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# Literature Review On Current Trends In Replacing Wheat Flour With Local Food Flours In Baking And Pastry Making, Case Study Of The Democratic Republic Of Congo

Daniel-Bienvenu Kwa Mungu Sifa, Angelique Kamari Feza, Eric Zola Sumbu
*Department Of Chemistry And Agricultural Industries, Faculty Of Agricultural Sciences And Environment, University Of Kinshasa - UNIKIN, Democratic Republic Of Congo.*

***Abstract:***
***Introduction:*** *Baked goods and pastries play an important role in the diet of the Democratic Republic of Congo (DRC). However, almost all of the wheat flour used to make these products is imported. To reduce import costs, one solution is to promote the use of local flours as a partial substitute for wheat flour. Several studies have already been conducted in this area. The aim of this study was to review studies aimed at partially replacing wheat flour with local flours in bakery and pastry products.*
***Literature:*** *A review of the literature has not only revealed the nutritional and technological potential of these flours, but also analysed the criteria for flours to be used in baking and pastry making, as proposed by international and national regulations. In the DRC, most locally produced flours (maize, sorghum, cassava, taro, sweet potato, yam, etc.) are gluten-free, even though gluten is an important criterion for selecting bread-making flour. On the other hand, these flours have very important nutritional properties that can improve the nutritional and organoleptic qualities of bread and other baked goods. This is why they are used as a substitute in certain percentages that do not affect the technological and organoleptic quality of the product. For several flours, the percentage of wheat flour replacement in bakery products did not exceed 20%, but for pastry products, it can be higher. There is a lack of regulatory texts concerning the use of local flours as a replacement for wheat flour (flour quality, substitution rate, etc.) in the DRC. Only cassava flour has benefited from a law authorising its use in baking, up to 20% as a substitute for wheat flour.*
***Conclusion:*** *The use of local flours as a partial substitute for wheat flour represents hope and a solution for a certain degree of food independence in several African countries. Each country needs to work on developing regulations governing the use of local flours in baking and pastry making.*
***Keywords:*** *Local flours, wheat, baking, pastry making, substitution.*

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## I. Introduction

The Democratic Republic of Congo (DRC) is one of the sub-Saharan African countries that relies heavily on food imports to meet local food needs. In this country, approximately US$1.5 billion is spent annually on food imports[1,2]. The second consequence of this reality, immediately after the expenditure of these huge sums on food imports, is that local food production faces great difficulty in intensifying, modernising and industrialising due to a lack of sustained attention from the public authorities.

Indeed, in his analyses of the causes of massive food imports in sub-Saharan Africa, Georges [3] explains that low prices for imported agricultural products, including wheat grains, lead African governments to implement agricultural policies based much more on the financial concerns of these states than on promoting local production. This has the effect of disadvantaging local African producers. The DRC imports around 200,000 tonnes of wheat per year [4]. If the DRC wants to create an environment of self-sufficiency or even food sovereignty, it is important that local food production attracts the attention of policy makers and the scientific community. This would be an opportunity to increase productivity and add value to these commodities.

A concrete example of the difficulties faced by Congolese agriculture in particular and African agriculture in general is provided by the importation of wheat and the incorporation of products derived from this cereal into the dietary habits of the Congolese population over several decades. In the DRC, wheat consumption continues to rise as a result of the country's rapid population growth, changing food preferences and socio-economic developments associated with urbanisation. This is particularly true in urban areas, where there has been a significant change in eating habits compared to what has been inherited from our customs and traditions.

Today in Kinshasa, people prefer to eat bread, a product made mainly from wheat flour, for breakfast rather than "foufou" made from cassava tubers. Similarly, bakery and pastry products are also preferred by those who eat their meals outside the home. This change in eating habits, which originated in the colonial period due to the prevalence of the eating habits of the colonisers (i.e. the dominant group) over the colonised [5], is currently maintained and even expanding in modern African societies, as people prefer to buy packaged products that are ready to eat, easy to store, readily available, and sold in larger quantities for the same price as local products [6].

However, as noted by Georges [3] and Kanani et al. [6], the expenditure incurred by sub-Saharan African countries on food imports does not necessarily imply a failure of local agricultural production or a clear desire to change Africans' eating habits. Maintaining and developing agricultural production in Africa in general, and in the Congo in particular, requires major changes in terms of increasing productivity and diversifying culinary preparations in order to meet the challenge of food imports [7]. This could even lead to the expansion of African foodstuffs and preparations to other continents.

In the DRC, ways and means of promoting local food products exist and are attracting increasing interest from the scientific community. One way of promoting local products would be to use them in preparations that have already become part of many people's eating habits, such as bakery and pastry products. These include bread, cakes, croissants, etc. This alternative of using our local agricultural products in the form of flour as a partial or total substitute for wheat flour would be very beneficial for dietary diversification, the promotion of local crops, the reduction of wheat imports, and as a solution for gluten-free diets. In this regard, on 15 April 2022, the DRC Ministry of Industry had the Council of Ministers adopt a project to promote cassava flour by incorporating it into bread-making wheat flour at a rate of 20% [8].

Another reason in favour of this approach is that most local flours are gluten-free, which is why they are used as a partial substitute for wheat flour in bread making, mainly to make it easier for people with gluten allergies to consume bread. Over the past twenty years, great hopes have been placed in the use of compound flours in baking in developing countries [9]. Indeed, partially substituting wheat flour with local cereals such as sorghum can be an attractive alternative to imported grains [10].

