

# ON THE CORRELATION OF CHEMICAL PROPERTIES OF *BROA*, A PORTUGUESE TRADITIONAL SOURDOUGH BREAD, WITH BAKING TECHNOLOGICAL FACTORS



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## OBJECTIVES

The present study was undertaken in attempts to find useful chemical parameters that would permit technological parameter changes to be accurately predicted during the baking process of *broa*.

Baking tests were carried out with all possible combinations of 4 different types of maize flours (Portuguese regional maize flour, *MR*, Dentated hybrid maize flour, *MHD*, White hybrid maize flour, *MHF*, and Flint maize flour type 175, *F175*), ground in 2 different types of mills (electric flour-mill, *ME*, and watermill, *MA*), mixed with one type of rye flour at 2 different relative proportions (15% and 50%), coupled with 2 kinds of starter culture (bakers' yeast, *yeast*, and sourdough, *isco*), thus giving rise to 18 distinct combinations. Five (replicate) breads were produced per combination, and one standard *broa* (used as control), manufactured with 50% maize flour *F175* (one of the most common industrial flours used for baking) and with bakers' yeast, was produced in each batch as well.

The chemical parameters studied were %Ashes, %As, %Total Acidity, %Ac, %Chlorides, %Ch, %Dietary Fibre, %Df, pH, %Moisture, %M, %Total Sugars, %TS, %Total Proteins, %TP, and %Total Lipids, %TL.

The results of the analyses of the flours used for the technological assays revealed that they were chemically distinguishable according to type. The chemical results produced for the manufactured bread using a number of conclusions. The type of maize flour may have a strong impact upon the chemical baking properties. Regarding the effect of the type of starter culture used (*isco* or *yeast*), one may conclude that baking with sourdough (*isco*) permits the bread to reach the highest %Ac, %TS, %Df and %TL. The complex wild microflora present may have an important role upon the increase of acidity and, consequently, for eventual differentiation of *broa*.

## EXPERIMENTAL METHODS & ABBREVIATIONS

### BAKING TESTS:

Baking tests were carried out with all possible combinations of:

- > 4 different types of maize flour:
  - Portuguese regional maize flour, *MR*
  - Dentated hybrid maize flour, *MHD*
  - White hybrid maize flour, *MHF*
  - Flint maize flour type 175, *F175*
- > Grinding in 2 different types of mill:
  - electric flour-mill, *ME*
  - watermill, *MA*
- > One type of rye flour at 2 different relative proportions:
  - 15%
  - 50%
- > 2 kinds of starter culture:
  - bakers' yeast, *yeast*
  - sourdough, *isco*

Five (replicate) breads were produced per combination, and one standard *broa* (used as control), manufactured with 50% maize flour *F175* (one of the most common industrial flours used for baking) and with bakers' yeast, was produced in each batch as well. Those gave rise to 18 distinct combinations, as shown below.

Table I - Correspondence between baking tests and nomenclature used

Standard	1	MHDxMA, 15% rye, Yeast	11	MHFxMA, 50% rye, Yeast	21
MRxMA, 15% rye, Isco	2	MHDxMA, 50% rye, Isco	12	MHFxME, 15% rye, Isco	22
MRxMA, 15% rye, Yeast	3	MHDxMA, 50% rye, Yeast	13	MHFxME, 15% rye, Yeast	23
MRxMA, 50% rye, Isco	4	MHDxME, 15% rye, Isco	14	MHFxME, 50% rye, Isco	24
MRxMA, 50% rye, Yeast	5	MHDxME, 15% rye, Yeast	15	MHFxME, 50% rye, Yeast	25
MRxME, 15% rye, Isco	6	MHDxME, 50% rye, Isco	16	F175, 15% rye, Isco	26
MRxME, 15% rye, Yeast	7	MHDxME, 50% rye, Yeast	17	F175, 15% rye, Yeast	27
MRxME, 50% rye, Isco	8	MHFxMA, 15% rye, Isco	18	F175, 50% rye, Isco	28
MRxME, 50% rye, Yeast	9	MHFxMA, 15% rye, Yeast	19	F175, 50% rye, Yeast	29
MHDxMA, 15% rye, Isco	10	MHFxMA, 50% rye, Isco	20		

### CHEMICAL PARAMETERS:

The flours used for the technological assays and the bread produced were submitted to several tests, which are duly described below.

Table II - Type of chemical tests in flours and bread and abbreviations used

%Ashes	%As	%Dietary Fibre	%Df	%Total Sugars	%TS
%Total Acidity	%Ac	pH	pH	%Total Proteins <td>%TP</td>	%TP
%Chlorides	%Ch	%Moisture	%M	%Total Lipids	%TL

