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Full Length Research Paper

Improvement of the traditional technology for the production of "gowé", a sour and sweet beverage from Benin

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The present study was carried out to evaluate the effect of water content, fermentation period, and the effect of various drying temperatures of saccharified sorghum malt flour on the quality of "gowé", an indigenous sour and sweet beverage from Benin with the ultimate objective of improving the processing technique and quality of "gowé". Our data revealed that the physicochemical properties of "gowé" were significantly modified with respect to dough moisture content, its fermentation period and with different drying temperatures. The best processing characteristics for high quality of dried "gowé" were obtained for saccharified dough with 58.6% moisture level and a fermentation period of 48 h at 70°C drying temperature.

Key words: Sorghum, malting, fermentation, technology, drying, "gowé".

INTRODUCTION

Fermented foods play a significant role in the diet of millions of people in Africa (Odunfa, 1985). In Benin, different types of these food products are obtained from cereals like sorghum. Sorghum consumption per capita is about 115 kg/year in northern Benin (ONASA, 2001) and 200 kg in Burkina-Faso (Diawara, 1995). The forms of sorghum consumption vary from one country to another. Sorghum-based foods have been classified into three main types of foods (Nago and Hounhouigan, 1998; Kayodé et al., 2005). These include the paste type of foods ("ogui", "akassa", "dibou" and "foura"); the gruels ("koko", "sorou" and "kamanguia") and the beverage type of foods ("tchoukoutou", "chapkalo" and "gowé").

"Gowé" is a traditional fermented beninese beverage made from germinated and non germinated cereals (Michodjèhoun et al., 2005). It is a reddish coloured sweet drink with a pleasant aroma and sour flavour. "Gowé" is rich in proteins (11.3%), vitamins and minerals. It is an important source of energy because of its high carbohydrate content (83.5%) (Michodjèhoun, 2000). Research contributions have shared important knowledge on the production technology, the physicochemical and microbiological attributes of "gowé". Basically, the preparation of "gowé" involves cleaning of sorghum grains, malting, grinding, saccharification, natural fermentation and cooking under various temperatures and time according to regional traditions. Unfortunately, these processing methods are not efficient resulting in a low quality of beverage. In addition, the resulted

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Table 1. Physicochemical characterisations of dried "gowé".

Treatments			Physicochemical properties							
Initial H_2O content (%)	Fermentation duration (h)	Drying (°C)	pH	Acidity (% acid lactic)	Water content (%)	Reducing sugars (% gluc.)	Total sugars (% gluc.)	Browning index	Final viscosity (URVA)	Swelling power (g/g)
58.59	24	70	4.0	2.79	6.51	3.44	6.05	32.9	129.0	10.7
58.59	48	70	3.83	3.46	6.95	3.17	5.45	34.9	203.0	7.5
58.59	24	80	4.01	2.66	8.67	2.81	5.72	30.8	110.0	10.4
58.59	48	80	3.81	2.95	7.48	3.36	4.31	32.8	98.0	10.1
62.31	24	70	3.95	2.69	6.67	3.73	5.06	33.4	81.0	8.4
62.31	48	70	3.73	3.35	7.13	3.28	4.38	34.8	87.0	7.7
62.31	24	80	3.9	2.8	6.9	3.7	5.66	30.0	113.5	11.2
62.31	48	80	3.83	3.29	7.6	5.08	3.55	33.2	153.0	10.7
66.59	24	70	4.0	2.94	7.56	1.79	4.01	33.6	76.0	7.4
66.59	48	70	3.78	3.4	7.25	1.36	3.29	35.8	76.5	7.2
66.59	24	80	3.91	2.97	7.77	3.87	4.57	30.1	126.0	11.5
66.59	48	80	3.78	3.33	8.8	2.5	3.08	34.6	137.0	10.2
71.35	24	70	3.9	3.22	8.06	2.48	3.25	33.4	74.0	6.8
71.35	48	70	3.77	3.72	7.75	2.11	3.34	34.0	72.5	7.1
71.35	24	80	3.82	3,15	7.77	3.31	3.9	29.7	128.0	10.9
71.35	48	80	3.76	3.57	8.8	2.46	3.85	28.8	131.0	12.5

beverages have a short period of shelf life due to its high moisture content which range from 75 to 77% (Michodjèhoun et al., 2005). It has been however demonstrated that rural and urban women's groups processing and selling "gowé" derive a direct benefit from increased marketing opportunities (Michodjèhoun, 2000). Thus, innovations to improve the traditional processing technology and the quality of "gowé" could significantly improve income and livelihood of rural households involved in this activity.

