Journal of Cereal Science 70 (2016) 192–198

Contents lists available at ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Dough mixing characteristics measured by Mixsmart software as possible predictors of bread making quality in three production regions of South Africa

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ARTICLE INFO

Article history:
Received 15 February 2016
Received in revised form
13 June 2016
Accepted 15 June 2016
Available online 16 June 2016

Keywords:
Baking quality
Dough rheology
Mixsmart
Wheat

ABSTRACT

South Africa has three wheat production regions, the winter rainfall region where spring wheat is planted; the summer rainfall where winter and intermediate wheat is cultivated; and the irrigation region where spring wheat is grown. The aim of this study was to determine dough mixing characteristics as measured by Mixsmart® software in these three regions over seasons and locations, and to relate this to important quality characteristics. In the winter rainfall area Mixsmart characteristics were very poor predictors of baking quality, especially of loaf volume, flour protein content and wet gluten content. The best predictors of loaf volume in this region were flour protein content and wet gluten content, which were highly interrelated. In the irrigation area, midline peak value and midline right value were very good predictors of flour protein content, gluten content and loaf volume. Midline peak value was highly correlated with protein content in both the irrigation and summer rainfall areas and was a better predictor than peak time of baking quality. The ideal would be to select several parameters from the mixograph and use them in a multivariate statistical analysis to obtain a more accurate prediction of loaf volume in the irrigation and summer rainfall areas.

1. Introduction

South Africa has three wheat production regions, the Western Cape region (winter rainfall) where spring wheat is planted; Free State region (summer rainfall) where winter and intermediate wheat are cultivated; and the Northern region (mainly irrigation) where spring wheat is grown. These regions have three separate breeding programs.

The mixograph performs certain rheological measurements during dough mixing (Bordes et al., 2008). Neacşu et al. (2009) indicated five mixograph parameters to be effective for selecting processing quality in breeding programmes and they are descriptive of all basic rheological aspects of mixing properties. These parameters are the initial slope (relating to water-absorption), peak time (relating to mixing requirement), peak height (relating to dough strength), end-width (relating to extensibility) and breakdown (relating to stability). These parameters explained 91% of the variance observed in loaf volume. Wikström and Bohlin (1996) also reported that five mixograph parameters namely build-up (up to the maximum height at the top of the curve), peak time, initial width, area below the mixograph curve and peak height, when combined with protein content, were effective in predicting loaf volume. In general, strong doughs have long mixing times, high peak values and band widths and low resistance to breakdown (Mao et al., 2013). Peak time is influenced by protein content and associated with the glutenin fraction of the flour. As peak time increases, dough extensibility decreases and dough stability, elasticity and mixing tolerance increase (Hoseney, 1994).

When using Mixsmart® software, a single mixograph curve can be used to measure 44 different parameters (Pon et al., 1989; Martinant et al., 1998). These parameters are the result from different heights, width slopes and areas on the mixograph curve that are measured. A midline curve is constructed by the software, which then divides the mixograph into two envelope curves. Analysis of the upper envelope and the midline curve is done (Walker and Walker, 1992; Dobraszczyk and Schofield, 2002). Curve-height measurements, determined as a percentage of the full scale, are informative about dough consistency. Curve-width

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http://dx.doi.org/10.1016/j.jcs.2016.06.008
0733-5210/

Abbreviations

LFV	loaf volume
FLP	flour protein content
WGLUT	wet gluten content
AlveoW	alveograph W value
AlveoDist	alveograph distensibility
ELT	envelope left time
EPI	envelope peak integral
EPT	envelope peak time
EPV	envelope peak value
EPW	envelope peak width
ERI	envelope right integral
ERT	envelope right time
ERV	envelope right value
ETI	envelope tail integral
ETV	envelope tail value
ETXI	envelope tail X integral
ETXV	envelope tail X value
ETXW	envelope tail X width
MLI	midline left integral
MLT	midline left time
MLW	midline left width
MLV	midline left value
MPI	midline peak integral
MPV	midline peak value
MRI	midline right interval
MRT	midline right time
MRV	midline right value
MTI	midline tail integral
MTV	midline tail value
MTXV	midline tail X value
MTXW	midline tail X width

measurements are the difference between the top and bottom envelope, and midline-width measurements obtain some information from the top envelope. Curve-widths are indicative of the dough's tolerance to mixing. Slopes are determined by dividing the value by the time in question, where small values will be indicative of flat, stable curves and large values will be indicative of a quick rise and/or breakdown which are undesirable, indicative of poor tolerance to mixing and sensitivity to the mixing time. Areas under the midline curve are indicative of dough strength.