## ACKNOWLEDGEMENTS

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## RESULTS & CONCLUSIONS

### Flours

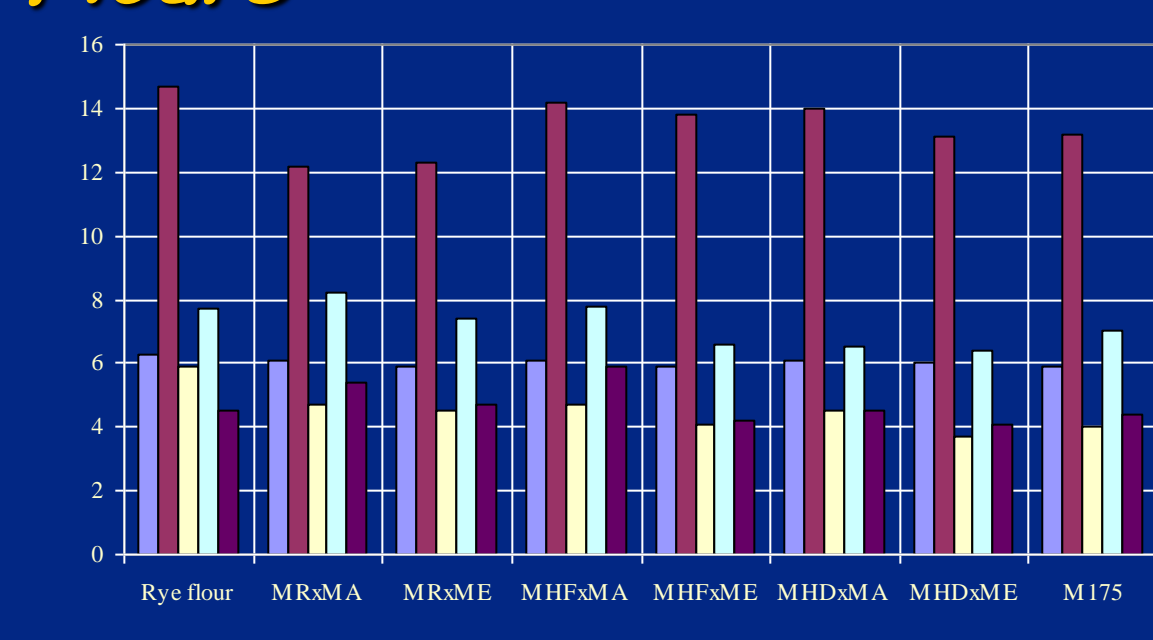


Figure 1 - Chemical parameters of flours used for the baking tests.

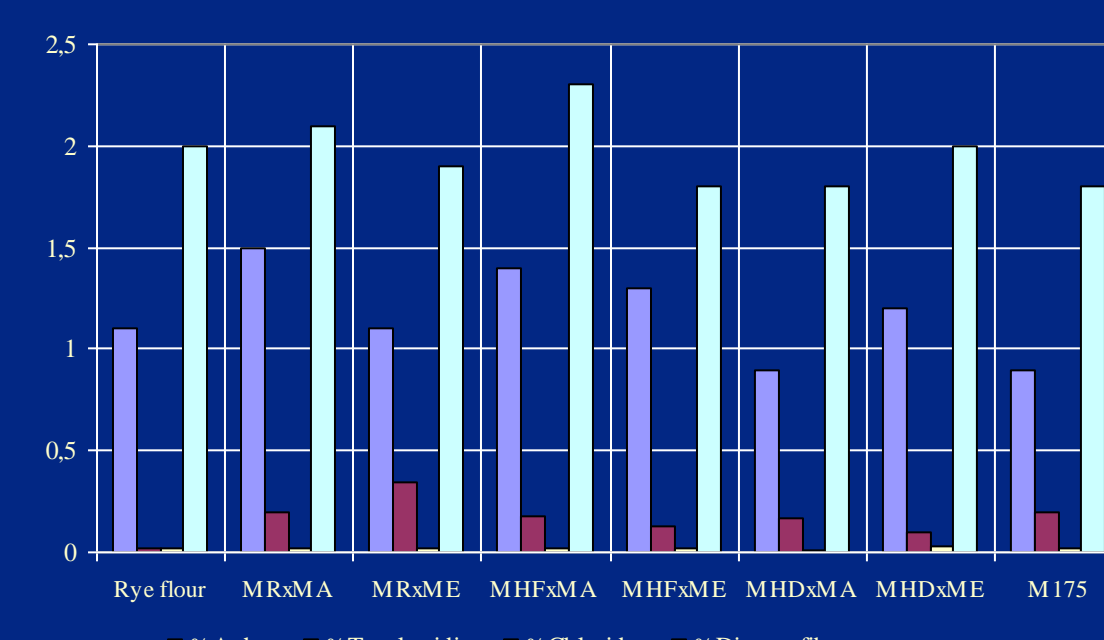


Figure 2 - Chemical parameters of flours used for the baking tests.