The present study was carried out to evaluate the effect of water content of sorghum malt flour, the fermentation period and the drying temperature on the quality of "gowé", with the aim of improving the quality and the processing technique of the product.

MATERIALS AND METHODS

Plant material

Red sorghum [*Sorghum bicolor* (L.) Moench] *abokun vovo* landrace, with high preference by "gowé" processors, was bought in Dantokpa market in Cotonou, Republic of Benin. The grains originated from the department of Donga in the Northern Benin and were grown on a tropical ferruginous type soil under the natural season of the Guinea Savannah climate of West Africa. The annual rainfall in the regions varies from 985 to 1473 mm with an average value of 1237 mm (Saïdou et al., 2003).

Experimental design

An experimental design with three factors was used to evaluate the effect of three process variables on the physicochemical characteristics of dried "gowé" using the traditional flow diagram as described by Vieira-Dalode et al. (2007). The variables (factors) were the water content of malt flour after saccharification, the duration of second fermentation and the drying temperature of the deriving dough. The responses were pH and titratable acidity, reducing sugars, total sugars, browning index and the final viscosity. The experimental design generated 16 observations as outlined in Table 1.

Experimental processing

Saccharification process

Sorghum grains (25% of the whole grain) were sorted, washed and soaked for 24 h at ambient temperature (28 to 30°C). The grains were drained and allowed to germinate for 72 h. The germinated grains were sun dried for 24 h and milled using a plate disc mill. The malted flour was

