RHEOLOGICAL BEHAVIOUR OF *BROA*, A PORTUGUESE TRADITIONAL SOURDOUGH BREAD, THROUGHOUT THE STORAGE PERIOD

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OBJECTIVES

The goal of this work was to seek correlations between the rheological behaviour of *broa*, a Portuguese traditional sourdough bread, on the one hand, and the geographical origin of the samples and the effect of the storage period, on the other. For this purpose, 6 bread series baked by 13 different producers (*I, II,…,XIII*) were assayed for changes in compression force and in selected chemical parameters (%Moisture and %Total acidity) and microbiological parameters (viable yeast and mould counts). The bread was stored during 15 d at 20°C and 80% relative humidity. Because *broa* possesses a relatively long storage period, 2 breads (from each producer) were analysed by 1, 7 and 15 d. For the compression tests, the entire bread was used and subject to the *Instron* universal testing machine.

Even though samples from distinct producers could not be well distinguished from one another, the effect of the storage period on the bread could be easily perceived.

It is known that such properties as firmness, hardness and softness of the crumb and crust are important sensory attributes of bread, and are as well influenced by a variety of factors, including storage (namely via temperature and relative humidity). One study suggested that the measurement of rheological properties is a simple and powerful technique to evaluate changes, and predict the final quality of *broa* throughout storage.

EXPERIMENTAL METHODS

Samples: 6 series of *Broa* from 13 different producers

Storage during **15 d** at **20°C** and **80%** relative humidity

Analyses of samples (*broa*) by *1, 7* and *15* d

❖ Compression tests with the *Instron* universal testing machine:
➢ Model 4501 Series IX Automated materials testing system (version 5.04)

➢ Conditions used:
- 0.9 cm-diameter head,
- Down test direction,
- 5 kN Load-cell, and
- 20 mm/min Crosshead constant speed.

❖ Selected chemical analysis:
- %Moisture – NP 2967
- %Total acidity – NP 515

❖ Selected microbiological analysis:
Total viable counts of **Yeasts** and **Moulds** were performed after inoculation and incubation on *Cook Rose Bengal Agar* with oxitetracycline

ABBREVIATIONS

- *Broa* - *b*
- Producers - *I, II,…,XIII*
- Days of storage: *1, 7* and *15*

- Compressibility parameters:
  - Displacement at maximum load - *A*
  - Load at maximum load - *B*
  - Energy between limits - *C*
  - Average load between limits - *D*
  - Slope (Man Young) - *E*
  - Modulus (Aut Young) - *F*

- Principal Component Analysis – *PCA*

ACKNOWLEDGEMENTS

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RESULTS

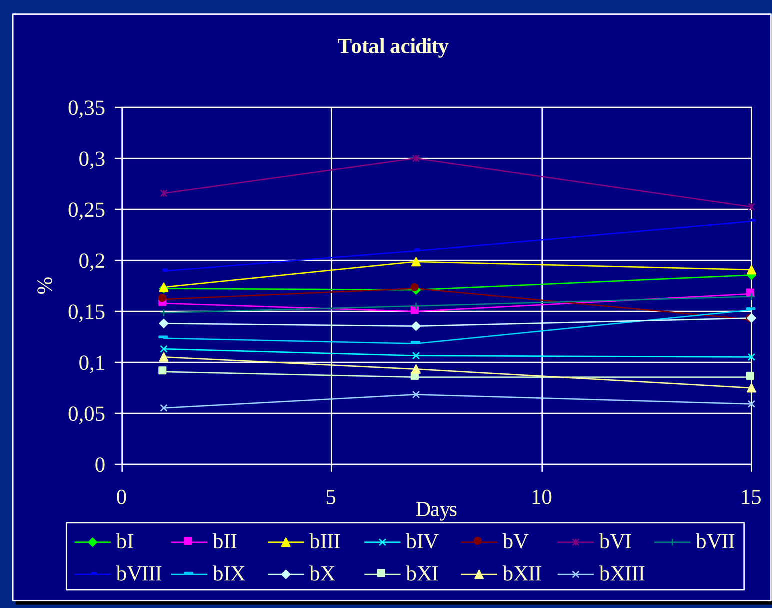

Figure 1 – % Total acidity measured of samples of *Broa* (b) from different producers (*I, II, III,… XIII*), by *1, 7* and *15* d.