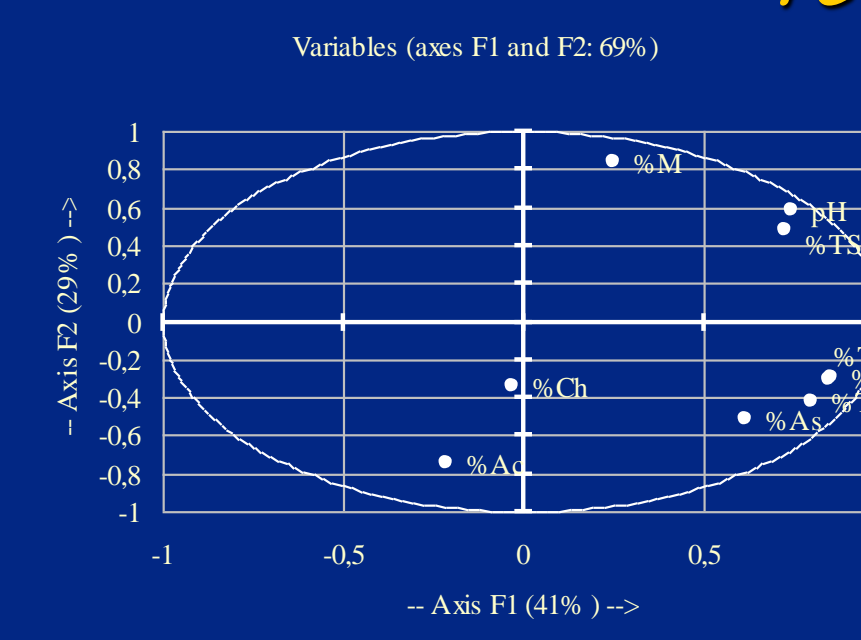


Figure 3 - Loading plot on axes 1 and 2.

### PC analysis

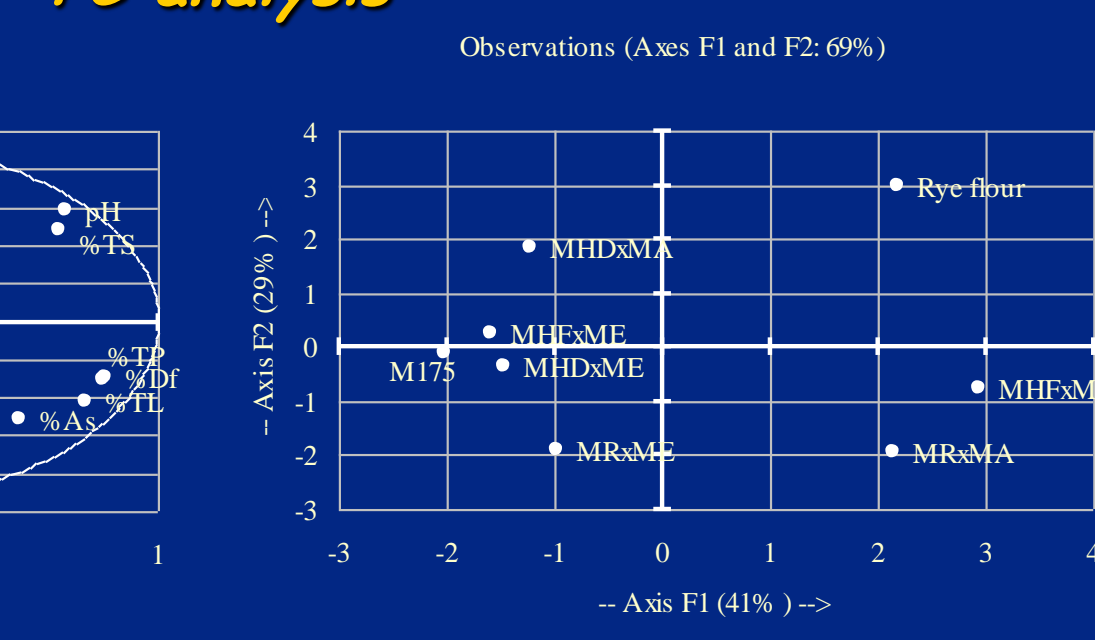


Figure 4 - Observation plot on axes 1 and 2.

Table III - Mean values of chemical results from the maize flours used for the baking tests, and comparison with rye flour

	pH	%Moisture	%Ashes	%Total acidity	%Chlorides	%Total sugar	%Dietary fiber	%Total protein	%Total lipids
Maize flours (average)	6,00 ± 0,100	13,3 ± 0,7955	1,19 ± 0,2340	0,187 ± 0,07819	0,0200 ± 0,005774	4,31 ± 0,3848	1,96 ± 0,1902	7,13 ± 0,6945	4,74 ± 0,6654
Rye flour	6,30	14,7	1,10	0,0190	0,0200	5,90	2,00	7,70	4,50

✓ The results of the chemical analyses in the flours used for the technological assays (see Figures 1 to 4, and Table III) revealed that they were chemically distinguishable according to their type:

- Rye flour had the highest values of pH, %M and %TS, and the lowest value of %Ac
- MR flour had the highest value of %TA and the lowest value of %M
- MHD flour had the lowest value of %TP
- MHF flour had no distinct character

✓ The principal components analysis carried out with our results demonstrated that there were very clear differences according to type of grinding:

- MA grind afforded the highest pH and %TS values when compared with ME grind
- Rye flour was more similar to maize flours ground with the watermill
- F175 was, as expected, more similar to maize flours ground with the electric flour-mill

