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Changes in nutrient content, phytate and soluble sugar production during cereal malting processing for hydrolytic enzymes development in infants' complementary foods

Sandrine E. Kouton[*1,3], Sènan Vodouhè[2], Waliou Amoussa Hounkpatin[3], Mohamed M. Soumanou[1]

[1]*Unité de Recherche en Génie Enzymatique et alimentaire/Ecole Polytechnique d'Abomey Calavi (EPAC), Université d'Abomey-Calavi (UAC), Cotonou, Bénin*

[2]*Ecole Nationale Supérieure des Biosciences et Biotechnologies Appliquées, Université Nationale des Sciences, Technologies, Ingénierie et Mathématiques (UNSTIM), Dassa, Bénin*

[3]*Département de Nutrition et Sciences Alimentaires, Faculté des Sciences Agronomiques (FSA), Université d'Abomey-Calavi (UAC), Cotonou, Bénin*

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Abstract

The traditional cereal malting process presents some biochemical modifications occurring in seeds. The malted red sorghum and maize were selected as a function of the ability of the malt flour to fluidify high energy density porridge. The red sorghum and maize seeds were malted in laboratory by traditional cereal malting process. Samples were collected after soaking, germination and drying step. Malting process increased protein (9.2 to 10.8 and 7.3 to 8.2 respectively for red sorghum and maize) and ash (3.5 to 4.2 and 1.3 to 1.7 respectively for red sorghum and maize) content while it decreased lipid contents (3.7 to 2.8 and 4.9 to 3.7 respectively for red sorghum and maize). A significant increasing was observed in sucrose, glucose and fructose contents (0.09 to 6.82 and 0.07 to 5.62 respectively for red sorghum and maize) during malting, in particular during the germination step. During malting, glucose and fructose production was higher than sucrose in red sorghum compared maize. The decrease in phytate content during malting was more obvious in red sorghum than in maize seeds. The germination induced a decreasing in phytate content of 77% in red sorghum and 41% in maize. Phytate' degradation was higher in red sorghum than in maize. The malted flour presented beneficial characteristics as increasing production of soluble sugar and nutrient contents for incorporation in infant flours to improve the energy and nutrient value of porridges and to confer a sweet taste.

* **Corresponding Author:** Sandrine E. Kouton ✉ sandrineskouton@gmail.com

Introduction

Despite an impressive array of nutrients in cereals-based foods have continued to be nutritional deficient and organoleptic inferior. This is largely due to the presence of anti-nutritional factors such as tannin, phytic acid and polyphenol which bind these food ingredients into complexes making them unavailable for human nutrition (Idris *et al.,* 2007). For instance, the presence of these anti-nutritional factors reduces the bioavailability of minerals and limits the digestibility of proteins and carbohydrates by inhibiting their respective proteolytic and amylolytic enzymes (Mohammed *et al.,* 2011). Several methods have been adopted to improve the nutritional and organoleptic qualities of cereal-based foods for infants. These include amino-acid fortification, supplementation or complementation with protein- rich sources and processing techniques which include malting, milling and fermentation (Mohammed *et al.,* 2011).

Malting of cereals is a traditional process used in many African countries for the manufacture of alcoholic drinks, juices, and malted drinks (Ogbonna *et al.,* 2012). Traditional malting of cereals consists of several stages: steeping, germination, maturation (during which the seeds are piled and protected from light) and sun drying. The germination and drying of cereal seeds are important process which to induce the development of hydrolytic enzymes in infants' complementary foods, that are not active in raw seeds (Ogbonna *et al.,* 2012; Kouton *et al.,* 2017). The main enzymes produced during germination that intervene in the hydrolysis of starch are α- and β-amylases (Vieira-Dalodé *et al.,* 2007). Many sources of amylase (animal, bacterial or plant α-amylase) can be used to simultaneously confer the suitable energy density, sweet taste and consistency to the porridge (Moursi *et al.,* 2003). The simplest solution seems to be the use of malted cereal flours, as this does not differ markedly from existing food habits and also benefits and economic from the technological know-how of the population (Kouton *et al.,* 2017).

In Benin, many other malted cereal products are consumed such as "gowé" and "tchakpalo" (Vieira-Dalodé *et al.,* 2007). "Gowé" is a traditional beverage made of malted and fermented sorghum flour. The substrate fermented for ''gowé" production is thus a malted flour, which gives to the final product a natural sweet taste and a soft texture appreciated. The malting of cereal seeds also has the advantage of reducing the phytate content (Traoré *et al.,* 2004; Kouton *et al.,* 2017), which should improve the bioavailability of some essential minerals (iron, calcium, zinc) in complementary food for the young children (Kouassi *et al.,* 2015). Another potential use of malted cereal flours is their incorporation in infant flours to allow the preparation of energy-rich porridge with a semiliquid consistency through the action of α-amylase. So, the malting improves the bioavailability of minerals, developing good specific flavours and sweet taste in complementary foods for the young children (Kouton *et al.,* 2017).

