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Effects of malting conditions on the properties of malt flour from some selected Cameroon maize varieties

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ABSTRACT
The effect of malting conditions on some biochemical and functional properties of malt flours of grains of four selected maize cultivars was studied in a 3x4x5 factorial design. The studied factors were: the hydration levels of the gains prior to germination (30%, 45%, 60%), the maize cultivars used (CMS 8501, CMS 8704, CHC 201 and hybrid 88094xM131xExp24) and the germination times (0, 1, 2, 3, 4 days). The micro-malting method was used to assess maize germination and resulting malt flours obtained evaluated for functional characteritics. Grain germination rate was significantly affected ($p<0.05$) by germination time and maize cultivar used. Activities of extracted amylase, total soluble sugars, solubility indices as well as least jellifying concentrate of malt flours increased with germination time for all cultivars. The maize cultivars used showed better aptitude to germinate at 30 and 45 % hydration levels. Thus, hydration levels between 30 and 45 % could be recommended for routine germination of maize for 72 hours, followed by drying and milling. For weaning food, malt flour pruduced under these conditions were of superior nutritional quality in terms of soluble sugar contents, solubility indices and least gellifying concentration compared to traditional wet starch independant of the maize variety used.

Key words: Malt, flour, maize, amylase, properties.

RÉSUMÉ
L'effet des conditions du maltage sur les propriétés fonctionnelles des farines de 4 cultivars de maïs a été étudié suivant un dispositif factoriel de 3x4x5. Les potentiels facteurs influents étaient : le niveau d'hydratation des graines (30, 45 et 60%), les cultivars de maïs utilisés (CMS 8501, CMS 8704, CHC 201 et un hybride 88094xM131xExp24) et le temps de germination (0, 1, 2, 3 et 4 jours). Apres la définition du temps de trempage, la germination était conduite par la méthode de micro maltage, suivie du séchage et de la mouture des graines germées. Les farines obtenues ont été évaluées pour leurs propriétés fonctionnelles. L'activité des amylases induites par la germination, l'indice de solubilité et la plus petite quantité gélifiante des farines maltées obtenues augmentent avec le temps de germination pour tous les cultivars. Les graines des différents cultivars de maïs utilisés ont montré une meilleure aptitude à la germination à des taux d'hydratation de 30 à 45 %. Les conditions de production des farines maltées pourraient être un trempage pour atteindre des niveaux d'humidité de 30 à 45% sur 4 à 12 heures, suivi de la germination pendant 72 heures, du séchage et de la mouture. Les farines pour les aliments de sevrage produites dans ces conditions sont de qualité supérieure pour les taux de sucres solubles, l'indice de solubilité et la plus petite quantité gélifiante comparées à celles obtenues après 3 jours de trempage sans germination pour les variétés de maïs étudiés.

Mots clés : farine, maïs, malte, amylase, propriétés

INTRODUCTION

Traditional weaning foods from cereals are characterized by their low micro and macro-nutrient contents due to the quality of grain used and the processing techniques [1]. The inability of most infant foods to satisfy their nutrient requirements is one of the major causes of malnutrition in areas where cereals are used as staple foods [2]. Cereal gruels, the common dietary bulk used is highly diluted to obtain the required viscosity for suitable infant feeding [3]. This lowers its energy level, nutrient density as well as its capacity to satisfy nutrient requirements [4]. Starch premix for cereal gruels are produced by soaking maize grains for 12 hours, drying for 2 to 3 hours followed by milling or alternatively soaking for 3 days, wet milled and wet starch extracted. These processes leading respectively to low activation of grain enzymes particularly amylases and excess leaching of protein and minerals need to be improved upon. A viable alternative to enhance the bio availability of nutrients in cereal gruels is through its production from malt flour [5]. The use of germinated grains can be considered since amylases produced during germination have the capacity to hydrolyse starch leading to more digestible gruels [6]. Germination is known to increase the bio availability of nutrients with a reduction of anti nutritional and flatus producing factors [7, 8]. However, the extinct to which germination affects the functional and biochemical properties of malt flours vary with the types of cereal used as well as the malting conditions [9, 10]. With sorghum different cultivars have demonstrated various ability to produced amylase suggesting that varietals effect should equally be considered. Over 20 maize cultivars developed by the Institute of Agricultural Research for Development (IRAD) [11] were released to farmers making corn gruels a potential stample food for infant feed in Central Africa. Malting conditions necessary to develop amylase-rich flours from the released maize cultivars has not been established. The adoption of these varieties will be guided by the aptitude of their grains to satisfy the needs of end users including agro businesses and producers of malt flour. This work was carried out to evaluate malt flour production potential of grains of four selected maize cultivars developed by agricultural research.