### Baking tests

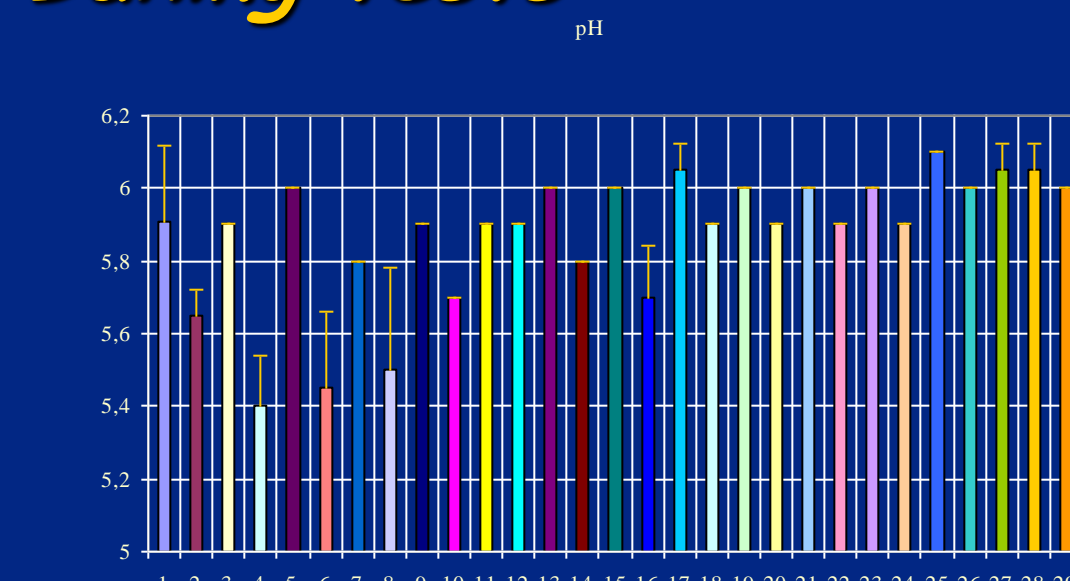


Figure 5 - pH values for bread manufactured under different baking conditions.

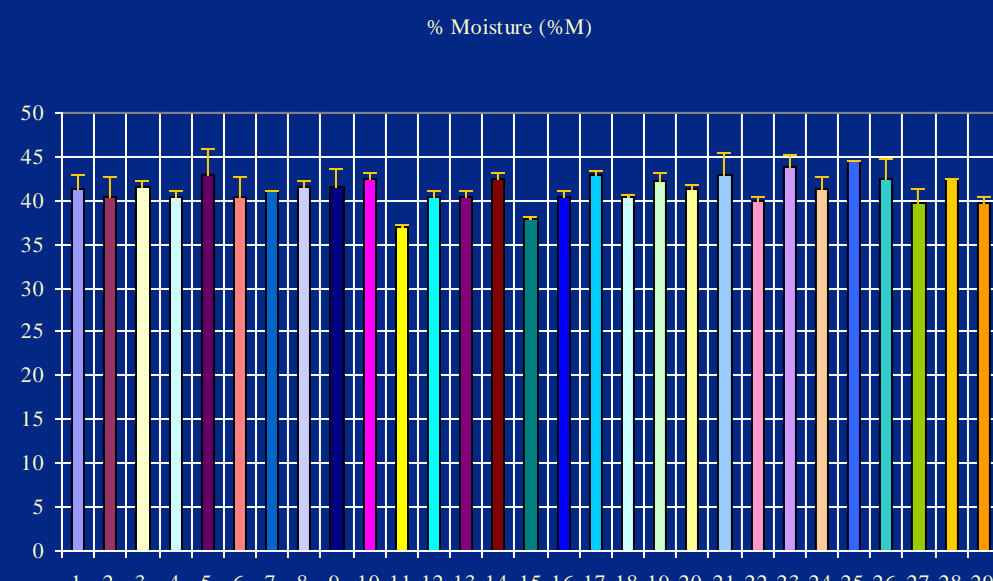


Figure 6 - % Moisture for bread manufactured under different baking conditions.

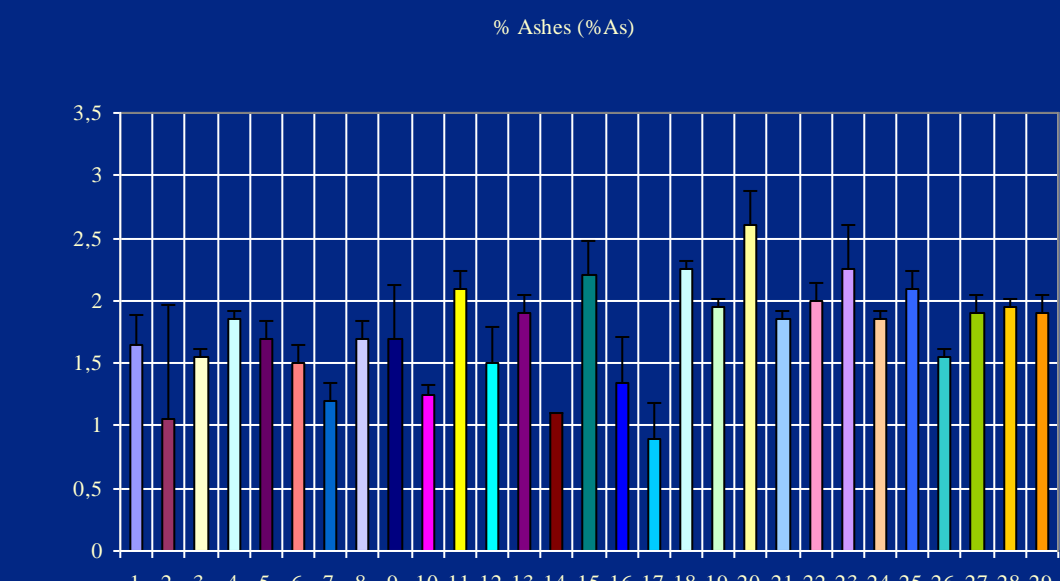


Figure 7 - % Ashes for bread manufactured under different baking conditions.