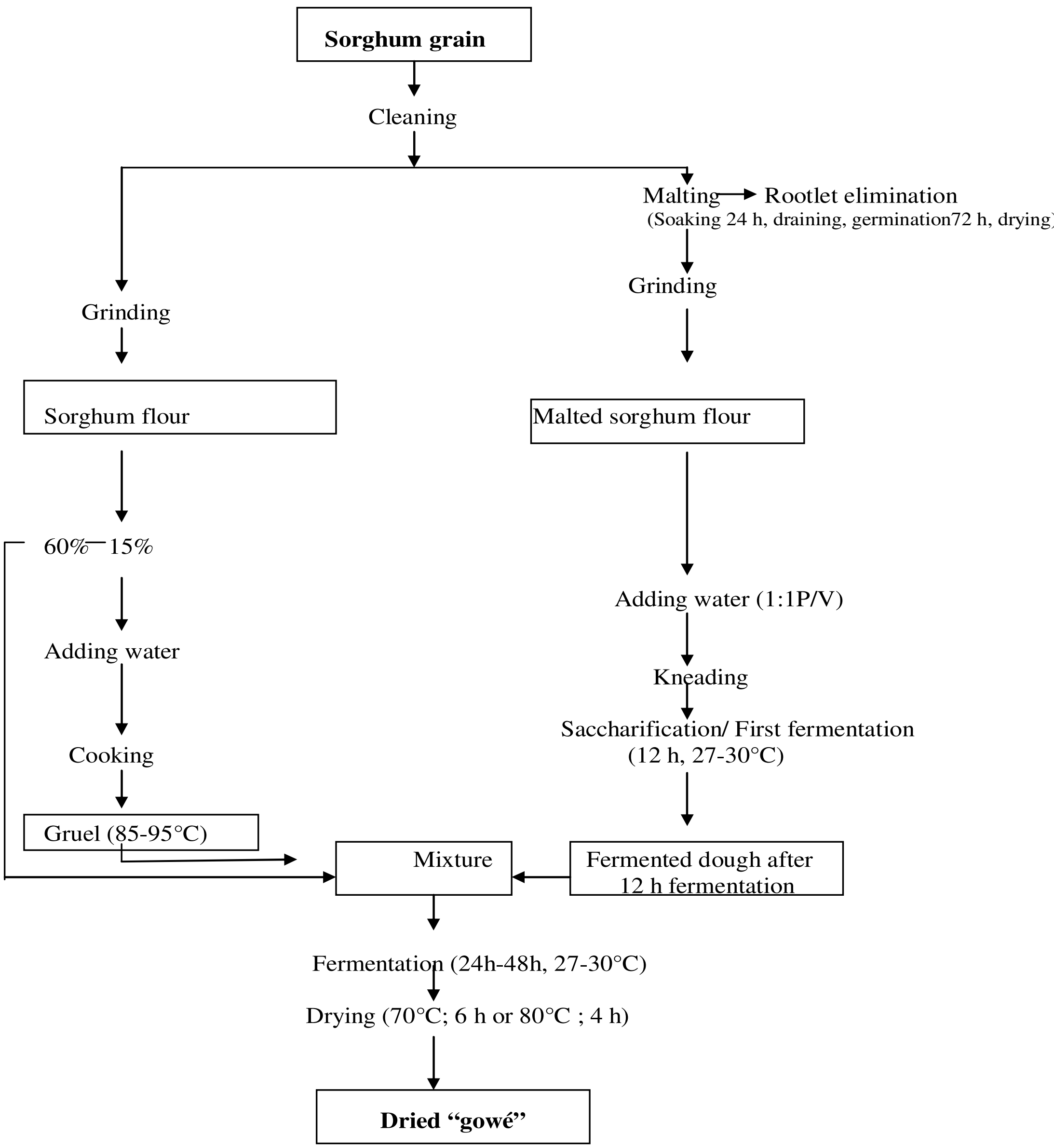


Figure 1. Flow diagram representation for an improved "gowé" production.

was moistened in a plastic bucket, kneaded, covered and left 12 h for saccharification and for a first step spontaneous fermentation. Then, slurry made from non malted sorghum flour (15% of the whole grain) was prepared and added. Finally, the mixture was blended using sorghum flour representing 60% of the whole grain. This mixture constitutes the substrate for the second fermentation (Figure 1).

Fermentation process

In view of optimizing the second fermentation process, two parameters were varied. These are the water content of the dough before the second fermentation and the duration of fermentation of the dough. For this purpose, 2 kg of saccharified dough was divided in 4 batches of 500 g in plastic buckets. Water was added to each bucket to obtained four different levels of moisture content ranging from 58.59 to 71.35% according to the mixture formula proposed by Hounhouigan et al. (1999). The samples were produced in duplicate and one part was left for 24 h of fermentation, while the second was left for 48 h of fermentation.

Drying process

Each of the fermented samples was divided into two parts. One part was submitted to drying at 70°C in an oven for six hours and the second part was dried at 80°C for four hours. Preliminary data have confirmed that these drying conditions were necessary to obtain a product with moisture content below 10%. A total of 16 samples were produced, packed in polythene bags and stored at -20°C until analysis. Two production trials were performed and physicochemical analyses were carried out in duplicate for each trial.

Physico-chemical analyses

Determination of dry matter, pH, titratable acidity, reducing sugars and total sugars

Dry matter was determined using the AACC method (AACC, 44-15 A, 1984). The pH was determined using a digital pH meter (Hanna instruments HI 8418, Limena, Italy) calibrated with buffers at pH 4.0 and 7.0 (WTW D-82362 Weilheim, Germany). The titratable acidity, expressed as lactic acid, was performed by titrating ten grams of “gowé” using 4 g l^{-1} NaOH (Merck) and phenolphtalein (Merck) as indicator. Luff-Schoorl method (Lees, 1968) was used for the measurement of reducing and total sugars content.

Measurement of viscosity

The final apparent porridge viscosity, that is, the viscosity after cooling the hot porridge to 50°C was measured using a Rapid Visco Analyser (RVA, Newport Scientific, Narrabeen, Australia) following the method of Mestres et al. (1997). Apparent viscosity was expressed in arbitrary RVA units, one unit corresponding to approximately 0.012 Pa.s.

Measurement of swelling power

The swelling power was measured on a flour suspension of 4% dry matter according to Kayodé et al. (2001). The product obtained after heating was immediately centrifuged at 3000 rd/ min for 15 min at 25°C. The supernatant and slurry were separated. The wet weight (W_W) of slurry and its dry weight (D_w) were recorded and the swelling power (SP) was calculated as follows: SP (g/g) = $(W_W - D_w)/ D_w$.

Colour determination

The colour of dried “gowé” flour was measured with a Minolta CR-210 portable chromameter (Illuminant D 65 CIE 1976) in reflective mode, standardized with a standard white tile (Y = 94.8, x = 0.315 and y = 0.3324). L*, a*, b* and ΔE values were recorded. The browning index (BI) was calculated from brightness L* and was given by the formula: BI=100-L* (Mestres et al., 2004).

Statistical analysis

The data were analysed using the statistical program SPSS 11.0 and the one-way ANOVA model was used applying the LSD test to evaluate significant difference among means.