MATERIALS AND METHOD

Grain samples from 4 leading maize cultivars already released to farmers by the maize breeding programme of IRAD were used. Their choice was guided by their specificities and suitability to various agro–ecological zones. They were : Cameroon Maize Selection (CMS) 8501, a lowland high yielding cultivar; Cameroon Highland Composite (CHC 201) or *Kassai* high, a high yielding and cold tolerant cultivar; *88094xM131xExp24* a hybrid for intensive production all of white colour and CMS 8704 a drought tolerant cultivar of yellow colour.

Hydration levels for germination

For the determination of the required hydration levels for higher germination, grain samples were put in a beaker and enough distilled water (20% w/v) at 30°C added to ensure their complete immersion. Hydration runs were carried out in triplicate to constant moisture content and data collected were used to construct hydration curves [12] from which the theoritical time required to reach hydration levels of 30, 45 and 60% (maximum water uptake) was calculated. These times were later used to soak the grains to reach the required hydration levels prior to germination trials [13].

Malt flour production

For malt production, the micro-malting method was used in a 3 x 4 x 5 factorial disign. Factor 1 was the hydration levels with 3 modalities (30%, 45% and 60%), factor 2 the maize cultivars (CMS 8501, CMS 8704, CHC 201 and hybrid 88094xM131xExp24) and factor 3 the germination time with 5 modalities chosen to simulate pregerminaion conditions and those of wet extraction of maize starch practiced by village women (0, 1, 2, 3 and 4 days). Grain samples were sterilized in water: ethanol solution (30:70 v/v), and soaked in distilled water (1:5 w/v, 30°C) for the time calculated to reach the required hydration level (HL). From each maize lot, 1000 grains were placed in plates lined with absorbent paper and the rest on sterile jute bags and allowed to germinate in the dark at a fixed temperature of 30°C and enough water sprinkled to moist the grains twice a day. Germination was monitored daily by visual observations of the apparition of rootlets throughout the experiment. At the end of each germination period, samples were dried at 50°C for 48h and rootlets removed. They were later ground followed by shifting thought 500 micron mesh sieve to obtain malt flours which were stored in sealed plastic bags till used.

Analyses

The 1000 grains weight was determined for the each cultivar. For proximate analyses, the AOAC methods [14] were used: moisture content by drying at 105 °C, proteins by Kjeldhal, lipids by Soxhlet ether extraction, ash content by burning at 550°C. Total carbohydrates were obtained by calculation [15]. Water soluble sugars and proteins were extracted [16] from malt suspension in distilled water (1:50 w/v) and centrifuged at 5600 rpm for 30 minutes. Sugar content and activity of amylase extracted from malt flours were determined by the colorimetric method with DNS (3,5 dinitro salicylic acid) [17]. The least jellifying concentration (LJC) was determined from various malt suspensions (2 to 60% w/v) as suggested by Coffmann and Garcia [18] and solubility index by centrifugation followed by extraction of soluble substances [19]. The SPSS statistical package was used for statistical analysis and mean separation was done with the Duncan multiple range method [20].

