BREAD-MAKING WITH MALTED AND FERMENTED SORGHUM

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Malting and fermentation were applied to modify endogenously the sorghum grain components, with the aim of alleviating grittiness, dryness and crumb firmness normally associated with inclusion of sorghum flour in composite bread. Malt amylases were effectively inactivated by boiling, before drying at high temperatures. A fractionation and reconstitution process revealed that malting and boiling dextrinized and gelatinized starch, increased water-soluble pentosans and crude fiber. Dextrinization and gelatinization of starch decreased gelatinization temperature and the rate of starch retrogradation, thus decreasing crumb grittiness and firmness. The increase in crude fiber and water-soluble pentosans caused by the germinating grain root and shoot growth and the hydrolysis of non-starch polysaccharides, respectively, during malting, increased water-holding capacity and dough viscosity, thus decreasing dryness and the crumb-firming rate. Malting and boiling also decreased the total protein and the *in vitro* protein digestibility (IVPD) of sorghum flour and sorghum and wheat composite bread. Fermentation of sorghum flour, followed by drying at 60°C, decreased the pH of sorghum flour and slightly increased gelatinized starch and pasting viscosity. Apparently, the low pH of fermented sorghum flour caused higher loaf volume and softer crumb by suppressing the malt amylases and increasing starch water-holding capacity, hence increasing dough viscosity and gas-holding capacity. Fermentation and drying of sorghum flour also increased the total protein and the IVPD of sorghum and wheat composite bread. Sensory evaluation revealed that malt bread was most liked most, apparently due to a softer and more moist crumb and fine malt flavor, whereas the fermented sorghum bread was less liked due to a pronounced sour taste. Fermentation, particularly applied in a simple sourdough type process, appears to be the more effective technology to improve the bread-making quality of sorghum flour, as it is simple to apply and also improves the volume and the protein quality of sorghum-wheat composite bread

INTRODUCTION

Sorghum flour has the potential to be used in composite bread[1]. However, when sorghum flour is included in composite flour it gives a drier, grittier and a faster firming crumb. These adverse effects have been attributed to the higher starch gelatinization temperature and low water-holding capacity of sorghum flour[2,3].

The simple technologies of malting and fermentation are thought to modify the sorghum grain components. The present work was conducted on the assumption that these modifications brought about by malting and fermentation on the sorghum grain components (starch, pentosans and proteins) can decrease the starch gelatinization temperature and increase the water-holding capacity of sorghum flour, thereby improving the bread-making property of sorghum flour.

The starting point of this work was to produce bread of reasonable acceptable quality with 30% sorghum flour. The sorghum flour was whole sorghum grain flour, milled by simple technologies such as hammer and pin milling, instead of the highly refined sorghum flour that can only be obtained by roller milling

The specific objectives of this work were:

- To evaluate the possibilities of using malting and fermentation to improve the bread-making properties of sorghum flour
- To determine how the modified grain components improve the bread-making properties of sorghum flour.
- To determine the effects of malting and fermentation on the *in vitro* protein digestibility (IVPD) of sorghum flour and sorghum and wheat composite bread.

EXPERIMENTAL

A white, tannin-free sorghum with a good germinability, Local White flour was produced by hammer and pin milling. The particle size distribution of sorghum flour was >95% <212 μm and >5% <75 μm and that of the wheat flour was >98% <212 μm and >32% <75 μm. Thus, the sorghum flour was slightly coarser than the wheat flour, but still within the acceptable range for wheat flour.

The wheat flour was "Favorita", a commercial bread flour produced by Companhia Industrial da Matola, Maputo, Mozambique. The wheat flour had a protein content of 12.9% (N x 5.7) and ash of 1.9%, db, a water absorption of 63%, and mixogram mixing times of 3.0 and 2.8 min for peak time and stability to mixing, respectively.

Whole boiled sorghum malt flour was produced by malting the sorghum grain according to standard sorghum malting procedure, then by boiling the malt for 20 min, to inactivate malt amylases, and drying and milling (external roots and shoots included) sequentially with a hammer and a pin mill[4].

To determine whether the bread improving effect of boiled sorghum malt was due to modifications of the starch or of the non-starch polysaccharides of sorghum grain, whole boiled sorghum malt flour and the whole sorghum grain flour were fractionated and the reconstituted flours used in bread-making.

Fermented sorghum flour was produced by fermenting whole sorghum grain flour (a 5-day natural lactic acid fermentation), then drying the fermented sorghum flour at 60°C, and milling by hammer and pin milling. Blending the fermented sorghum flour, still wet, straight with the wheat flour, in a process similar to the wheat and rye sourdough bread-making[4], was found to improved further the sorghum composite bread-making quality.