RESULTS AND DISCUSSION

Effect of final water content, pH and titratable acidity of dried “gowé”

The water content of a food product is a good indicator of its storability. For all treatments applied, the water content of died “gowé” ranges between 6.5 and 8.8%. The multivariate analysis revealed that the water content of malt flour as well as the drying temperature has a significant effect on the final water content of dried “gowé” ($p<0.05$). The lower the water content of malt flour is, the more quickly the product dries and the higher is its dry matter content. The interactive effect of the three processing factors that is, water content of malt flour, fermentation time and drying temperature is not significant on the final water content ($p<0.05$). The lower water content of “gowé” (6.5%) was obtained with the water content of malt flour of 58.6% (Table 1) after drying at 70°C for six (06) hours. Previous reports demonstrated that cereal products are well preserved with water content < 12% (Cecil, 1992). In addition, decreasing the weight, volume and drying processing condition of the products improves the distribution/transportation of the products across the State. The sour taste is one of the criteria determining the acceptability of the fermented sorghum-based products (Kayodé et al., 2005). The pH of “gowé” ranges from 3.7 to 4.0, while the titratable acidity ranges from 2.7 to 3.7% (Table 2).The linear effect of each processing parameter is significant on the pH and acidity of “gowé”. Clearly, we noticed a reduction of pH and an increase of the titratable acidity with an increased water content of malt flour and fermentation period (Figure 2a). These results are similar to those obtained by Michodjèhoun et al. (2005). The combined effect of water content of malt flour, drying temperature and fermentation period is not significant on the pH and titratable acidity of dried “gowé”. Furthermore, the interaction between the fermentation period and the drying temperature has a significant effect on the pH ($p<0.05$). According to Sefa-Dedeh (2003), the low pH and short period of fermentation is necessary for the hydrolysis of carbohydrates into sugars, alcohol and organic acids by the lactic acid bacteria. Our multiple comparative analyses showed that the drying temperature has no effect on the pH of “gowé” but significantly affects the titratable acidity of the product. Thus, the values of titratable acidity obtained for samples dried respectively at 70 and 80°C were definitely different. The samples dried at 70°C were more acidic than those dried at 80°C. This could be explained by the fact that pH does not actually reflect the acid content of a product because of the buffer effect of proteins on the reduction of the pH, as highlighted by Hounhouigan et al. (1993) for “mawè”.

Nevertheless, the statistical analyses showed that for 24 h of fermentation, there is a significant difference between the pH of dried products obtained at different drying temperatures, whereas there is no significant difference between the pH and acidity of the products at 48 h of fermentation. Consequently, the fermentation period is the factor that allows a low pH and an optimum acidity at 48 h of drying condition. It clearly appears that, after 48 h of fermentation, the titratable acidity of the products dried at 70°C for 6 h is definitely higher than that of the products dried at 80°C for 4 h (Table 3). Thus, we suggested a temperature of 70°C as the optimal drying temperature of “gowé”. This result confirms previous findings of Houndélo (2004) who reported that dried “gowé” can be obtained at 70°C.

Table 2. Analysis of variance showing the effect of technological factors on the physicochemical parameters of dried "gowé".

Parameters	F-Value							
	pH	Titratable acidity	Final water content	Total sugars	Reducing sugar	Browning index	Final viscosity	Swelling power
Water content (WC)	8.112**	17.54**	3.86 **	55.86**	35.51**	2680.36 **	529.12**	192.1**
Fermentation (F)	100.72**	106.6**	1.24 ns	5.78*	42.86**	115.12 **	33.87**	802.78**
Drying temp. (DT)	0.92 ns	5.31 ns	9.86 **	58.04**	0.07ns	2695.67 **	2.83 ns	272.25**
WC X F	1.91 ns	0.51 ns	0.84 ns	11.47**	5.53**	1998.89 **	66.45	852.33**
WC X DT	1.21 ns	2.66 ns	0.87 ns	16.192**	4.12**	1025.68 **	355.45**	1420.09**
F X DT	5.25 ns	3.53 ns	0.73 ns	2.54 ns	9.68*	350.5**2	209.82**	529.0**
WC X F X DT	1.29 ns	0.57 ns	2.39 ns	11.15**	1.21	695 **	95.19**	504.68**

*Significant with the threshold of 5%; ** significant with the threshold of 1 %; ns = not significant.