RESULTS

Characterization of maize grains

The characteristics of the grains used are presented in Table 1. There were some significant differences ($p<0.05$) in their chemical composition. However, the contents of major constituents of maize fell within reported limits (5 to 9% for protein, 3 to 5% for fat and 84 to 88% for carbohydrate) for grains of maize cultivars already released to farmers [21]. Despite some variability observed in their chemical composition, the grains of all maize cultivars used showed similar pattern of water sorption (Figure 1). A rapid increase in grain moisture content was observed in the first 5 hours, with the total amount of water absorbed converging towards a maximum water uptake (MW) which stood at 60% moisture content. The calculated times required for the grains to reach respectively 30% and 45% HL were 4 to 4.5 and 12 to 14 hours. Beyond hydration levels of 45 %, water absorption was slowed and the time needed to reach complete saturation increased exponentially to reach 96 to 100 hours. This could be explained by water saturation of the grains that occurred around 60% hydration and thus reduced water uptake. Analysis of the entire data showed that the hydration process fitted a linear model (R^2 =0.99). On sorghum, similar hydration pattern was reported [22, 23].

Table 1 : Physico-chemical and composition of maize grains (% w/w)

	Grain properties*					
Maize cultivars	Weight**	Moisture	Proteins	Lipids	Ash	Carbohydrate
CMS 8501	197.2±3.2^a	10.6±0.6^b	6.03±0.2^b	4.3±0.0^a	1.3±0.0^b	77.8±1.4^b
CMS 8704	268.5±3.1^d	11.0±0.3^b	5.77±0.1^a	5.0±0.0^b	1.1±0.0^a	77.1±1.9^b
CHC 201	262.5±1.1^c	11.0±0.0^b	8.35±0.3^c	4.4±0.0^a	1.3±0.1^b	74.9±1.5^a
88094xM131xExp24	212.2±6.6^b	11.1±0.1^b	8.79±0.2^d	4.8±0.0^b	1.1±0.1^b	74.2±1.5^a

* Means with the same letters in the same column are not significantly different at 5%
** 1000 grain weight in g.

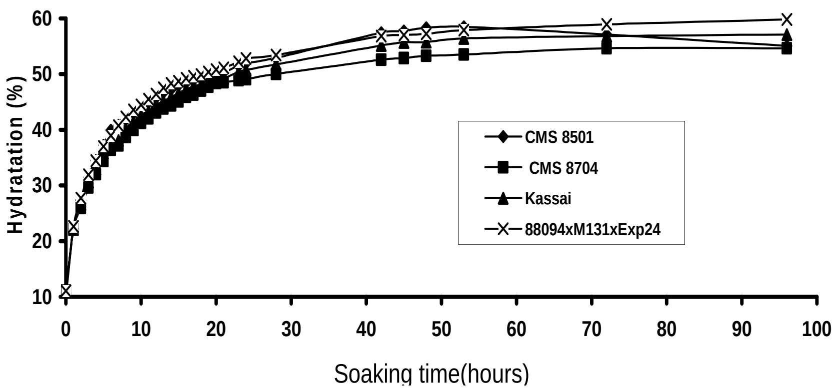

Figure 1: Hydration curves of maize grains as affected by soaking time and maize cultivars at 30^{0}C

Production factors

Among the factors considered for its production, maize variety and germination time affected significantly (P<0.05) the properties of resulting malt flours (Table 3). The grains of the maize cultivars used demonstrated different abilities to produce malt flours of various characteristics as expressed by extracted amylase activity, soluble sugar contents, solubility indices, and the least gellifying concentrations. The various modalities of hydration proposed had similar effects of malt flours suggesting that increasing hydration time of maize grains to reach higher hydration rates had no beneficiary effect on malt flours. Production should be done at the lower possible hydration levels that can allow germination. This has as advantage the possibility of a considerable reduction in hydration time without affecting grain germination.

Germination rates (GR) were significantly affected (p<0.05) by germination times and the maize varieties used (Table 4). Germination rates increased with germination time to reach its maximum after 3 days respectively at 30% HL for CMS 8501, *CHC 201* and hybrid 88094xM131xExp24. CMS 8704 needed more moisture to favour germination and its peak was observed with 45% HL. Prolonging incubation of soaked grains beyond day 3 did not increase germination rates which were much lower compared to other treatments irrespectively of the maize cultivars used.