Nutritionally adequate complementary foods are high priority for young children feeding in developing countries (WHO, 2003). Researchers have recognized that it's important to increase the energy value and micro-nutrient of complementary food in order to prepare high energy porridge that could cover nutritional and energy needs for African young children (Suri *et al.,* 2014; Ponka *et al.,* 2016; Songré-Ouattara *et al.,* 2016). In Benin, complementary feeding practices are not optimal. Complementary foods introduced by the mothers are mostly simple maize porridge and/or whether or not fermented sorghum porridge obtained from recycled maize dough. Porridge is slightly enriched with protein materials and daily distribution frequency is low (Atègbo, 1993; Kouton *et al.,* 2017). These practices, which are the use of poor quality complementary foods and inappropriate conduct of complementary feeding practices, partly explain the prevalence of 32% of stunting observed in Benin preschool children (EDSB, 2017-2018). It is then necessary to propose to mothers, the high energy dense foods and adequately fluid consistency porridges which will cover infants 'needs. In this context, an enzymatic treatment which has ability to reduce the viscosity of highly concentrated porridges and give them a semi-fluid consistency could increase on the young children's energy intake (Kouton *et al.,* 2017).

This study is to characterise the effect of a modulated malting on the biochemical and nutrient modifications for producing good malted cereal flours intended for incorporation in infant food.

Materials and methods

Cereal seeds

The raw material is consisted of two cereals such as: maize (*Zea mays*) and red sorghum (*Sorghum bicolor*). The cereal was obtained from local market located in southern Benin.

Description of the malting process

Grains of cereals were taken at the step of production process of the malted cereal flours. The raw seeds (RS), soaked seeds (SS), germinated seeds (GS) and dried seeds (DS) were taken for different analysis. The grains of maize and red sorghum were malted as described by Traoré *et al*., (2004). After a steeping phase (24h), the seeds are germinated and spread out on cloth humidified for 72h. Malted seeds passed through a maturation step and are sun dried for 48h, sorted out, degermed, and crushed. After these step, malted maize and sorghum flours were obtained.

Biochemical analysis

Proximate composition

The samples were analysed for dry matter, crude protein, crude fat and ash content. Dry matter was determined by oven drying at 105°C to constant weight. Protein, fat, and ash contents of the samples were determined following AOAC (2017).

Soluble sugars

Soluble sugars were determined by a high phase liquid chromatography according to Vieira-Dalodé *et al.* (2007). The standard solution of glucose, fructose and sucrose were used. The results were expressed in g/100g of dry matter.

Phytate contents

Phytate contents were extracted in acid solution (HCl 0.5 M) and after determined according to the method described by Kouton *et al.,* (2017). The values are expressed in mg /100g of dry matter.

Statistical analysis

Means and standard deviation of factors examined were calculated. The effects of soaking, germination and drying periods on the nutritional and anti-nutritional factors of cereals were resolved by analysis of variance (ANOVA) in Statistica 7.1. Significance was accepted at $p \leq 0.05$.

Results and discussion

Biochemical changes at different steps of the malting process

Dry matter content

The characteristics of different sample at each stage in the malted cereal flours process were presented in Fig. 1. The results showed a considerable decrease in dry matter content at the end of steeping stage in red sorghum and maize seeds (30% and 31% respectively). In malted red sorghum and maize, we observed respectively a decrease of dry matter of 12% and 14% compared to soaked seeds. This shows that the decrease in dry matter content continues during germination as long as the seeds are periodically watered or washed so as to be maintained under the moist conditions. In dried seeds, the dry matter content significantly increases from 55 to 95% and 51 to 92% respectively in red sorghum and maize. Steeping is a very important stage in the malting process which the metabolic process starts in the seeds (Idris *et al.,* 2007). Adequate hydration of seeds is needed for the enzymatic modifications of the substrate in the endosperm during germination (Ogbonna *et al.,* 2012). Our results are comparable with those reported by some authors who carried out experimental tests of malting in laboratory conditions Ogbonna *et al.* (2012) also noted an increase in water content during germination of sorghum.