### PC analysis

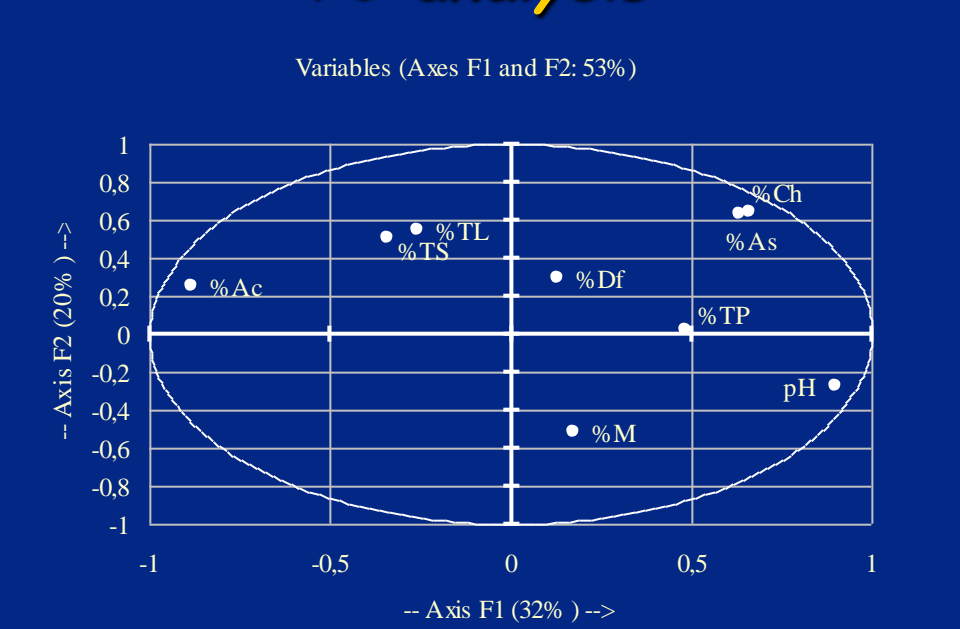


Figure 14 - Loading plot on axes 1 and 2.

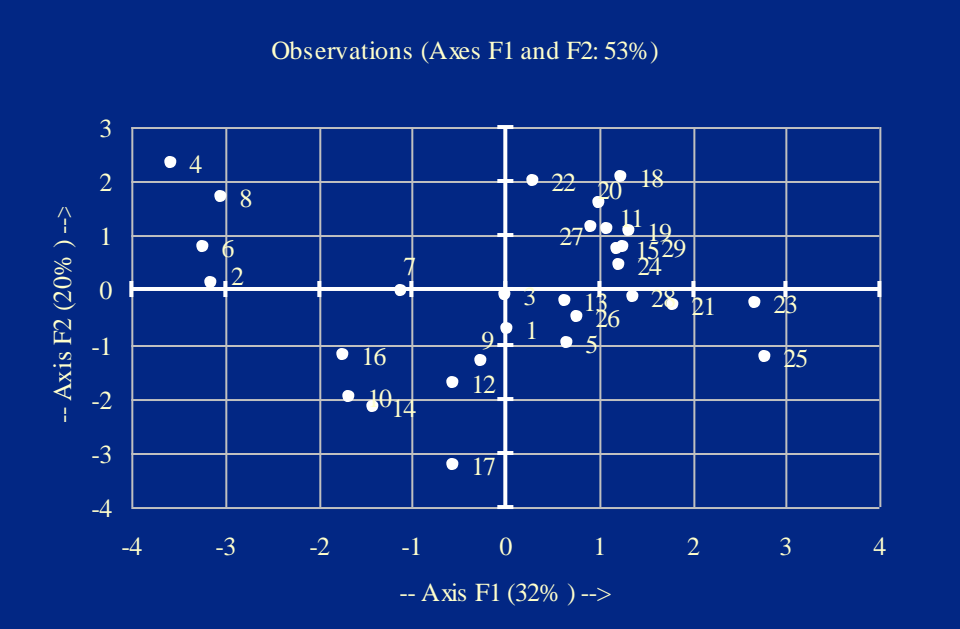


Figure 15 - Observation plot on axes 1 and 2.