Table 2: Hydration parameters of maize grains as affected by soaking time and maize cultivars

Maize cultivars		Time to reach % hydration* and kinetic contants								
		$T_{50\%}$(h)	$T_{75\%}$ (h)	$T_{90\%}$(h)	$T_{100\%}$(h)	Mw (%)	Rw (%/h)	k_1	k_2	R^2
CMS 8501	Cal.	4.0±0.5[a]	12.5±1.5[a]	36.0±4.5[a]	65.6±11.0[a]	59.6±1.6[bc]				
	Exp.	3.4±0.2[a]	10.2±0.6[ab]	30.5±1.8[a]	nd	58.5±0.9[b]	14.1±3.8[b]	0.071	0.021	0.994
CMS 8704	Cal.	4.3 ±0.3[bc]	13.5±2.6[ab]	39.0±2.6[abc]	80.0±13.8[b]	54.8±1.4[a]				
	Exp.	3.7 ±0.1[ab]	11.0±0.2[ab]	33.0±0.7[ab]	nd	54.3±0.3[a]	11.8±3.9[a]	0.085	0.023	0.990
CHC 201 or KASSAÏ	Cal.	4.2±0.3[ab]	14.1±1.0[b]	37.5±2.6[ab]	96.0±0.0[c]	57.1±1.5[b]				
	Exp.	3.8±0.4[b]	11.5±1.2[b]	34.6±3.6[abc]	nd	56.7±2.4[ab]	11.9±4.2[a]	0.084	0.022	0.992
88094xM131xExp24	Cal.	4.5±0.0[ab]	13.3±0.6[ab]	40.5±0.0[c]	96.0±0.0[c]	59.8±0.8[c]				
	Exp.	3.8±0.0[ab]	11.4±0.1[ab]	34.1±0.2[c]	nd	58.8±6.6[b]	12.6±4.2[a]	0.079	0.021	0.996

* Means (calculated or experimental) with different letters within a column are significantly different at 5% level

$T_{50\%}$, $T_{75\%}$, $T_{90\%}$, $T_{100\%}$: Times to reach 50, 75, 90 and 100% of the total water absorbed by maize grain; Mw : Maximum water absorption (%) by maize grain; Rw : Rate of water absorption (%/h) by maize grain; k_1, k_2 : water absorption kinetic constants; Cal. : Calculated value; Exp.: Experimental value ; nd: not determined

Table 3: Analysis of variance of malt flour production factors

Parameters measured	Factors of malt flour production (Sources)	DF	Type III SS	Mean Square	F Value	Pr > F
Grain germination rates	Hydration rate	2	957.62924	478.81462	2.10	0.1333
	Germination time	4	40959.08982	10239.77246	44.85	<.0001
	Cultivar type	3	2560.99586	1280.49793	5.61	0.0063
Activity of malt extracted Amylase	Hydration rate	2	0.00405333	0.00202667	3.70	0.0318
	Germination time	4	0.26175667	0.06543917	119.34	<0.0001
	Cultivar type	3	0.01704667	0.00568222	10.36	<0.0001
Soluble sugar contents of malt flours	Hydration rate	2	13.5127633	6.7563817	1.10	0.3415
	Germination time	4	962.8622233	240.7155558	39.12	<0.0001
	Cultivar type	3	0.01704667	0.00568222	10.36	<0.0001
Solubility indices of malt flours	Hydration rate	2	16.7550100	8.3775050	4.77	0.0127
	Germination time	4	386.4033100	96.6008275	54.99	<0.0001
	Cultivar type	3	88.8453117	29.6151039	16.86	<0.0001
Least gellifying concentrate of malt flours	Hydration rate	2	25.175070	12.587535	0.71	0.4987
	Germination time	4	9182.324040	2295.581010	128.66	<0.0001
	Cultivar type	3	556.190133	185.396711	10.39	<0.0001

Table 4: Germination rates of soaked maize grains at various hydration levels (numbers of germinated grains per 100)