While the absence of gluten in local Congolese flours is a health benefit for people who are allergic to this protein, it poses a technological problem because gluten is essential for bread making. Sorghum flour, for example, cannot be used to make bread because, when hydrated and kneaded, its proteins do not have the property of forming a viscoelastic network, such as gluten, which allows the dough to rise by resisting the pressure of carbon dioxide during fermentation. However, it can be incorporated into wheat flour up to a level that does not alter the elasticity of the dough [11].

One way to overcome this difficulty is to maintain a high proportion of wheat flour by determining the proportion of other types of flour that can be added without compromising the quality of the expected product. In short, a product must be developed that is acceptable in nutritional, technological, sensory and economic terms. Several authors have worked on the development of compound flours in which part of the wheat flour has been replaced by local flours. Among these, we can mention the research by Ngalani and Crouzet [12] on the partial substitution of wheat by plantain flour; that of Balla et al. [10] in which part of the wheat flour was replaced by sorghum flour, and the incorporation of fermented cassava flour into wheat flour in bread preparation [13].

However, in the DRC, this prospect of partially replacing wheat flour raises a number of questions, the most relevant of which are:

1) What are the main types of flour that can be used to replace wheat in baking and pastry making?
2) Up to what percentage can wheat be replaced in baking/pastry making, especially for products that do not require leavening?
3) How do these alternative flours compare in terms of nutritional, technological and organoleptic properties and availability?

The aim of this study is to review the studies that have already been conducted on (1) food flours produced in the DRC that can replace, in part or in whole, wheat flour in bread-making and various pastry products; (2) the procedures for obtaining these flours; and (3) the resulting bakery and pastry products.

The main purpose of this research is to identify the potential of flours produced in the DRC to be used as a partial or total substitute for wheat flour in the preparation of bakery and pastry products. This will constitute added value for these flours.

Apart from the introduction and conclusion, this work is divided into ten (10) parts:

1. Methodological approach
2. Criteria for evaluating flours suitable for use in baking and pastry making
3. Criteria for assessing flour in baking and pastry making
4. Regulations on bread-making flour
5. List of local flours that can replace wheat in baking and pastry making
6. Methods for obtaining local flours

7. The nutritional properties of flours
8. Percentages of wheat flour substitution
9. Critical analysis of the use of local flours in bakery and pastry making
10. Future prospects

## II. Methodological Approach

This study was based on documentary research. To this end, scientific literature on the use of alternative flours to wheat flour in baking and pastry making around the world was consulted.

## III. Criteria For Evaluating Flours Suitable For Use In Baking And Pastry Making

Bakery and pastry products are made from various types of raw materials which, on the one hand, must meet certain criteria and, on the other hand, involve various preparation procedures and require certain conditions for their preservation. The taste and nutritional qualities of these foods are highly dependent on the three variables mentioned above and require them to be maintained at a certain level.

Thus, flour assessment criteria can be defined as measurable and/or observable parameters used to evaluate the quality, performance and suitability of flour for its intended use.

It is important to note that the criteria for selecting raw materials and other variables involved in baking and pastry making are as varied as the nature of the expected products.

Indeed, bakery and pastry products cover a very wide range, varying from one part of the world to another. In the DRC, the Ministry of Industry [14] (2020) categorises them as follows:

a) Bakery products: Plain bread, Wholemeal bread, Sandwich bread, English bread, Cyclist bread, Batare bread, Baguette, Round loaf, Large loaf;
b) Pastry products: Biscuits, Doughnuts, Cakes, Waffles/pancakes.

However, although the legal framework defines these products, in reality the list is much longer. This is not specific to the DRC but is found in all countries around the world. For example, other products can be found such as pizza and spaghetti (of Italian origin), tortillas (of Mexican origin), etc.

The preparation of bakery and pastry products primarily involves flour obtained by grinding cereal grains, mainly wheat. Flours from other cereals may also be used as a total or partial substitute for cereal flours. In addition, these products may also involve the use of non-cereal flours and other food additives during their preparation, as will be discussed further below.

Several criteria can be taken into account when assessing which flours are suitable for use in bakery and pastry products.

## IV. Criteria For Assessing Flour In Baking And Pastry Making

Various types of criteria can be used to assess flour:

~ Biochemical criteria;
~ Technological criteria;
~ Organoleptic criteria.

**Biochemical criteria**

Biochemical criteria are measurable parameters that enable the quality, composition or biological state of a foodstuff to be assessed on the basis of its natural chemical components. These criteria can be divided into two main groups.

First, there are the main biochemical components found in flour. Their nature and quantity determine the nutritional value of a given flour. Then there are measurable indicators that show the degree of degradation of a flour that can be used in baking or pastry making.

The main biochemical components that can be used to classify flours are:

a. Moisture

This is the percentage of water contained in the flour. This parameter has a major influence on its shelf life. If the moisture content of a flour is too high, it can cause various types of deterioration, such as the development of mould and mould toxins.

b. Lipids

This is the fat content in flour, expressed as a percentage. Lipids, or fatty substances, are one of the three major families of macronutrients (carbohydrates, lipids and proteins) in the living world. Mainly composed of carbon and hydrogen, they are insoluble in water but soluble in organic solvents. Their main role is to store energy.

c. Carbohydrates

Carbohydrates are the sugars or carbohydrates present in flour. They are essential macronutrients that provide energy to the body. There are simple sugars found in certain foods such as sugar cane (sucrose) or milk (lactose) and complex sugars found in grains (starch) or vegetables (cellulose). Starch is the most abundant carbohydrate found in most plant-based flours.

d. Proteins

Proteins are organic molecules that are essential for life. They are composed of small units called amino acids. The main protein found in wheat flour is gluten. Its content varies between 10.5 and 14% [15] (Dogo et al., 2019).