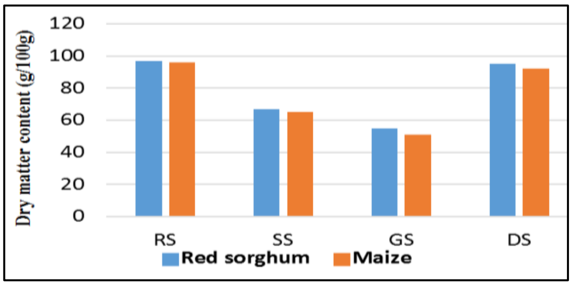

Fig. 1. Changes in dry matter during the preparation of malted cereal flours (RS: raw seeds; SS: soaked seeds; GS: germinated seeds; DS: dried seeds)

Nutrient contents

The changes in proximate composition and soluble sugar content during the malted processing were summarized in Table 1. The malting process slightly increased protein content in raw seeds to germinated seeds respectively 9.2±0.20 to 10.8±0.10% for red sorghum and 7.3±0.30 to 8.2±0.20% for maize. The increase protein content was higher in red sorghum. This is attributed to a passive variation due to a decrease in the carbohydrate compounds used for respiration (Traoré *et al.,* 2004). Kouassi *et al.* (2015) also observed an increasing of protein content of red sorghum and maize malted flours compared at raw seeds flours. This capacity of malted cereals has very important to increase a protein content of infant's complementary porridges. A highly significant ($p \leq 0.05$) decrease in fat was observed of raw to dried seeds. The result showed a decreased significantly ($p \leq 0.05$) by 3.7±0.12 to 2.8±0.12% and 4.9±0.02 to 3.7±0.21% respectively for germinated red sorghum and maize seeds. The modifications in fat content were significant and it observed by other authors. Ogbonna *et al.* (2012) were showed similar observations, who noticed that a decreasing of fat content of the malted samples. This decrease could be explained by the fact that lipids are used to produce the necessary energy for the biochemical and physiological modifications that occur in the seed during germination (Syed *et al.,* 2011).

The malting process considerably increased ash content in cereals. On the other hand, ash content increased in germinated red sorghum and maize (3.5±0.30 to 4.2±0.10g/100g and 1.3±0.11 to 1.7±0.20g/100g respectively), but during the drying of germinated seeds, there was an increase in ash content.

Table 1. Change of nutrient contents (g/100g) and variation observed during the preparation of malted flours.

	Raw seeds	Soaked seeds	Germinated seeds	Dried seeds
Proximate composition Protein				
Red sorghum	9.2±0.20	9.5±0.20	10.8±0.10	10.9±0.20
Maize	7.3±0.30	7.4±0.20	8.2±0.20	8.2±0.10
Lipid				
Red sorghum	3.7±0.12	3.7±0.13	2.4±0.15	2.8±0.12
Maize	4.9±0.02	4.8±0.10	3.8±0.05	3.7±0.21
Ash				
Red sorghum	3.5±0.30	3.6±0.2	3.8±0.2	4.2±0.10
Maize	1.3±0.11	1.3±0.11	1.6±0.18	1.7±0.20
Soluble sugars				
Sucrose	1.8±0.02	0.8±0.05	2.3±0.18	3.2±0.12
Red sorghum	1.32±0.01	0.5±0.03	3.36±0.22	3.45±0.15
Maize				
Glucose				
Red sorghum	0.15±0.02	0.13±0.03	4.6±0.30	5.2±0.25
Maize	0.11±0.01	0.09±0.02	3.7±0.20	3.2±0.10
Fructose				
Red sorghum	0.09±0.03	0.09±0.04	6.82±0.10	6.23±0.31
Maize	0.07±0.02	0.05±0.03	5.61±0.15	5.75±0.34

Phytate content

In the case of sorghum, the observed ash contents are comparable with those reported by Makokha *et al.* (2002). This may be due to the incorporation of mineral elements into cell constituents during the germination process. Thus, malting improved the content of both the major and trace mineral ions. This observation may be a result of proportional increment in the content of the minerals possibly as a result of enzyme solubilisation and leaching of the anti-nutritional factors binding them through leaching (Ogbonna *et al.,* 2012). Sucrose contents in raw red sorghum seeds (1.8g/100g) were higher than in raw maize seeds (1.32g/100g). During steeping, there was a decrease in sucrose content. So, the step of germination and drying led to a very significant increase in sucrose content.