Table 3. Pearson correlation matrix showing the relationship between various parameters.

	pH	Titratable acidity	a*	Reducing sugar	Total sugar
Titratable acidity	-0.744**				
a*	-0.278*	0.203			
Reducing sugars	0.134	-0.308*	0.035		
Total sugars	0.435**	-0.532**	0.149	0.323**	
ΔE	-0.208	0.267*	-0.837**	-0.219	-0.251*

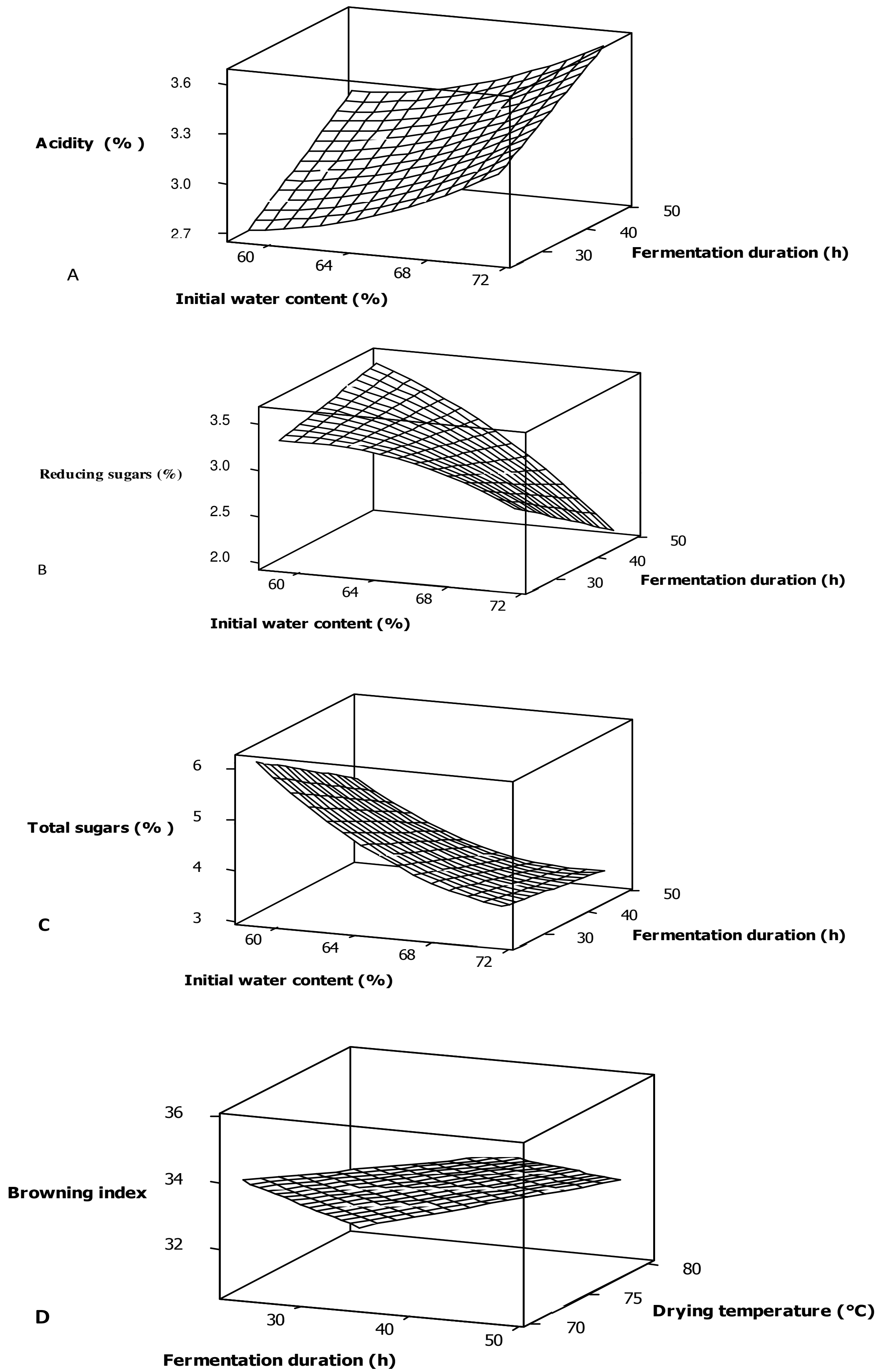
*significant at 5%; **significant at 1%.