All bread flour must contain a sufficient amount of gluten because it is a compound that gives the dough its elasticity and ability to retain the gas produced during fermentation. In addition, gluten is the main determinant of the quality of baking flour.

Finally, it should be noted that wheat is not the only cereal that contains gluten. It is also found in others such as rye, spelt, barley, etc. [16] (Brabant et al., 2013).

In addition to the content of major macromolecules, two other criteria may be involved in the biochemical classification of flours used in baking and pastry making. These are the Hagberg falling number and the Zeleny falling number.

e. 'Falling Number (FN)'

Also known as the 'Hagberg falling number' or 'falling time'. This index measures the enzymatic activity of the flour obtained from the grains to be analysed, in particular that of amylase, an enzyme that breaks down starch into fermentable sugars.

This parameter indicates that the starch in the grain has already been broken down into directly metabolizable sugars. This may be a sign that the grains have germinated on the ear before harvesting or during storage. Such flour retains less water, produces a sticky dough (high viscosity) that is difficult to handle, and results in smaller, misshapen loaves [17] (Dabo et al., 2017).

A deterioration in the Hagberg falling number results from the triggering of alpha-amylase activity in the grains. This can be strictly due to water ingress from physiological maturity onwards. According to this criterion, i.e. the falling numbers of their flours, wheat grains can be classified into different categories:
a) Fall number of 120 to 150 seconds: flours with very high amylase activity. These flours cannot be used in baking; they come from wheat grains that have begun to germinate.

b) Fall number of 150 to 220 seconds: high amylase activity. Flours with these indices are acceptable for baking. However, they ferment quickly;

c) Falling time of 220 to 280 seconds: these flours have the amylase activity sought after in bread making and offer optimal fermentation;

d) Fall time greater than 330 seconds: flours with low amylase activity. These flours are not preferred in baking because they produce bread with a risk of dry crumb or low volume. However, it is possible to correct this defect by adding alpha-amylase enzymes or barley malt [17] (Dabo et al., 2017).

f. The Zeleny index:

This index determines the quantity and quality of wheat proteins that can be used in bread making. It is determined by the sedimentation test described in ISO 5529:2007 [18]. In summary, ground wheat is suspended in a graduated test tube with lactic acid and isopropanol. Bromothymol blue is added as a colour indicator. The mixture is shaken twice for five minutes. After resting for five minutes, the height of the deposit is measured. The proteins and gluten swell in the reagent. A minimum height of 22 ml is required for a sufficient quantity of protein for bread making.

**Technological criteria**

Technological criteria determine how flour behaves during bread making. These criteria include ash content, baking strength, tenacity and absorption rate.

a. Ash content:

Ash content represents the amount of minerals contained in the flour. The outer layers of the wheat grain (the bran) are richer in minerals than the kernel.

The ash content of flour is a criterion that reflects the level of wheat bran incorporated into the flour obtained after grinding the grains. The mineral richness of cereal flours is proportional to the amount of bran included at the time of milling.

The lower the ash content of a flour, the more 'pure' it is considered to be. Conversely, if the ash content is high, there is a lot of bran in the flour, and it is referred to as wholemeal flour [17] (Dabo et al., 2017).

This characteristic allows flours obtained by grinding wheat grains to be classified into different groups according to their ash content. These groups are named with the letter 'T', which stands for 'teneur' (content), followed by a number indicating the ash content.

Example: T45 wheat flour contains 0.45% mineral matter (dry weight). This categorisation gives a scale ranging from T45 flour (lower ash content) to T150 flour (higher ash content).

Depending on their ash content, wheat flours can be preferentially used for a given food application. For example, T45 flours are more suitable for pastries (ash content or TC varying between 0.45 and 0.5%), T55 flour for bread and pastries (TC 0.5 to 0.9%), and T110-150 for speciality breads (TC 1 to 1.4%) [17] (Dabo et al., 2017).

b. Baking strength (W):

Baking strength, denoted by W, reflects the viscoelastic capacity of dough that can be used in baking and/or pastry making. The device used to measure it is called a Chopin alveograph. Knowing this parameter is important because it determines the texture and volume of bread. The higher the gluten content of a flour, the more it is said to be 'strong' or 'high-gluten flour', meaning that the network formed by the gluten during bread-making will be able to resist deformation and bursting during rising.

In reality, Chopin's alveograph measures two other parameters involved in calculating baking strength. These are tenacity, denoted by P, and extensibility, denoted by L. An elastic dough is one that has the ability to return to its original shape after being stretched, while an extensible dough is one that resists tearing when stretched.

Baking strength is therefore obtained by the ratio between elasticity and extensibility [15] (Dogo et al., 2019): W=P/L. In the case of bread-making flour, it has a value between approximately 100 and 300 [15, 17] (Dabo et al., 2017; Dogo et al., 2019).

c. Consistency or tenacity:

The consistency or tenacity of cereal flour is the resistance to deformation of the dough obtained from this flour, or the firmness of the dough [17] (Dabo et al., 2017). This parameter is closely linked to the gluten content of the flour and has a huge impact on the quality of the final product in baking and pastry making.

In the case of wheat, based on this characteristic, there is durum wheat (Triticum durum) and common wheat (Triticum aestivum). The former has a high protein content of up to 12-15%, while the gluten content of the latter ranges from 10.5-14% [15] (Dogo et al., 2019). Dough made from durum wheat flour is more tenacious and less extensible, whereas that from soft wheat flour is more elastic and flexible, which promotes rising. As a result of this characteristic, durum wheat flour is mainly used to make foods that do not require the dough to rise, such as spaghetti and pizza, while soft wheat flour is mainly used in bread-making and in various pastry products (biscuits, cakes, etc.).

d. Water absorption rate:

This is the amount of water needed to hydrate the flour during kneading, measured by a farinograph. Bread flour must have a water absorption capacity of between 55% and 65% of its dry weight. This affects the consistency of the dough and, consequently, the texture of the bread. Flour with a higher water absorption capacity is preferred for bread production (improved dough handling properties, better quality bread in terms of taste and structure), while flour with a lower absorption rate is preferable for producing pastries and biscuits [19] (Parrenin et al., 2021).