The sucrose content of germinated red sorghum seeds (2.3g/100 g) was lower than in germinated maize seeds (3.36g/100g). Germination was the determining process in the production of glucose whose content respectively reached 4.6g/ 100g and 3.7g/ 100g in red sorghum and maize. The fructose contents of germinated red sorghum and maize were respectively 6.82g/100g and 5.61g/100g. Glucose and fructose contents increased considerably. The production of glucose and fructose during malting was higher than that of sucrose. Nirmala *et al* (2000) also observed a significant increase in glucose, fructose and sucrose contents during the germination of millet. This increase could be due to the action of an invertase that hydrolyses sucrose into glucose and fructose (Traoré *et al.,* 2004). The production of glucose and fructose during malting was higher than that of sucrose in red sorghum compared a maize. So, this might be due to presenting of the strongest α-amylase activity of red sorghum at the end of germination. The result showed that the red sorghum presented the highest α-amylase activity compared to maize. Thus, germinated red sorghum appears to be potentially more useful as a source of α-amylase for the formulation of infant flours than germinated maize.

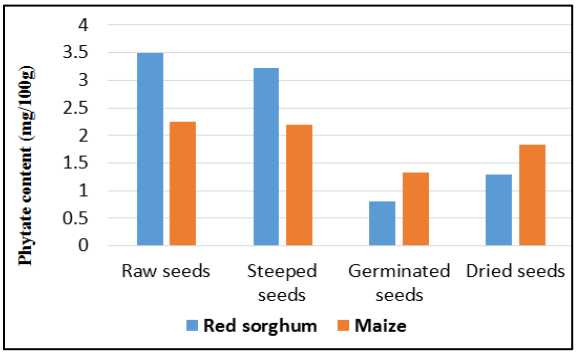

Fig. 2. Changes in phytate content during the cereal malted process**.**

Phytate content decreased significantly (p≤0.05) with the steeping and germination steps indicating the occurrence of some form of modification during the malting process (Fig. 2). The seeds of red sorghum had the highest phytate content (3.50 mg/100g) and maize (2.25 mg/100g). Steeping in the traditional malting process 24 h for seeds did not reduce phytate content. Similar results were showed by Ogbonna *et al.* (2012), who noticed that the leaching during steeping was suspected to have contributed in the reduction of some of the anti-nutritional factors considering a change in colour of the steep water. This contribution of steeping in phytate content could be due to the solubilisation of phytic acid salts (Makokha *et al.,* 2002) and its use as primary source of energy during germination step.

There was no diffusion of phytate during steeping or that the duration of steeping was not sufficient to involve in the diffusion of phytate into the steeping water. The germination had a high effect on the reduction in phytate content (Kouton *et al.,* 2017). Others such as phytate may have been significantly affected by the endogenous enzymes as phytases activated during germination. Phytases degrade phytate into inorganic phosphorus and inositol and its intermediate forms (Idris *et al.,* 2007).

The germination caused a decrease in phytate content of 77% in red sorghum and 41% in maize. The degradation of phytate was higher in red sorghum than in maize. The decrease in phytate content in red sorghum is high compared with that reported by Traoré *et al.* (2004). The capacity of the malting of cereal seeds has the advantage of reducing the phytate content (Kouassi *et al.,* 2015), which should improve the bioavailability of some essential minerals (iron, calcium, zinc) for complementary foods of the young children.

Conclusion

Traditional process of cereal malting in laboratory had a significant effect in the biochemical characteristics and phytate content. On the one hand, the malting of cereal induced a reduction in lipid contents and a considerable increase in protein, ash contents. It also induced a significant increase in sugar content such as fructose and glucose contents which confers the sweet taste to the malt flours. This ability of malt flours confers the sweet taste to infant's complementary food, which is the one of factor to improve the infant's nutrient intake. On the other hand, the malting of cereal was effective in reducing phytate content.

Malt flours of red sorghum and maize presented interesting characteristics that could be incorporated in infant flours produced in small production units or in the household to improve micro- nutrient content, energy and nutrient densities of porridges intended for infants and young children. So, it is important to optimize the traditional process of malting with a view to maximizing effectiveness for the production of amylase.

This study confirmed that malting as a processing technique can be used to effectively enhance the nutritional and organoleptic characteristics of infant's cereals based foods while reducing their anti-nutritional factors.

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References

AOAC. 2017. The Official Methods of Analysis of the Association of Official Analytical Chemists (20th ed.), Washington DC 3172 p.

Atègbo EA. 1993. Food and nutrition insecurity in northern Benin: impact on growth performance of children and on year to year nutritional status of adults, PhD Thesis Wageningen University, Netherlands p 1-150.