Hydration levels (%)	Germination time (hours)	Maize cultivars			
		CMS 8501	CMS 8704	*CHC 201*	88ME
30	12	0,00[a]	0,00[a]	0,00[a]	0,00[a]
	24	50,33[b]	11,00[c]	56,33[c]	58,00[c]
	48	89,67[cd]	29,33[d]	92,67[g]	92,00[f]
	72	91,33[d]	30,67[d]	94,00[g]	93,00[f]
	96	91,33[d]	31,00[d]	94,00[g]	93,00[f]
45	12	9,00[a]	2,67[ab]	10,33[b]	15,33[b]
	24	76,67[c]	56,00[f]	59,00[cd]	54,00[c]
	48	88,33[cd]	80,00[g]	78,67[f]	74,33[de]
	72	89,67[cd]	82,00[g]	82,00[f]	77,33[de]
	96	89,67[cd]	82,00[g]	82,00[f]	77,33[de]
60	12	10,67[a]	8,00[bc]	19,00[b]	22,67[b]
	24	50,33[b]	40,67[c]	66,67[de]	68,67[d]
	48	55,67[b]	57,33[f]	74,33[ef]	77,33[de]
	72	56,00[b]	59,00[f]	77,00[f]	79,67[e]
	96	56,67[b]	59,00[f]	77,67[f]	79,67[e]

Means with different letters within a column are significantly different at 5 %
88ME= 88094xM131xExp24

Characterization of maize malts

Activity of extracted amylase of malt flours increased with germination time to reach its maximum after 3 days for all hydration levels and maize cultivars followed by a decline on the fourth day of germination (Table 5). The control flours obtained before germination both at 30 and 60 % hydration had significantly ($P<0.05$) lower levels of amylase activity for all maize varieties. Allowing the grains to germinate after hydration contributed to drastic increases in amylase activity of corresponding malt flours.

The soluble sugars (SS) contents and solubility indices of malt flours are presented on Table 6 and 7. At 30 % HL malt flours from cultivar CHC 201 had higher levels of SS while at 45 % HL, it was CMS 8704 which showed higher values of SS for similar germination periods. Both SS contents and solubility indices followed an increasing trend with increases in germination time from day one to day 4. Malt flour from maize cultivars of CMS 8501consistently showed the least SS contents and solubility indices independently of the hydration levels.

The least gellifying concentration (LJC) is an index of jelly tendency of flour which is very important with respect to weaning food. High values of LJC are desirable for weaning foods as it allow for more solids in the gruels. The maximum LJC values were obtained after four days with 30%HL with malts of *88094xM131xExp24* and CHC 201 (Table 8). Germination lead to increases of 3 to 4 folds in the amounts of LJC between day 1 to day 4. High values of LJC obtained suggested that more than trice as much malt flour will be needed to form a gel similar to that of raw ungerminated maize. As a consequence, gruels from these high LJC malt flour will contain enough nutrients and will be more suitable to meet dietary requirements.

Table 5: Activities of amylases extracted from malt flours obtained from soaked maize grains at various hydration levels (mg of glucose liberated/ g of malt per minute)

Hydration levels (%)	Germination time (days)	Maize cultivars			
		CMS 8501	CMS 8704	CHC 201	88ME
30	0	$0,06^{a}$	$0,08^{a}$	$0,09^{b}$	$0,09^{b}$
	1	$0,06^{a}$	$0,17^{c}$	$0,16^{c}$	$0,16^{d}$
	2	$0,22^{f}$	$0,23^{e}$	$0,21^{e}$	$0,26^{ij}$
	3	$0,26^{k}$	$0,27^{g}$	$0,26^{g}$	$0,28^{m}$
	4	$0,23^{ghi}$	$0,26^{f}$	$0,16^{c}$	$0,23^{g}$
45	0	$0,07^{ab}$	$0,09^{a}$	$0,10^{b}$	$0,12^{a}$
	1	$0,13^{d}$	$0,19^{d}$	$0,19^{d}$	$0,22^{f}$
	2	$0,22^{fg}$	$0,27^{g}$	$0,25^{g}$	$0,28^{l}$
	3	$0,25^{ij}$	$0,27^{g}$	$0,27^{h}$	$0,28^{kl}$
	4	$0,24^{hi}$	$0,20^{d}$	$0,23^{f}$	$0,27^{ij}$
60	0	$0,09^{bc}$	$0,08^{a}$	$0,07^{a}$	$0,10^{c}$
	1	$0,10^{c}$	$0,14^{b}$	$0,20^{d}$	$0,19^{e}$
	2	$0,18^{e}$	$0,25^{f}$	$0,25^{g}$	$0,26^{h}$
	3	$0,24^{hij}$	$0,25^{f}$	$0,29^{j}$	$0,28^{l}$
	4	$0,23^{gh}$	$0,24^{h}$	$0,27^{i}$	$0,27^{jk}$