**Organoleptic criteria**

These are sensory criteria, i.e. those that can be perceived by the senses. Flour that can be used for bread or pastry making must have the following organoleptic properties:

~ Colour: it must be uniform and white or cream-coloured;
~ Smell: it must be neutral or slightly cereal-like (no rancidity);
~ Fineness (grain size): this influences the texture of the dough and bread;
~ Taste: must be neutral and without bitterness.

## V. Regulations On Bread-Making Flour

Regulations are defined as the set of legal and regulatory measures governing a particular issue, subject or field [20] (www.larousse.fr). Regulations on bread-making flour include international texts or standards and local regulations developed and applicable by each country.

**International and general standards**

A standard is a rule that sets the conditions for carrying out an operation, executing an object or developing a product for which uniform use or interchangeability is desired [20] (www.larousse.fr). It is also the reference document that contains this rule.

There are several standards that may apply to flour. These include: the Codex Alimentarius, ISO (International Organisation for Standardisation) standards, European and American standards, etc.

a. The Codex Alimentarius

The Codex Alimentarius is a set of international food standards developed by the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO) [21] (FAO and WHO Codex Alimentarius, 2025…). It is the global benchmark for food standards for consumers, food producers, food processors and governments around the world. It provides guidelines on food safety and quality, including flour. Some Codex Alimentarius standards applicable to the production and processing of bread flour are listed below:

~ CODEX STAN 152-1985 [22]: CODEX Standard for Wheat Flour;
~ CXS 176-1989 [23]: Standard for edible cassava flour;
~ CODEX STAN 154-1985 [24]: Standards for wholemeal maize flour;
~ Etc.

b. ISO standards

The International Organisation for Standardisation (ISO) is an institution based in Geneva, Switzerland, which has more than 18,000 standards. It is composed of representatives from national standardisation organisations in 171 countries around the world. It provides the business world, governments and society as a whole with tools for harmonising or standardising practices in all areas covered by the Sustainable Development Goals (SDGs): technology, economy, society and the environment.

In terms of bread-making flour, a few relevant ISO standards are given below:

~ ISO 7970:2021 standard [25]: criteria for bread-making wheat flours, including protein content, baking strength and other physicochemical properties;
~ ISO 5530-1:2025 standard [26]: Soft wheat flours - Physical characteristics of dough, Part 1: Determination of water absorption and rheological characteristics using the farinograph.
~ ISO 5530-2:2025 standard [27]: Common wheat flours - Physical characteristics of dough, Part 2: Determination of rheological characteristics using the extensograph
~ ISO 5530-3:1988 [28]: Common wheat flour - Physical characteristics of dough. Part 3: Determination of water absorption and rheological characteristics using the valorigraph.
~ Etc.

There are other international standards such as European or American laws, etc. Regional standards such as those of COMESA for the DRC can also be used [29] (CNN, 2023).

**Congolese national regulations**

Each country may have its own specific standards. In the DRC, there are ministerial decrees and standards relating to bread-making wheat flour, issued by a number of national institutions responsible for standardisation.

a. Ministerial decrees

Most of the decrees relating to bread flour are drawn up by the DRC Ministry of Industry [14](2020). These include Decree No. CAB.MIN/IND/OJA/012/12/2020 of 3 December 2020 adopting Congolese National Standards in the agri-food sector, which lists the main types of bakery and pastry products recognised in the DRC.

b. National standards

In the DRC, standards for foodstuffs in general, and bread-making flour in particular, are issued by two institutions. The National Standardisation Committee (CNN), which is attached to the General Secretariat for Industry, and the Congolese Control Office (OCC), an institution belonging to the Ministry of Foreign Trade. The CNN [29] (2023) has published a directory of 1,252 Congolese national standards, which includes the rules applicable to bread-making flour used in the DRC.

## VI. List Of Local Flours That Can Replace Wheat In Baking And Pastry Making

Several foodstuffs produced in the DRC are now processed into flour, which is increasingly used in baking and pastry making.

Local products that can replace wheat

Cereals, legumes, tubers and fruits used in the preparation of local dishes can provide flours of good nutritional and technological quality. These flours are obtained after certain treatments and can partially replace wheat flour in the preparation of bakery and pastry products.

**Cereals**

Cereals are plants belonging to the Poaceae or Gramineae family. Since their domestication in the Neolithic period, cereals have been a rich source of nutrients for humans, taking up little space, easy to store and transport, and well suited to a wide variety of environments and climates [30] (Cruz et al., 2019). Cereals are plants cultivated for their starch-rich grains, which are used for human or animal consumption. They are a very important source of flour after their dried grains have been ground. Among the cereals consumed in our country are maize, rice, sorghum, millet, eleusine, etc.

a. Maize (*Zea mays*)

Maize is consumed in various forms in the DRC, such as foufou, porridge, pre-cooked porridge [1] (Tshite et al., 2015), popcorn, beer, and alcohol such as lotoko, which is produced from fermented cassava and maize purée [31] (Tabu et al., 2023).