EDSB. 2018. Enquête Démographique et de Santé du Bénin : rapport de résultats clés-Bénin de la cinquième enquête p 212-218.

Idris WH, Abdel Rahaman SM, Elmaki HB, Babikar EE, Eltinay AH. 2007. Effect of malt pre-treatment on HCl extractability of calcium, phosphorus and iron of sorghum (*Sorghum bicolor*) cultivars. International Journal of Food Science and Technology **42,** 194-199.

Kouassi AKA, Agbo EA, Dago AG, Gbogouri AG, Brou DK, Dago G. 2015. Comparaison des caractéristiques nutritionnelles et rhéologiques des bouillies infantiles préparées par les techniques de germination et de fermentation. International Journal of Biological and Chemical Sciences **9(2),** 944-953.

Kouton SE, Amoussa Hounkpatin W, Ballogou VY, Lokonon, Soumanoumm JH. 2017. Caractérisation de l'alimentation des jeunes enfants âgés de 6 à 36 mois en milieu rural et urbain du Sud –Bénin. Journal of Applied Biosciences **110,** 10831-10840(a).

Kouton SE, Amoussa Hounkpatin W, Ballogou, Soumanoumm VY. 2017. Nutritional, microbiological and rheological characteristics of porridges prepared from infant flours based on germinated and fermented cereals fortified with soybean. International Journal of Current Microbiology and Applied Sciences **6(10),** 4838-4852 (b).

Makokha AO, Oniang'o RK, Njoroge SM, Kamar OK. 2002. Effect of traditional fermentation and malting on phytic acid and mineral availability from sorghum (*Sorghum bicolor*) and finger millet (*Eleusine coracana*) grain varieties grown in Kenya. Food and Nutrition Bulletin **23(3),** 241-245.

Mohammed NA, Mohammed IA, Barbiker EE. 2011. Nutritional evaluation of sorghum flour (*Sorghum bicolour* L. Moench) during processing of Injera. International Journal of Biological Life Sciences **7,** 1.

Moursi M, Mbemba M, Trèche S. 2003. Does the consumption of amylase-containing gruels impact on energy intake and growth of Congolese infants? Public Health Nutrition, **6(3),** 249-257.

Nirmala M, Subba Rao MVSST, Muralikrishna G. 2000. Carbohydrates and their degrading enzymes from native and malted finger millet (Ragi, *Eleusine coracana*, Indaf-15). Food Chemistry **69,** 175-180.

Ogbonna AC, Abuajah CI, Ide EO, Udofia US. 2012. Effect of malting conditions on the nutritional and anti-nutritional factors of sorghum grist. Food Technology **36(2),** 64-72.

Ponka R, Nankap ELT, Tambe ST, Fokou E. 2016. Composition nutritionnelle de quelques farines infantiles artisanales du Cameroun. International Journal of Innovation and Applied Studies 280-292.

Songré-Ouattara LT, Gorga K, Savadogo A, Bationo F, Diawara B. 2016. Evaluation de l'aptitude nutritionnelle des aliments utilisés dans l'alimentation complémentaire du jeune enfant au Burkina Faso. Journal de la société Ouest Africaine de Chimie **041,** 41- 50.

Suri DJ, Tano-Debrah K, Ghosh SA. 2014. Optimization of the nutrient content and protein quality of cereal–legume blends for use as complementary foods in Ghana. Food and Nutrition Bulletin **35,** 3.

Syed AS, Aurang Z, Tariq M, Nadia N, Muhammad S, Abdul A, Asim M. 2011. Effets de la germination sur la qualité nutritionnelle des variétés de haricot mungo. Revue Africaine de la Recherche Agricole **6(22),** 5091-5098.

Traoré C, Mouquet C, Icard-vreniere C, Traoré A, Trèche S. 2004. Change in nutrient composition, phytate and cyanide content and -amylase activity during cereal malting in small production unit in Ouagadougou (Burkina Faso). Food. Chemistry **88,** 105114.

Uvere PO, Adenuga OD, Mordi C. 2000. The effect of germination and kilning on the cyanogenic potential, amylase and alcohol levels of *Sorghum* malts used for burukutu production. Journal of the Science of Food and Agriculture **80,** 352-358.

Vieira-Dalodé G, Jerpersen L, Hounhouigan J, Moller PL, Nagocm, Jakobsen M. 2007. Lactic acid bacteria and yeasts associated with "gowé" production from sorghum in Benin. Journal of Applied Microbiology **103,** 342-349.

WHO. 2003. Alimentation complémentaire des jeunes enfants dans les pays en développement. OMS: Genève; 130131.