Means with different letters within a column are significantly different at 5 %
88ME= 88094xM131xExp24

Table 6: Soluble sugar contents of malt flours from soaked maize grains at various hydration levels (g of sugar/100g of malt)

Hydration levels (%)	Germination time (days)	Maize cultivars			
		CMS 8501	CMS 8704	CHC 201	88ME
30	0	$1,87^{a}$	$2,95^{a}$	$3,34^{b}$	$1,73^{a}$
	1	$2,05^{a}$	$4,09^{b}$	$4,68^{c}$	$3,45^{b}$
	2	$4,78^{c}$	$5,13^{c}$	$6,80^{d}$	$6,16^{f}$
	3	$6,44^{d}$	$10,86^{h}$	$8,47^{f}$	$8,39^{g}$
	4	$7,21^{e}$	$15,98^{i}$	$25,23^{j}$	$17,77^{l}$
45	0	$1,91^{a}$	$3,20^{a}$	$2,55^{a}$	$2,98^{b}$
	1	$3,93^{b}$	$4,01^{b}$	$3,22^{b}$	$4,96^{d}$
	2	$4,91^{c}$	$8,05^{e}$	$8,46^{f}$	$9,25^{h}$
	3	$7,26^{e}$	$10,14^{g}$	$10,71^{g}$	$10,73^{i}$
	4	$10,94^{h}$	$21,34^{j}$	$13,22^{i}$	$12,48^{k}$
60	0	$4,01^{b}$	$3,37^{a}$	$2,97^{ab}$	$2,12^{a}$
	1	$4,28^{b}$	$4,36^{b}$	$2,95^{ab}$	$4,07^{c}$
	2	$8,82^{f}$	$6,82^{d}$	$4,99^{c}$	$5,58^{e}$
	3	$8,94^{f}$	$9,33^{f}$	$7,45^{e}$	$7,92^{g}$
	4	$9,74^{g}$	$10,30^{gh}$	$11,75^{h}$	$11,81^{j}$

Means with different letters within a column are significantly different at 5 %
88ME= 88094xM131xExp24

DISCUSSION

The production of amylase-rich flour from maize is feasible through controlled hydration and subsequent germination for 3 days. Malt flours obtained with higher levels of soluble sugar contents, solubility indices, and the least gellifying concentrations were more suitable for weaning food than premix prepared by conventional methods without any germination. The various maize cultivars used demonstrated different capacity to produce amylase, soluble substances and jellifying attribute of malt at various stages of germination. The differences in their chemical composition may explain these observations. The overall effect of increases in amylase activity, SS and SI was translated by considerable improvements in the nutritional properties of malt flours particularly the LJC. Similar results were earlier obtained on sorghum. The increase in LJC is attributed to excessive starch break down due to increases in amylases produced during germination [24-26]. The actions of endogenous enzymes produced early during cereal germination [28] are responsible for the hydrolysis of endosperm protein and starch reserve leading to more soluble substances produced [29]. Under thermal process, these enzymes act on the starch to give the by-products leading to the desired properties of malted gruels.

In the traditional wet process of maize into weaning food, starch is stored in a wet form. Allowing maize grain to soak in water for 3 days (100% hydration level) improved the quality of malt flour compared to flour from raw untreated maize, but lead to considerable reductions in germination rates. If germination is not practiced, this common production technique of weaning food did not seem to improve other attributes such as SS, SI and LJC of the malt flour. However, if germination is practiced, in the wet process, extensive soaking is usually accompanied by leaching of nutrients leading to the production of wet malt of inferior nutritional quality. Drying the germinated grain helped to reduce these losses and thus improve the quality of maize malt flours. Milling dry germinated grains produced amylase rich flour which is stable at room temperature if properly dried [30]. This process has the advantage of avoiding the daily replacement of water when starch is stored in a wet form. The results obtained suggest that malt flour could be a good substitute to wet starch for weaning food. For its routine production, maize could be either soaked for 4 or 12 hours to reach hydration level of 30% or 45% respectively, allowed to germinate for 72 hours followed by drying and milling.