Maize is used in baking and pastry making as a substitute for wheat flour in several preparations (bread, biscuits, cakes, etc.) [32] (Benlemmane et al., 2015).

c. Rice (*Oryza sativa*)

In Africa, the explosion in demand for rice among urban consumers is met by imports rather than domestic production. Imports of milled rice almost tripled between 2000 and 2012, reaching 13.8 million tonnes. West Africa alone accounts for some 20 per cent of rice sold internationally [33] (FAO, 2016). Rice flour is also used in baking to make cakes, doughnuts, bread, etc.

d. Sorghum (*Sorghum bicolor*)

Sorghum is the second most widely grown cereal in Africa after maize, accounting for 22% of total cereal acreage. It is generally consumed in the form of porridge, fufu and beer. It can also be used in baking and pastry making as a substitute for wheat flour in the preparation of bread, biscuits and other products [10, 34] (Balla et al. 1999).

e. Millet (*Panicum miliaceum*)

Millet is one of the cereals widely grown in the arid and semi-arid regions of Africa and Asia. It is one of the most promising crops for meeting the energy needs of the populations of these two continents in the context of climate change [35] (Prakash et al., 2023). Millet flour is also increasingly being incorporated into wheat flour in bread and pastry making [36] (Raffak, 2023).

f. Cowpea (*Eleusine coracana*)

Cowpea, scientific name *Eleusine coracana* (L.) Gaertn, is a cereal found in warm temperate regions (Africa, Asia, Oceania). It is a staple food in certain regions of Africa. It can be ground into flour and used to make bread [37] (Hoare and al, 2017).

**Legumes**

Legumes, or Fabaceae, are dicotyledonous plants that are often cultivated for their seeds (sometimes called pulses). They play an important role in human and animal nutrition due to their high nutritional value [30] (Cruz et al., 2019). Soybeans, peanuts, beans, lentils and various types of peas are legumes that are widely produced around the world.

a. Soybeans (Glycine max)

Soybeans originate from East Asia. They are widely consumed in Asia, usually in the form of fermented or unfermented foods. However, a large part of the production of this legume is now used in animal feed [30] (Cruz et al., 2019). It is also used in several preparations to combat malnutrition. In baking, it is already used in the preparation of bread, biscuits and other pastry products.

b. Beans (*Phaseolus vulgaris*)

Beans are relatively rich in plant-based protein. They are often eaten boiled or roasted, but they can also be ground into flour to enrich various rations. This flour can also be used in baking to enrich other flours that are lower in protein [38] (Alina et al., 2023).

c. Peanuts (*Arachis hypogaea*)

Native to Central America, peanuts are generally used for the production of edible oil [30] (Cruz et al., 2019). They are rich in vegetable protein and fibre.

Peanuts can be eaten roasted, boiled or as a paste; they can also be added to certain foods to enrich them with protein and fat. Peanut flour can also be used to make porridge or in baking as a substitute for wheat. In bakeries and pastry shops, peanut flour or paste is used to make bread, biscuits and doughnuts to enrich wheat flour [39, 40] (Orly and Conkerton, 1983; Seth and Kochhar, 2017).

**Tubers**

Tubers are underground organs found in certain plants that store nutrients such as starch, water, etc. Tubers are considered staple foods in many regions of Africa. Among the tubers consumed in the DRC are cassava, taro, yams, sweet potatoes, etc.

a. Cassava (*Manihot esculenta*)

Cassava is widely cultivated and consumed in the DRC, often in the form of boiled tubers, chikwange (fermented paste) or dried and ground tubers, which are used to make flour for various dishes such as foufou. Today, cassava is in high demand for use in bread making, as a partial or total replacement for imported wheat flour [9, 13] (Bokossa et al., 2022; Fofiri and Ludovic, 2023). In the DRC, cassava flour has been chosen for use in baking as a partial replacement for imported wheat flour.

b. Taro (*Colcasia esculenta*)

Taro is consumed in the form of boiled tubers, but its dried and ground flour can be used in baking. This flour is also recommended for diabetics. It is a tuber of great nutritional importance for human and animal consumption [41, 42] (Imar, 2011; Panyoo et al., 2014).

c. Yams (*Dioscorea spp*)

Yams are often eaten boiled. However, they can also be ground into flour that can be used to make soups [43] (Fakorede et al., 2021). Yam flour has been used as a substitute for wheat flour in bread making [44] (Bwebwe et al., 2023). The production of instant pounded yam flour involves six steps: washing, peeling, slicing, pre-cooking, drying, grinding and sieving [45] (Hounhonigan et al., 1998). In the Democratic Republic of Congo (DRC), yams have been known since ancient times as 'Mbala nguvu' in the province of Kongo Central, 'Maole' in Maniema, 'Tshimena' in Kasaï, "Mboma" in Equateur and 'Isongu' in Greater Bandundu.

d. Sweet potato (*Ipomoea batatas*)

Sweet potatoes are often eaten boiled or even raw; they can also be consumed in the form of flour obtained after drying and grinding the tubers. This flour can be used in baking as a substitute for wheat flour [46] (Ndangui, 2015).

**Fruit**

Due to their contribution to vitamin and fibre requirements in the human diet, fruit is increasingly being incorporated into bread and pastry making. The fruits generally used are plantains, strawberries, etc.

a. Plantain (Musa paradisiaca)

Bananas are widely consumed in Africa and are a staple food for many populations. Plantains in particular are used in pastries as a substitute for wheat flour [9, 12] (Ngalani and Cruset, 1995; Forfiri et al., 2023).

b. Strawberries (*Fragaria vesca*)

Strawberries are used in baking to improve the taste of the final product.