Effect of sugar content on dried "gowé"

The multivariable analyses revealed that the linear effect of water content of malt flour, the fermentation period and the drying temperature significantly affect the reducing sugar content of "gowé". For water contents of dough ranging from 60.0 to 67.5%; the reducing sugar content of "gowé" expressed as glucose equivalents increases significantly from 2.8 to 3.9%. Above 67.5% of water content of malt flour, the reducing sugar content decreases and tends to stabilize thereafter (Figure 2b). This is probably due to the fact that water facilitates the hydrolysis activities of the endogenous amylases of the flour.

However, the reducing sugars content decreased with the fermentation period due to the fact that these sugars were progressively being used as substrates by the fermentative micro-organisms for the lactic acid and related metabolite production over time.

Our result is in agreement with that of Michodjèhoun et al. (2005), who reported a positive correlation between the reducing sugar content of two types of "gowé" and the fermentation period. The interactive effect of the three processing factors was highly significant on the reducing sugar content but had no effect on the total sugar content of the product. However, the interactions of water content and fermentation period were significant on the total sugar content. The total sugar content varied significantly according to the water content of malt flour of the substrate. A reduction in the total sugar content was observed as the water content of malt flour increased (Figure 2c). This reduction in total sugars was conversely correlated with the titratable acidity of dried "gowé" (Table 3). This clearly demonstrates that the higher moisture


Acidity (%)
3.6
3.3
3.0
2.7
60
64
68
72
Initial water content (%)
50
40
30
Fermentation duration (h)
A
Reducing sugars (%)
3.5
3.0
2.5
2.0
60
64
68
72
Initial water content (%)
50
40
30
Fermentation duration (h)
B
Total sugars (%)
6
5
4
3
60
64
68
72
Initial water content (%)
50
40
30
Fermentation duration (h)
C
Browning index
36
34
32
30
40
50
Fermentation duration (h)
80
75
70
Drying temperature (°C)
D

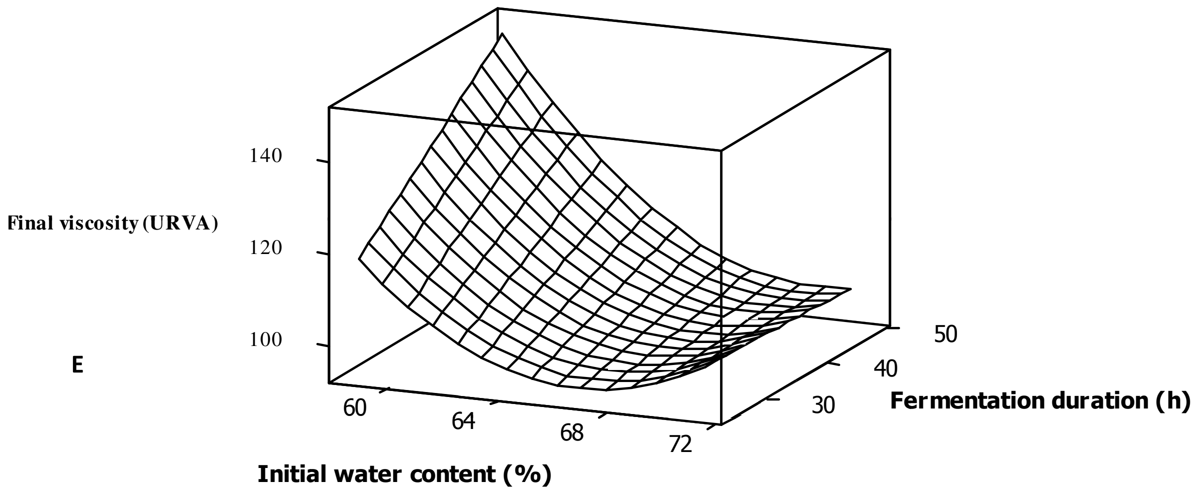


Figure 2. Response surface curves showing the effects of fermentation period and the water content of malt flour on (a) titratable acidity, (b) reducing sugars, (c) total sugars, (d) browning index, and (e) final viscosity of dried "gowé".

content favoured the metabolism of sugars.

Conclusion

The present study showed that water content of the saccharified malt flour, the fermentation period of the resulting dought and the drying temperature of the product have significant effects on the physicochemical characteristics of "gowé". The best characteristics of dried "gowé" were obtained for saccharified dough with a water content of malt flour of 58.6%, at a fermentation period of 48 h and a drying temperature of 70°C.

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