Bread was produced by straight-dough process using the formulation: wheat flour (70%), sorghum flour (30%), water (63%), active dried yeast (1%), salt (2%), sugar (1%), ascorbic acid (20 ppm) and fat (1%), based on flour weight. The dough mixing time was 15 to 20 min, and the dough resting time was 15 min. The dough was divided into 950 g pieces, molded and proofed for 50 min, at 40°C and 95% RH and baked at 230°C for approximately 30 min.

Sensory evaluation test was conducted using the liking and the preference ranking test. The consumer panelists were all untrained and semi-illiterate women.

RESULTS AND DISCUSSION

Malting and boiling dextrinized and gelatinized the starch and decreased the pasting temperature of sorghum flour (Table I). Malting and boiling also increased the crude fibre and water-soluble pentosans, thus increasing the water-holding capacity of sorghum flour, preventing the grittiness, the dryness and decreasing the crumb firmness of breads. In addition, malting and boiling improved the crumb structure, the moisture content and the flavour of the sorghum and wheat composite bread. However, it decreased the bread volume (Figure 1), presumably due to boiling producing too much gelatinized starch. It did not improve the IVPD of breads due to boiling decreasing greatly the IVPD of sorghum flour (Table II).

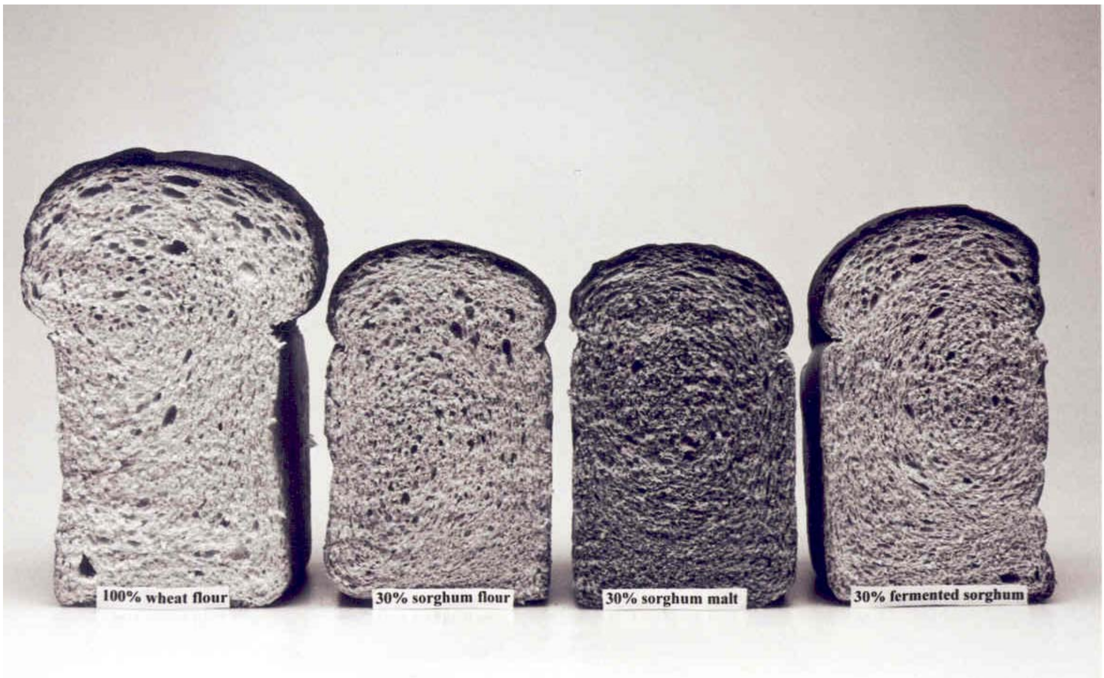

Figure 1 The volume, crumb structure and colour of sorghum and wheat composite breads

Bread ingredient	Pasting tempe-rature (°C)	pH	WAC[5] (cm^3/g)	Starch (%)	ESS[1] (%)	Crude fiber (%)	Total pentosans (%)	Water-soluble pentosans (%)	Protein (%)	IVPD[2] (%)
Sorghum grain flour	72a	6.2a[3]	1.1c	71.6a	1.6c	2.2b	5.5a	0.7b	12.3b	35.3b
Whole boiled sorghum malt flour	66b	nd	1.6[a]	68.6c	87.0a	3.6a	4.8b	1.0a	12.0c	24.0c
Fermented and dried sorghum grain flour	64c	3.4b	1.2b	69.5b	10.5b	nd	nd	nd	12.8a	52.7a

[1] ESS, enzyme susceptible starch, expressed as % of total starch

[2] IVPD, *in vitro* protein digestibility, expressed as % of total protein

[3] Values followed by the same letter in the same column are not significantly different (P >0.05).