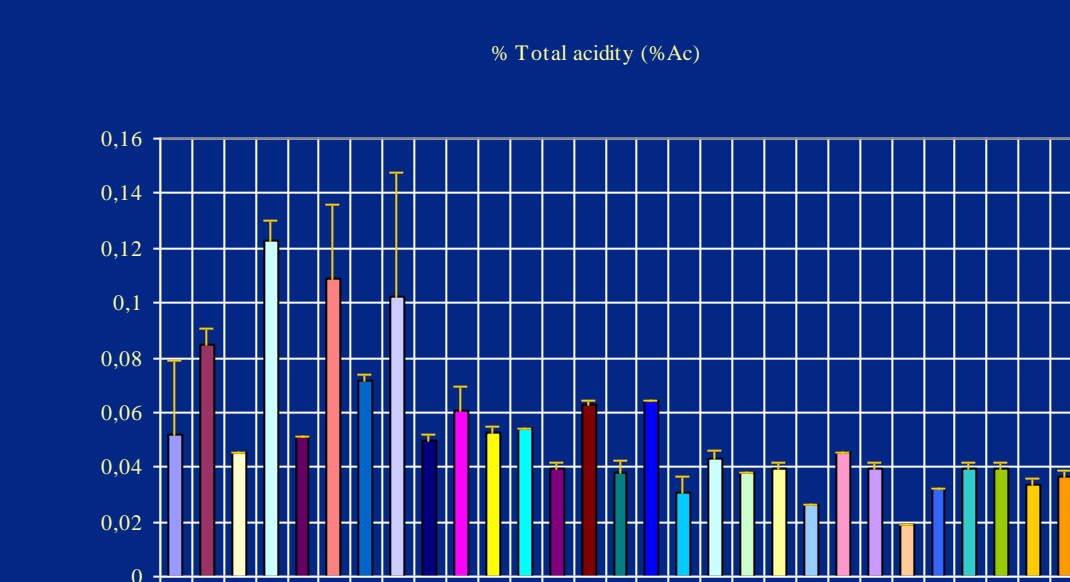


Figure 8 - % Total acidity for bread manufactured under different baking conditions.

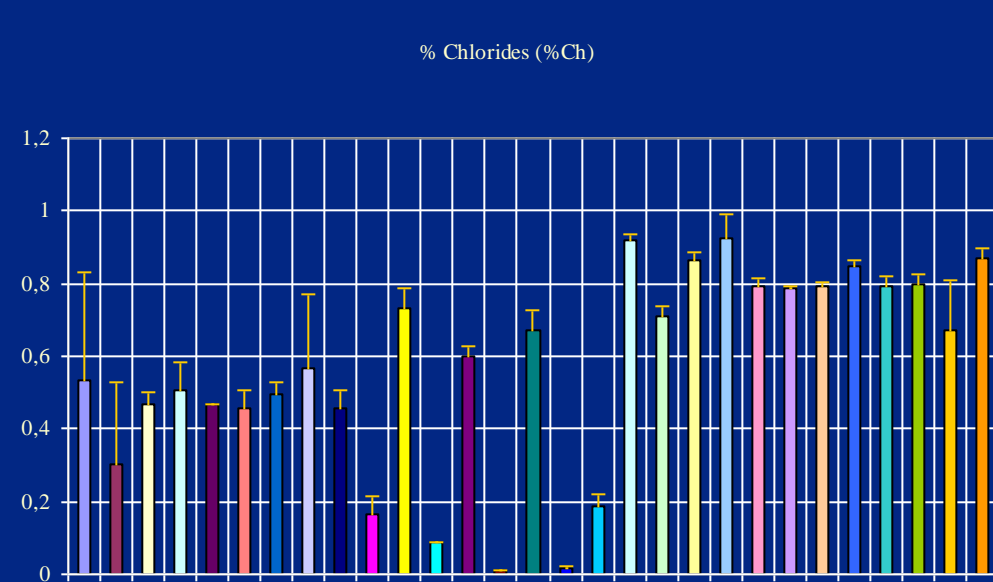


Figure 9 - % Chlorides for bread manufactured under different baking conditions.

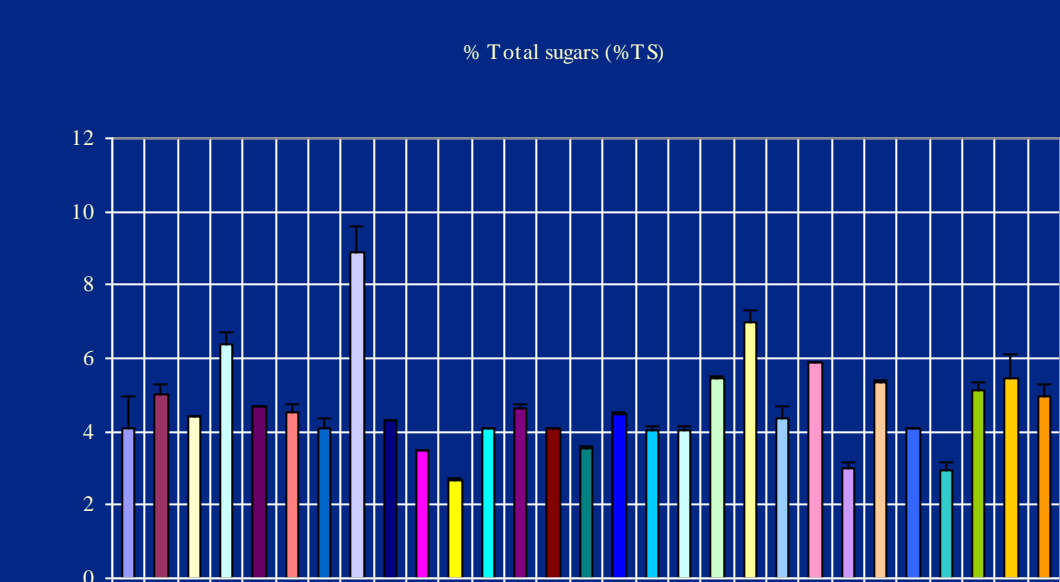


Figure 10 - % Total sugars for bread manufactured under different baking conditions.