**Animal sources**

Animal sources in bread and pastry making consist of flours derived from animal products. Generally speaking, they are used to enrich bakery and pastry products. Certain local flours are relatively low in protein and can be enriched with a small amount of protein-rich animal-based flours. Among the animal species whose flours are incorporated into bread and pastry dough are fish, caterpillars, and

a. Fish

Among the fish species that have been used for protein enrichment of dough in bakery and pastry products are *Ethalosa fimbriata Bodwich*, *Selaroides lepotolepis*, etc. [47, 48] (Olapade et al., 2011; Bandara et al., 2019). In general, an intermediate stage of drying the fish must precede their transformation into powder.

b. Caterpillars

Caterpillars are the larvae of lepidoptera. Like fish, caterpillars can be dried and ground to obtain a flour that can be used to enrich the protein content of bakery and pastry products [49, 50] (Opondo et al., 2022; Ouma et al., 2022).

**Other sources**

In addition to the above sources, there have been attempts to enrich the nutritional or organoleptic qualities of flours intended for baking and pastry making.

a. Brewer's grains:

Brewery spent grain can be used in human food thanks to its nutritionally rich compounds, which include proteins, sugars and various phenolic compounds [51] (Johnson et al., 2021).

BSG has the potential to be used in value-added products by extracting its various nutritionally essential components such as proteins, sugar fractions and phenolic compounds [51] (Johnson et al., 2021). Several experiments have been conducted in which spent grain has been incorporated into bread flour to improve its organoleptic and nutritional properties [52, 53] (Amoriello et al., 2020; Baiano et al., 2023).

b. Blood

Blood is a potential source of protein that can be used to enrich bread and pastry products with protein. However, its use faces two types of obstacles: hygienic issues, as it is too easily infected, and religious issues, as several religions do not allow its use in food (Muslim, Jehovah's Witnesses, etc.) [54] (Jamilah et al., 2021).

## VII. Methods For Obtaining Local Flours

Local, traditional and/or artisanal methods for obtaining flours differ depending on the products and environments. Generally speaking, there are two main operations involved in obtaining any type of flour: drying and grinding.

For flours intended for baking, it is important to have a local flour of good technological quality in order to compete with wheat and provide a product that is acceptable to consumers. This is why it is necessary to monitor certain important parameters that will influence the assessment of the bakery and pastry products that these flours will produce. These parameters are colour, smell, consistency and taste.

It is in this context that the International Institute of Tropical Agriculture (IITA) has developed a technology for producing a type of flour known as 'Panifiable', which is in fact a high-quality cassava flour, abbreviated to HQCF (High Quality Cassava Flour). This flour is produced from fresh cassava that has been peeled, washed, grated, pressed, dried and sifted. The flour is not fermented; it is white and has no acidic taste.

When drying tubers, exposure time should not be too long to avoid the flour turning slightly blackish, which is generally due to the oxidation of the carbohydrates in the flour. Grinding should be carried out in such a way as to obtain a fine flour, if possible passing it through a sieve of known particle size. It is in this context that several studies have been carried out to modernise sorghum processing and thus obtain a better quality flour, depending on the purpose for which it is to be used.

It is therefore important, with regard to flour production, to develop a reference method based on the raw material used (cereals, tubers, legumes, etc.). This would provide reference processing methods, i.e. methods that could be used when necessary to obtain better quality flour. An illustration of the above is provided by similar work carried out on sorghum, which led to the development of a reference method for assessing the hardness of sorghum and thus determining its best use [55] (Fliedel et al., 1994).

**Transforming cereals into flour**

Traditionally, the production of flour from cereals begins with drying in the field. The ears of corn intended for flour production are harvested when they are dry. This may be followed by a second drying process in the sun. The next step is threshing, which involves removing the seeds from the ears. This can be done by beating, for example, to remove the sorghum seeds from their panicles. The seeds are then winnowed and sorted to separate them from other waste, and then ground.

For certain local preparations, malted flour may be required (in this case, the grains are moistened and germinated before being dried) or fermented flour (the seeds are fermented and then dried). To eliminate most of the microorganisms, the grains can be washed in water at room temperature, then dried in the sun or in a dryer at low temperatures so as not to affect the nutritional quality of the food.

**Transforming tubers into flour**

The first step in this transformation, after harvesting, is washing. This is followed by peeling, cutting or grating before drying and grinding. In some cases, cutting or grating must be done before drying. This produces

thin slices that dry quickly. In other cases, the tubers must be washed, soaked and fermented before drying to obtain fermented flour, such as fermented cassava flour [13, 42] (Bokossa et al., 2012; Panyoo et al., 2014). Lafu, for example, produced using endogenous and modern technologies, is a fine flour obtained from fermented cassava roots. It can be used as a substitute for wheat in the production of bread consumed in Benin [13] (Bokossa et al., 2012).

Sometimes the yield of useful product obtained after processing can be very modest. In a study conducted on the substitution of wheat flour with yam flour, it was found that the quantity of flour obtained (1.945 kg) represented only 24.3% of the quantity of raw yam tubers (8 kg) and 31.2% of the quantity of cleaned and peeled yam tubers (6.225 kg) [44] (Bwebwe et al., 2023).

**Processing fruit into flour**

The process of transforming fruit into flour begins with peeling, followed by washing, cutting and drying. The fruit must be blanched in order to preserve its derivatives, including flour [56] (Kante-Traore et al., 2023). In the work of Ngalani and Crouzet [12] (1995), plantain flour was obtained after blanching at 800°C for 2 to 3 minutes before being sliced and dried. Traditionally, drying is done in the sun at room temperature. There are locally manufactured dryers to facilitate drying.

