are therefore rich in water-soluble substances and swell more than the composed flours containing Menarevaka cassava flour and Fotsy cassava flour. They can therefore be used as a basic ingredient in bread making. Thus, in Madagascar, the creation of the businesses necessary to transform cassava roots into flour that can be incorporated into wheat flour is important in order to reduce the expenditure linked to the importation of wheat flour and to produce breads at an affordable cost.

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