[4] Soluble protein as a percentage of total protein

[5] WAC, water absorption capacity

TABLE I Effect of Malting and boiling and fermentation and drying on the properties of sorghum flour

Bread Ingredient	Total protein[1] (%)	IVPD[2] (%)
Wheat flour (100%)[1]	13.2a	74.8a
Sorghum grain flour (30%)[1]	12.5c[8]	64.0c[8]
Whole boiled sorghum malt flour	12.6	64.8
Fermented and dried sorghum grain flour (30%)[1]	12.9b	68.0b
Fermented sorghum grain flour (30%) (sourdough process)[1]	13.0b	nd

[1] Dry matter basis
[2] IVPD, *in vitro* protein digestibility, expressed as % of total protein [3] nd, not determined

TABLE II The protein content and the i*n vitro* protein digestibility of sorghum and wheat composite breads

Fermentation and drying decreased the pH of dough and gelatinized some of the starch, thus improving the gas-holding capacity of dough, increasing the bread volume (Figure 1) and preventing grittiness and dryness and decreasing crumb firmness (Figure 2). Fermentation and drying increased the IVPD of sorghum flour and composite bread (Table II). However, it did not decrease the gelatinization temperature of the sorghum starch and did not increase the water-holding capacity of sorghum flour much. Fermentation and drying also produced too much sourness in the flour and bread. The low pH of fermented sorghum flour it is thought to have caused higher bread volume and softer crumb by suppressing flour amylases and increasing water soluble-pentosans.

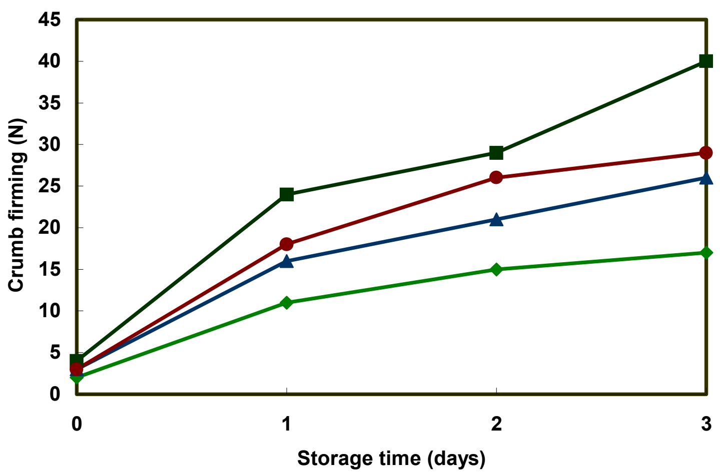

Figure 2. Crumb firmness of sorghum and wheat composite breads as a function of storage time. (◆) Wheat flour (100%), (▲) boiled sorghum malt flour (30%), (●) fermented and dried sorghum grain flour (30%), and (■) whole sorghum grain flour (30%).

Consumer panelists liked the sorghum malt bread best (Table III), because it was softer, had a more moist crumb and had a fine malt flavour. The fermented sorghum bread was less liked due a slightly firmer crumb and pronounced sour taste.

BREAD INGREDIENTS	**Panelists liking bread (n) (Total panelists 62)**	**Rank sum of the sample[2]**
Sorghum grain flour (30%)[1]	47	111a[3]
Fermented and dried sorghum grain flour (30%)[1]	38	136b
Whole boiled sorghum malt flour (30%)[1] (Hugo et al 2000)	53	86c

[1] Dry matter basis
[2] Rank sum of the sample = ∑(number of panelists x the respective rank position). Lower rank sum indicates the better liked sample.
[3] Values followed by the same letters in the same column are not significantly different ($P > 0.05$).

TABLE III Sensory evaluation of fermented and dried and non-fermented sorghum and wheat composite breads.

CONCLUSIONS AND RECOMMENDATIONS

Malting and boiling and the natural lactic acid fermentation of sorghum flour decreased grittiness, dryness and crumb firmness of sorghum and wheat composite bread.

The sourdough process increases further the bread volume and softness, and simplifies the bread-making process.

Pilot trials with the sourdough process should be carried out.

The possibilities of steaming the sorghum malt, instead of boiling, to decrease the amount of gelatinized starch, the loss of water-soluble pentosans and proteins should be investigated. These measures might increase the volume and the IVPD of malted sorghum breads.

Acknowledgement

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