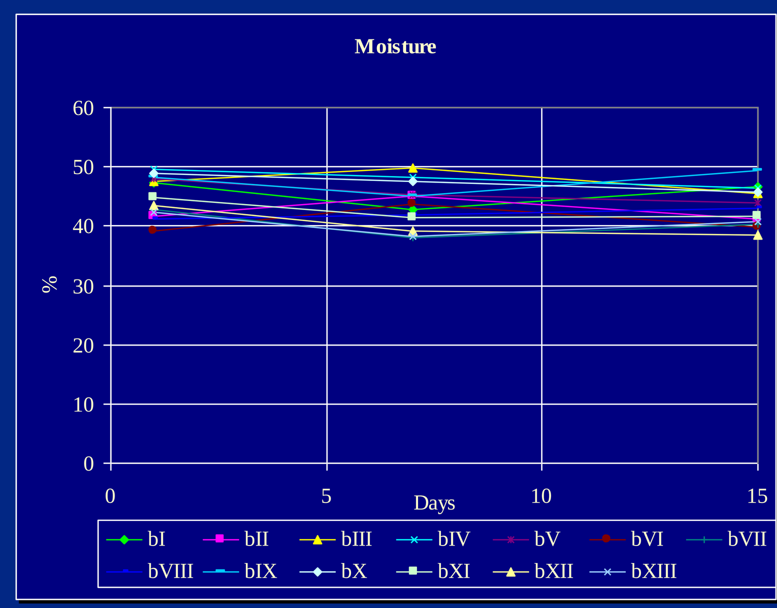

Figure 2 – % Moisture measured of samples of *Broa* (b) from different producers (*I, II, III,… XIII*), by *1, 7* and *15* d.

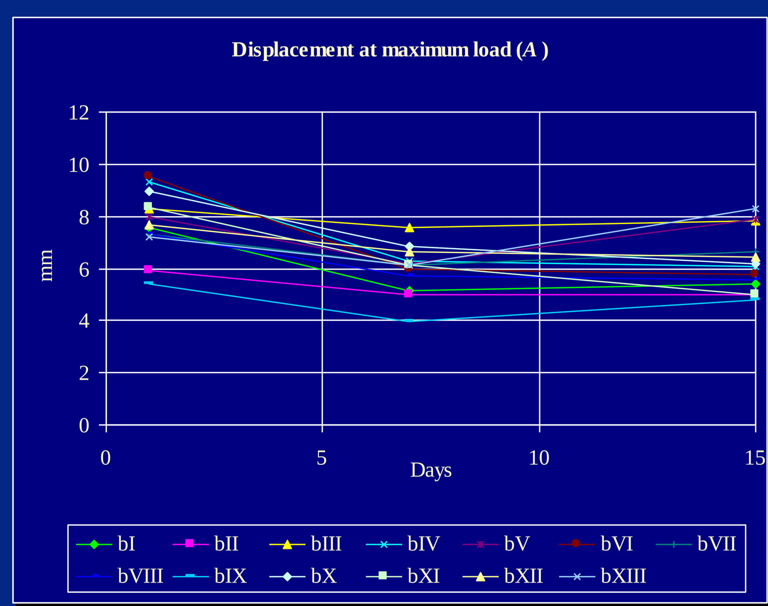

Figure 3 – Displacement at maximum load (*A*) of samples of *Broa* (*b*) from different producers (*I, II, III,… XIII*), by *1, 7* and *15* d, measured with the *Instron*.