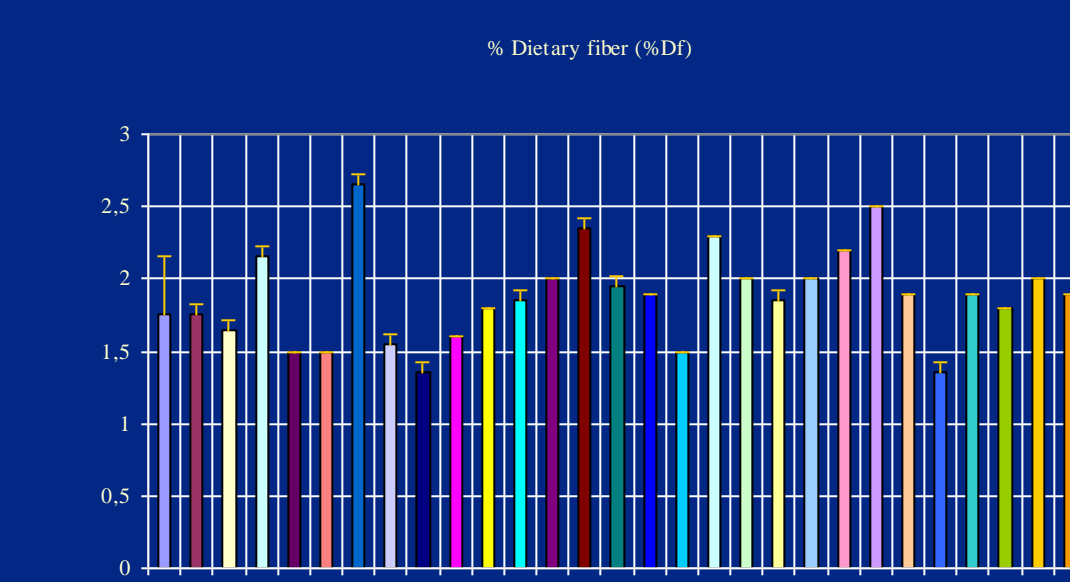


Figure 11 - % Dietary fiber for bread manufactured under different baking conditions.

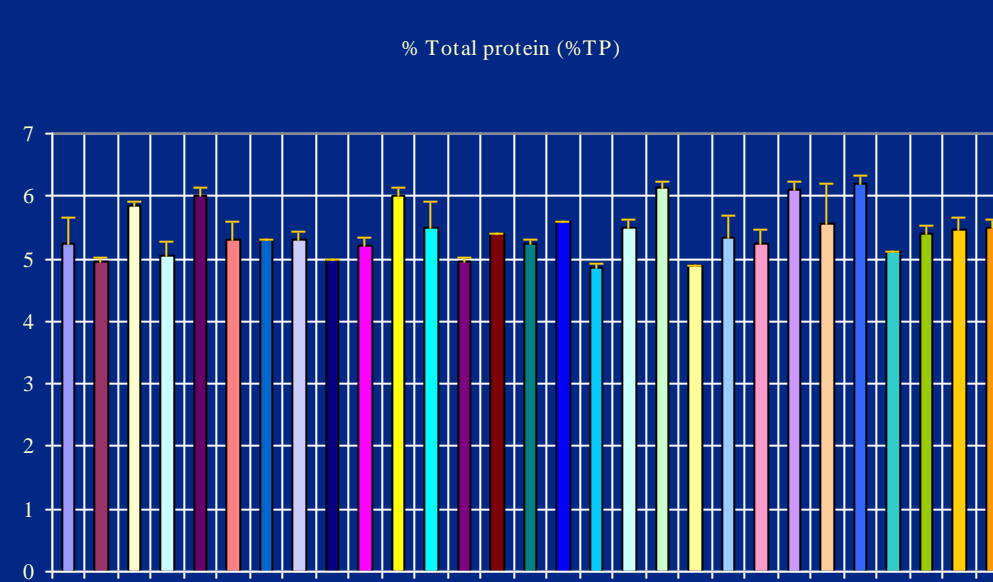


Figure 12 - % Total protein for bread manufactured under different baking conditions.