Drying is a crucial step in obtaining good quality flour, especially flour that can be used in baking, as the drying temperature can have a negative effect on the product if it is too high, the moisture content has an impact on preservation, and the drying time can influence the colour of the flour, bearing in mind that the acceptability or rejection of the product may be linked to its colour. Today, with technological advances, it is possible to use modern dryers that allow the temperature and humidity to be adjusted. This is a significant improvement because when drying in the sun, if the period is poorly chosen, the colour of the flour may change and, in some cases, flour may even be lost due to rot if there is no sun.

## VIII. The Nutritional Properties Of Flours

The local flours used in bread-making and baking in the DRC do not contain gluten. This is an advantage for people who are allergic to this protein. However, this absence of gluten means that these flours cannot be used for bread-making, as it is gluten that gives dough its elasticity. This is why local flours are used as a partial substitute for wheat flour in bread making. Some have nutritional properties dominated by their high carbohydrate, protein, fibre or vitamin content, which is similar to or higher than that of wheat.

**Cereals**

From a nutritional point of view, whole grains of the main cereals are essentially carbohydrate foods with 60 to 75% digestible carbohydrates consisting mainly of starch, and containing a variable amount of dietary fibre ranging from 5 to 15%. Cereals are therefore energy-rich foods: 1,400 to 1,600 kJ/100 g. Their protein content remains modest, most often varying from 8 to 13%, with a lysine deficiency but rich in methionine and cysteine in certain cereals such as fonio. Lipids, which are mainly concentrated in the germ of the grains, are present in small quantities (2 to 4%) and are practically eliminated during husking [30] (Cruz et al., 2019).

For rice, the water and dry matter contents are 10.03% and 89.97% respectively. Its pH is 6.30 and its total acidity is 0.16% (equivalent to lactic acid). Its water and oil absorption capacities are 17.56% and 127.52% respectively. The hydrophilic/lipophilic ratio for this flour is 0.14. Its swelling power is 6.04 g/g of flour [57] (Razafimahefa et al., 2021).

**Tubers**

Taro (Colocasia esculenta): Thanks to its high carbohydrate content (60 to 90%), taro is an economical source of energy in producing countries. The protein content of taro is low, at 1.0-4.5% of dry matter, and it also has a very low lipid content (0.23-0.52% of dry matter) and mineral content (1-2% of dry matter) [41] (Imar, 2011). In a study on the substitution of wheat flour with cashew nut flour, an increase in protein content was observed, which could be attributed to the high protein content (28.03%) of cashew nut flour [15] (Dogo et al., 2019).

**Legumes**

From a nutritional point of view, most legumes are protein-rich starchy foods. They are rich in arginine, fairly rich in lysine but deficient in methionine and cysteine. They therefore complement cereals well, which are low in lysine but balanced in other amino acids. Legumes are also richer in various minerals such as potassium, calcium and iron than cereals and contain various trace elements such as copper and zinc, and they are a source of B vitamins. The presence of antinutritional factors (protease inhibitors and tannins) can affect their digestibility, but these are generally eliminated during cooking. Problems with bloating or flatulence can be avoided by using traditional methods such as soaking, sprouting or fermentation [30] (Cruz et al., 2019). Legume seeds, sometimes called pulses, contain between 20 and 25% protein, and as much as 35% in the case of soybeans [30] (Cruz et al., 2019).

## IX. Percentages Of Wheat Flour Substitution

The wheat grain consists of four distinct parts: the germ (3% of the total mass of the grain); the albumen or floury kernel or endosperm (84%); the husks (13%) and the bran (negligible mass).

Wheat flour contains gluten, which gives dough its elasticity and allows it to rise during fermentation. When making bread, for example, high elasticity is needed to produce light loaves. With local gluten-free products, up to 20 per cent of the wheat flour can be substituted without adding other additives and without altering the quality of the bread.

In the DRC, on Friday 15 April 2022, the government adopted a bill in the Council of Ministers aimed at promoting the use of cassava flour in bread and pastry making [8] (Ministry of Communication and Media DRC, 2022). In concrete terms, this initiative will now make it possible to mix up to 20% cassava flour with wheat flour in bread production and to make pizzas, cakes and waffles entirely from cassava flour [44] (Bwebwe et al., 2023).

Several studies have been conducted to determine the percentage of certain local flours that can be incorporated into pastries. The results differ depending on the type of flour used and the product being prepared. For example, a study was conducted on the partial substitution of wheat with fermented cassava flour, in which 20% fermented lafu cassava flour was used, with an overall acceptability rating of 75.70% [13] (Bokossa et al., 2012). Another study looked at incorporating yam flour into wheat flour, where 20% yam flour produced bread of appreciable quality [44] (Bwebwe et al., 2023).

Baking tests have shown that voandzou seed flour can be incorporated into wheat flour at a rate of up to 20% without any significant deterioration in the physical and organoleptic characteristics of the bread. In addition, the protein, lipid and ash content are also improved. Voandzou seed flour can be considered a good source of protein and other nutrients for fortifying baked goods, particularly bread [58] (Diallo et al., 2015). Sweet potato flour can be incorporated into a bread formulation at up to 25% without any significant deterioration in the organoleptic qualities of the bread [46] (Ndangui, 2015). There is also work on incorporating sorghum flour into wheat flour, where 30% sorghum flour could be incorporated without any noticeable deterioration in the characteristics of the bread [10] (Balla et al. 1999).

Good quality bread (texture, appearance, crumb cohesion) comparable to 100% wheat bread can be obtained with up to 10% barley and 20% maize for binary mixtures, and for ternary mixtures composed of up to 10% maize flour and 5% barley flour, producing good bread. Above these levels, the volume of the bread decreases and the qualities of the crumb (cell structure, cohesion) deteriorate [32] (Benlemmane et al., 2015).