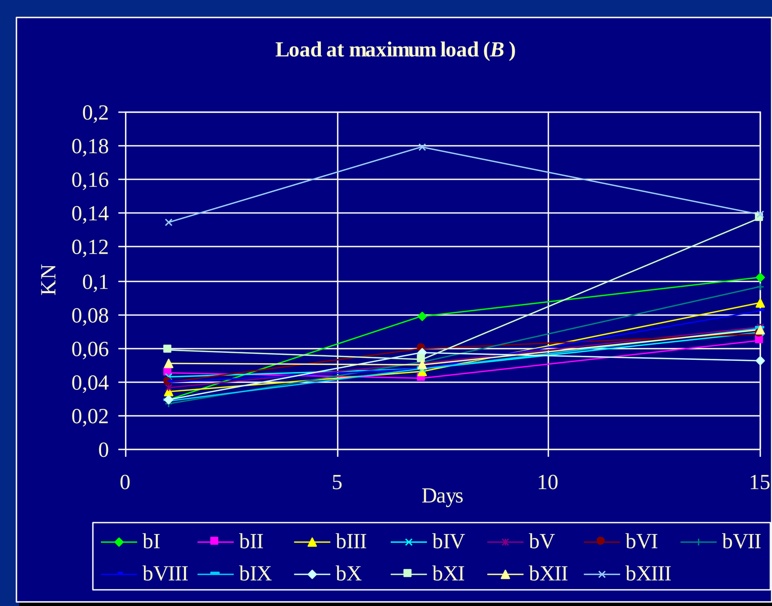

Figure 4 – Load at maximum load (*B*) of samples of *Broa* (*b*) from different producers (*I, II, III,… XIII*), by *1, 7* and *15* d, measured with the *Instron*.

PC analysis

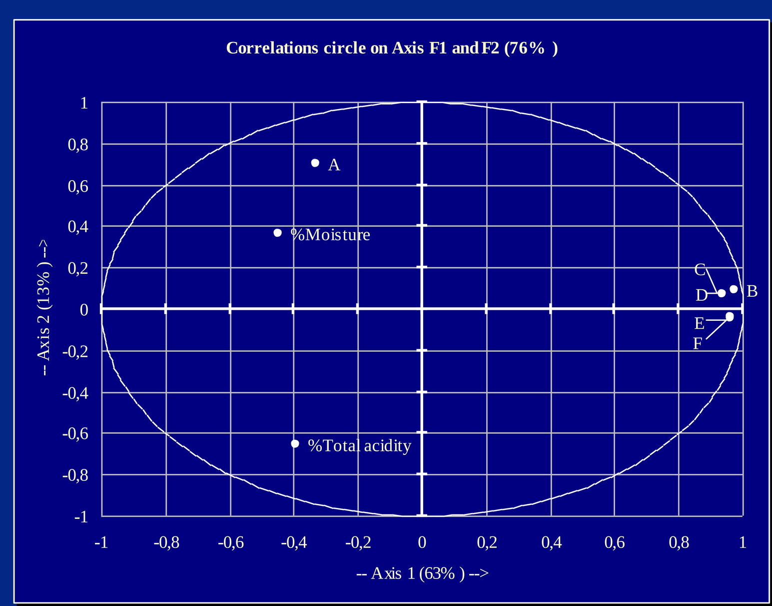

Figure 5 – Loading plot on axes 1 and 2.

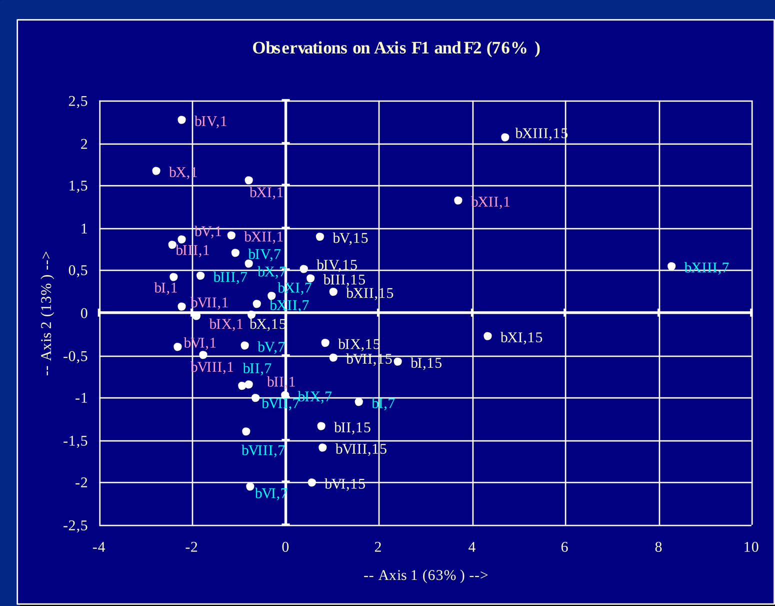

Figure 6 – Observation plot on axes 1 and 2.