Table 7: Solubility indices (%) of malt flours from soaked maize grains at various hydration levels (g of soluble substances in 100 g of malt)

Hydration levels (%)	Germination time (days)	Maize cultivars			
		CMS 8501	CMS 8704	CHC 201	88ME
30	0	13,64^{b}	14,53^{b}	14,84^{b}	14,31^{ab}
	1	16,71^{f}	18,98^{fg}	18,72^{de}	17,44^{d}
	2	17,68^{g}	18,29^{de}	18,39^{d}	18,80^{e}
	3	18,42^{h}	19,39^{g}	19,32^{ef}	19,74^{ef}
	4	17,73^{g}	22,57^{i}	24,28^{h}	24,98^{h}
45	0	14,70^{c}	13,74^{a}	15,1^{b}	15,14^{bc}
	1	15,56^{d}	17,08^{fg}	18,63^{de}	17,22^{d}
	2	16,52^{ef}	18,83^{f}	18,98^{de}	19,88^{f}
	3	16,19^{e}	17,89^{d}	22,98^{g}	25,52^{h}
	4	18,37^{h}	22,79^{i}	22,37^{g}	23,08^{g}
60	0	12,79^{a}	13,82^{a}	13,74^{a}	13,42^{a}
	1	13,78^{b}	17,23^{c}	17,16^{c}	15,86^{c}
	2	15,11^{cd}	18,40^{e}	18,46^{de}	17,57^{d}
	3	16,72^{f}	19,27^{g}	20,12^{f}	18,98^{ef}
	4	17,42^{g}	20,66^{h}	24,23^{h}	22,56^{g}

Means with different letters within a column are significantly different at 5 %
88ME= 88094xM131xExp24

Table 8: Least jellifying concentration of malt flours from soaked maize grains at various hydration levels (g/l)

Hydration levels (%)	Germination time (days)	Maize cultivars			
		CMS 8501	CMS 8704	*CHC 201*	88ME
30	0	13,41[b]	10,27[b]	10,15[b]	11,39[c]
	1	16,83[c]	10,13[b]	10,09[b]	11,45[c]
	2	26,19[d]	13,42[c]	18,87[d]	25,73[d]
	3	28,79[e]	28,07[e]	36,81[f]	40,61[f]
	4	31,43[f]	38,89[h]	52,15[i]	46,13[h]
45	0	8,10[a]	8,18[a]	8,09[a]	5,19[a]
	1	8,11[a]	8,79[ab]	8,05[a]	9,45[a]
	2	16,89[c]	16,79[d]	19,39[d]	26,18[d]
	3	32,82[f]	30,13[f]	41,50[g]	42,21[g]
	4	36,05[g]	32,05[g]	46,87[h]	45,01[h]
60	0	8,11[a]	10,14[b]	11,44[bc]	9,53[b]
	1	8,16[a]	10,27[b]	12,12[c]	12,09[c]
	2	16,89[c]	14,78[c]	31,37[e]	28,82[e]
	3	26,18[d]	29,49[ef]	36,86[f]	42,15[g]
	4	32,27[f]	32,85[g]	45,45[h]	40,33[f]

Means with different letters within a column are significantly different at 0.05 %
88ME= 88094xM131xExp24

CONCLUSION

Malt production had proven useful in upgrading the quality of grains of the maize cultivars tested for flour production for weaning food. Malting parameters (hydration levels and germination time) for the production of amylase-rich flours from maize were defined from hydration runs and micro malting method. Amylase activity of malt flour, controlled by germination of the grains was the most important criterion governing maize malt quality. The maize cultivars used showed better aptitude to germinate at 30 and 45 % hydration levels. Thus, hydration levels between 30 and 45 % obtained after soaking for 4 to 12 hours could be recommended for routine germination of maize for malt flour production.

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