Products that require significant rising, such as bread, have low incorporation percentages, while products that do not require significant rising, such as biscuits, have high incorporation percentages. In a study replacing wheat flour with sweet potato flour, it was found that 50% incorporation produced biscuits of good quality that were acceptable from an organoleptic point of view [59] (Vodouhe et al., 2017).

## X. Critical Analysis Of The Use Of Local Flours In Bakery And Pastry Making

With regard to the selection criteria and use of flours as a substitute for wheat in baking and pastry making, the question arises as to whether local Congolese flours meet certain criteria for use in baking and/or pastry making. The answer is both yes and no, depending on the parameters considered.

The answer is 'no' if the only criterion required for flours that can be used in baking is the presence of gluten. However, the presence of gluten is not a sine qua non condition, as these flours can be mixed with wheat flour in certain proportions. So, in reality, the answer is partially affirmative because these flours can partially substitute wheat flour in bakery and pastry products.

In fact, flours produced in subtropical countries in general, and in the DRC in particular, contain other qualities that are sought after in baking and pastry making. These are mainly nutritional value (rich in protein, lipids, trace elements, dietary fibre, etc.), organoleptic qualities (taste, flavour, colour, etc.) and local food identity (specific preferences). It is also an alternative for gluten-free diets.

From the above, the literature indicates that several types of flour produced in the DRC have already been used in baking and pastry making as a partial replacement for wheat flour, both locally and elsewhere. These include corn flour (Benlemmane et al., 2015), cassava flour (Bokossa et al., 2012), voandzou flour [58] (Diallo et al., 2015), yam flour [44] (Bwebwe et al., 2023), sorghum flour [10] (Balla et al. 1999), etc. Most of the above-mentioned studies confirm that local flours have nutritional and organoleptic properties that are appreciated by consumers to whom the products obtained have been offered.

With regard to the rate of replacement of wheat flour with selected local flours for bread making, the percentages range from 10 to 30% without affecting the nutritional and organoleptic quality of the product (DRC Ministry of Industry, etc.).

The advantages of using local flours as a partial substitute for wheat flour in baking and pastry making are:
- Local availability: local flours are made from local agricultural products that are easily grown in the area.
- Lower cost: these flours are less expensive in the area where they are produced. There are no transport costs for importing them.
- It should be noted here that in urban areas, some local flours can be more expensive than imported wheat flour. This is due to the lack of agricultural roads in good condition or the lack of good practices for processing raw products for preservation.
- The promotion of local flours in baking and pastry-making supports the local economy because it encourages local producers and promotes artisanal processing and job creation.
- Most local flours have very interesting nutritional values. Some are rich in starch, while others contain fibre, vitamins and minerals such as iron, calcium, zinc, etc. For example, orange-fleshed sweet potatoes are very rich in beta-carotene (vitamin A) compared to wheat flour.
- These flours are gluten-free, making them an alternative for people who are gluten intolerant.
- Thanks to these local flours, consumers can enjoy a variety of tastes, flavours and textures.

However, the main difficulties encountered when replacing wheat flour with local Congolese flours are:
- The availability of sufficient quantities of local flour: some local products are seasonal and therefore not available on the market all year round. The quantity of these local products is also insufficient. For example, sweet potatoes are grown for fresh consumption by families, and there is no risk of producing large quantities that can be processed and preserved as flour or crisps.
- The quality of blended flours, which must meet standards: lack of expertise in the proper techniques for processing our local products into flour. This is especially true for flour used in baking, which must be of good quality in order to compete with wheat flour by increasing the percentage of incorporation. See the fineness of the flour, the colour, and even improved technological qualities such as water absorption rate, etc.
- Acceptability of blended flours: Consumers of wheat-based bakery products, for example, already have a fixed idea of the taste and colour they expect in order to enjoy a product. Products made from local flours must therefore meet certain criteria in order to be accepted. They must have a colour, aroma, consistency and taste that does not differ from existing products.

The failure to use local flours may be due to major factors such as the quality of blended flours, which must meet certain standards, hostility from the traditional sector (mills and bakeries), uncertainty regarding the regular supply of local cereals (availability) and consumer eating habits (acceptability).

From the above, it goes without saying that it is therefore necessary for the DRC legislature to consider, in addition to cassava, local flours that are already producing good results in baking and pastry making. Promoting local Congolese flours in baking and pastry making will create a demand for these flours, depending on how popular they become. However, local production must be able to meet the resulting demand. This is why Congolese agricultural producers must be involved in any initiative to promote local flours and refine the processing of raw materials. Local bakers and pastry chefs must not be excluded, as their expertise can influence the marketability of products.

## XI. Future Prospects

The use of local flour alternatives to wheat in baking and pastry making remains an essential solution in Africa today, as wheat flour is almost entirely imported. It would therefore be necessary to set up large-scale production units for high-quality local flours that can replace wheat at a rate of incorporation that can exceed 50%. African countries should work on standards for the proper use of local flours and, if possible, market baker's flour in which local flour is already incorporated at a given percentage.

## XII. Conclusion

The use of local flours in baking and pastry making is one way of achieving a certain degree of food independence in our country. Although these flours do not contain gluten, they have very interesting nutritional potential and their use promotes our local flours, which are prone to deterioration due to a lack of good processing and storage methods. However, methods need to be put in place to obtain higher quality flours that can compete with wheat flour by increasing the substitution rate, which often does not exceed 20% in baking. The government must regulate the use of local flours by introducing laws that must be followed when using them as a substitute for wheat flour in baking and pastry making.

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