Results from ***Figure 1*** to ***4*** and other compressibility parameters (not shown), measured by *Instron* as well, are presented in the table below.

Table I – Mean values and standard deviations of the compressibility parameters of samples from all producers

DAY	***A*** (mm)	***B*** x 10^2 (KN)	***C*** x 10^1 (J)	***D*** x 10^2 (KN)	***E*** (N/mm)	***F*** x 10^2 (Mpa)	**Total acidity x 10^1** (%)	**Moisture** (%)
1	7,75 ± 1,205	4,59 ± 2,818	1,43 ± 0,6929	1,43 ± 0,6927	12,5 ± 9,373	0,743 ± 0,5672	1,46 ± 0,5218	45,0 ± 3,413
7	5,98 ± 0,8973	6,25 ± 3,619	2,48 ± 1,570	2,48 ± 1,5694	18,6 ± 13,04	1,11 ± 0,7849	1,51 ± 0,6232	43,6 ± 3,740
15	6,22 ± 1,158	8,57 ± 1,182	3,37 ± 1,182	3,37 ± 1,1823	24,2 ± 8,663	1,45 ± 0,5201	1,51 ± 0,5902	43,3 ± 3,253

DISCUSSION and CONCLUSIONS

✓ As expected, our results unfolded a significant increase of the yeast and the mould viable counts througout storage (data not shown) and a higher resistance imparted by the crust during compression (see ***Figure 4***)

✓Mechanical and chemical tests revealed slight differences in samples provided by distinct producers

✓ PCA carried out using our experimental results indicated a high correlation between the compressibility parameters Load at maximum load (*B*), Energy between limits (*C*), Average load between limits (*D*), Slope (Man Young) (*E*) and Modulus (Aut Young) (*F*) (**figure 5**). Those variables do not allow a good distinction for the objects studied, *i.e.* samples from different producers and in different storage periods

✓ On the contrary, the Displacement at maximum load (*A*) (see ***Figure 3***), as well as the %Total acidity (see ***Figure 1***) and the %Moisture (see ***Figure 2***) did not entertain a significant correlation between them, or with the cluster composed by *B, C, D, E* and *F* variables as well. Therefore, the latter variables can better distinguished within the variables studied (see ***Figure 5***)

✓ Even though samples from different producers could not be well distinguished from one another, the effect of the storage period on the bread could easily be perceived via the clusters formed. Except for one sample (the composition of which is quite different from that of the others), all other samples could be told apart using the storage period as argument (see ***Figure 5*** and ***6***):

– On the first day (*1*), samples were characterized by maximum values of displacement at maximum load (*A*) and minimum values in the aforementioned cluster; in many cases, they also exhibited the highest values of moisture

– The 15th day (***15***) was characterized by the highest values in the aforementioned cluster; the majority also yielded the smallest percentages of moisture

– The highest and the lowest values for acidity were also found on the 15th day

✓ The above results made it apparent that as bread ages, the amount of compression force required increases, the maximum load is obtained in a smaller depth, and the %Moisture generally decreases

✓ It is known that such properties as firmness, hardness and softness of the crumb and crust are important sensory attributes of bread, and are as well influenced by a variety of factors, including storage (namely via temperature and relative humidity)

✓ Bread hardening is, undoubtly, the most important factor for its decay. The hardening is not necessarily caused by loss of water; indeed, bread can gain hardness without actual loss of moisture. Physical changes in bread caused by hardening bring up changes such as the taste and aroma, and crumb hardness and opacity. Therefore, this study suggests that the measurement of rheological properties is a simple and powerful technique to evaluate changes, and predict the final quality of *broa* throughout storage