The aim of this study was to determine the dough mixing characteristics as measured by Mixsmart® software in the three production regions in South Africa over two consecutive seasons in two representative locations in each region, and to relate this to economically important quality characteristics, including loaf volume.

2. Materials and methods

Entries of the National Cultivar Trials which include all commercial cultivars released by the wheat breeding companies in the country for the three production areas of South Africa, were tested in 2012, and again in 2013. These areas vary considerably in climate and soil conditions. Annual rainfall, followed by temperature are the primary factors shaping production practices.

The summer rainfall region is located in the interior part of South Africa, and receives approximately 50% of its annual precipitation between November and end of February (Table 1). Soil types in this region on which dryland wheat is produced, are generally loamy sand or sandy loam which promote rapid water infiltration. All trials were planted as randomized complete block designs with three replications. Trials were planted with six-row commercial seeders adapted for planting yield plots. For the dry land summer rainfall region 12 cultivars (Elands, Gariep, Koonap, PAN3161, PAN3195, PAN3368, PAN3379, Senqu, SST316, SST317, SST347 and SST356) were tested at Bethlehem and Clarens as representative locations (Table 2). Seeding density was 45–60 plants per m^2. Fertilization consisted of a commercial mixture of 4:2:1 (28) applied during seeding at an amount of 60 kg N ha^{-1}.

In the production of irrigated wheat, the predominant soil types are red and yellow, free-draining soils with no soil structure. Irrigation is applied through centre-pivots and amounts peak in early to mid-summer from onset of anthesis to end of grain filling. Seeding rate was 200 kg ha^{-1}. Irrigation plots were seeded with a Wintersteiger Plotman. Experimental sites for the irrigation region were Upington and Vaalharts with 18 cultivars (Buffels, Duzi, Krokodil, PAN3471, PAN3478, PAN3489, PAN3497, Sabie, SST806, SST822, SST835, SST843, SST866, SST876, SST877, SST884, SST895, Tamboti) (Table 2). A full irrigation schedule according to standard production practises in the region was applied. A balanced soil fertility status was achieved through application of 2:3:4 (28) and K.A.N (28) to a total amount of 280 kg N ha^{-1} in split applications of 160 kg N ha^{-1} at seeding, 60 kg N ha^{-1} between tillering and stem elongation and 60 kg N ha^{-1} between flag leaf to anthesis.

Wheat is also produced under dryland conditions in the winter rainfall region located along the southern and western regions of the Cape Province. This Mediterranean-type climate has mild minimum and maximum temperatures (Table 1) throughout the growth period of wheat and allows cultivation of spring-type varieties. Approximately half of the annual rainfall occurs from May to August and coincides with the seeding period for the region. Soils of this region are shallow and have high amounts of gravel and stone with very limited water holding capacity. The two experimental sites planted in this region were Moorreesburg and Riversdale (Table 2) with 12 cultivars (Tankwa, Kwartel, Ratel, PAN3408, PAN3471, SST047, SST105, SST027, SST88, SST056, SST087, SST096). Seeding density was sufficient for establishing 250 to 300 plants per m^2. A total of 130 kg N ha^{-1} was applied through a commercial mixture of 4:1:1 (31). Fertilizer application was split between 100 kg N^{-1} during seeding and the remaining 30 kg N ha^{-1} applied as K.A.N (28) between tillering and stem elongation.

Field plots of experiments in each region were harvested with Wintersteiger Plot combines, seed air-dried, cleaned and quality analysis done at the ARC - Small Grain Institute in Bethlehem. Wheat samples were conditioned for 18 h prior to milling, according to AACC method 26e95 and milled on a laboratory pneumatic mill (Bühler model MLU-202, Bühler-Miag, Uzwil, Switzerland). The percentage break flour yield (AACC method 26-21A) and flour extraction (AACC method 26-21A) was determined. Flour protein content was established with AACC method 46-30 and wet gluten content with AACC method 38-12A. Loaf volume was determined by rapeseed displacement following the optimised, straight dough baking procedure (AACC 10-10B). Alveograph analyses (AACC method 54-30A) were performed on a Chopin alveograph. Mixographs were constructed as two envelope curves and one midline curve. The Mixsmart software uses the midline as well as the top-envelope curve to analyse the mixographs. Time values were determined directly from the horizontal axis and were expressed in minutes. Heights, expressed as value (%), were