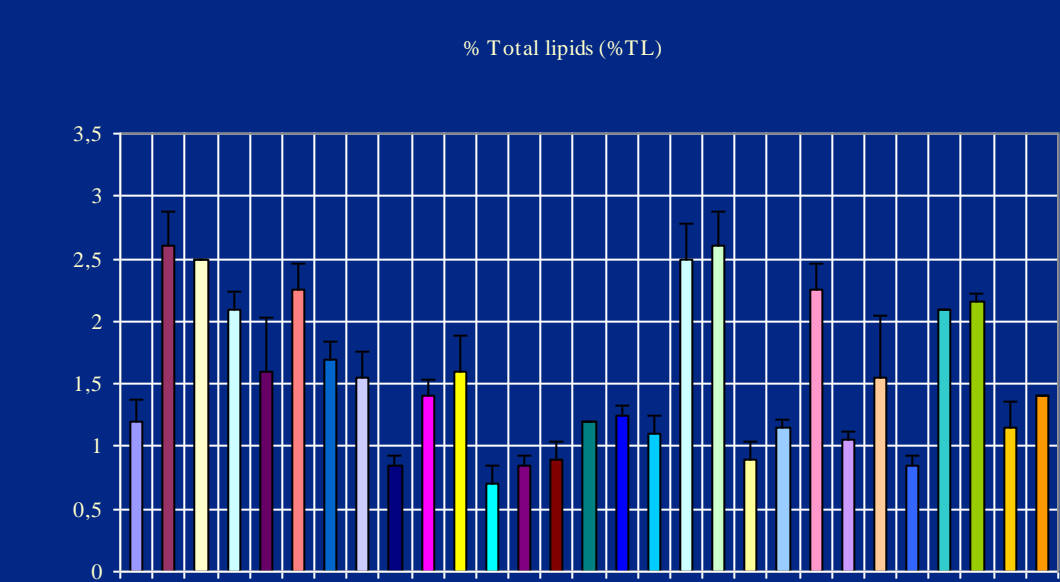


Figure 13 - % Total lipids for bread manufactured under different baking conditions.

Table IV - Mean values of the chemical results pertaining to the bread manufactured, and which have in common at least one process variable

	pH	%Moisture	%Ashes	%Total acidity	%Chlorides	%Total sugar	%Dietary fiber	%Total protein	%Total lipids
Type of maize flour									
MR	5,71 ± 0,2460	41,3 ± 0,9086	1,88 ± 0,3128	0,0785 ± 0,03106	0,494 ± 0,1153	5,425 ± 1,5820	1,81 ± 0,4362	5,38 ± 0,4527	1,91 ± 0,5973
MHD	5,88 ± 0,1361	40,6 ± 2,159	1,94 ± 0,4787	0,05019 ± 0,01264	0,308 ± 0,3052	3,88 ± 0,6335	1,87 ± 0,2590	5,33 ± 0,3688	1,13 ± 0,3000
MHF	5,96 ± 0,07440	42,0 ± 1,618	2,11 ± 0,2542	0,03525 ± 0,008936	0,829 ± 0,07351	4,90 ± 1,264	2,01 ± 0,3451	5,63 ± 0,4773	1,61 ± 0,7360
F175	6,03 ± 0,02887	41,1 ± 1,945	1,83 ± 0,1848	0,0373 ± 0,002872	0,783 ± 0,08302	4,63 ± 1,135	1,90 ± 0,08165	5,36 ± 0,1797	1,70 ± 0,5017
Type of starter culture									
Isco	5,77 ± 0,2063	41,2 ± 0,9346	1,68 ± 0,4397	0,06275 ± 0,03085	0,4954 ± 0,3276	5,12 ± 1,5586	1,91 ± 0,2663	5,29 ± 0,2255	1,66 ± 0,6367
Yeast	5,98 ± 0,07774	41,3 ± 2,155	1,80 ± 0,3772	0,04207 ± 0,01142	0,6436 ± 0,2072	4,24 ± 0,7763	1,85 ± 0,3855	5,56 ± 0,4761	1,47 ± 0,5905
Amount of rye flour									
15% rye flour	5,86 ± 0,1678	40,85 ± 1,8460	1,704 ± 0,4409	0,05482 ± 0,02101	0,5782 ± 0,2709	4,17 ± 0,9807	2,00 ± 0,3522	5,48 ± 0,8851	1,91 ± 0,5972
50% rye flour	5,89 ± 0,2098	41,7 ± 1,330	1,78 ± 0,3827	0,050 ± 0,02930	0,561 ± 0,2975	5,20 ± 1,3842	1,77 ± 0,2651	5,37 ± 0,4042	1,21 ± 0,3900
Type of mill									
MA	5,85 ± 0,1827	41,07 ± 1,612	1,80 ± 0,4261	0,05471 ± 0,02594	0,5625 ± 0,2816	4,69 ± 1,186	1,87 ± 0,2320	5,43 ± 0,4568	1,71 ± 0,7283
ME	5,84 ± 0,2054	41,5 ± 1,782	1,65 ± 0,4485	0,0552 ± 0,02989	0,505 ± 0,2989	4,70 ± 1,521	1,89 ± 0,4537	5,43 ± 0,3957	1,38 ± 0,4957

The chemical results produced for the manufactured bread lead to a number of conclusions (see Figures 1 to 15, and Table IV):

- ✓ Bread made with maize flour type *MHF* had the highest %Ch, %Df, %TP, %As and %M, although *MHF* flour did not show such as trend
- ✓ Bread produced with *MR* flour had the highest %Ac and %TL (like the flours) and the lowest pH, %Df and %TP
- ✓ Bread manufactured with *MHD* flour resulted in the lowest %M, %As, %Ch, %TS and %TL, and one of the lowest %TP

Consequently, one concluded that:

- ✓ The type of maize flour may have a strong impact upon the chemical baking properties
- ✓ The bread obtained with Portuguese regional maize flour (*MR*) led to the highest acidity, which is intended for long term storage and development of its unique character; however, the %TP (and the correlated parameter, %As) was one of the lowest

Regarding the effect of the type of starter culture used (*isco* or *yeast*), one may conclude that:

- ✓ Baking with sourdough (*isco*) permits the bread to reach the highest %Ac, %TS, %Df and %TL
- ✓ The complex wild microflora present may have an important role upon the increase of acidity and, consequently, for eventual differentiation of *broa*
- ✓ The time of fermentation (a parameter not studied) may also have an important effect upon the final chemical characteristics of *broa*

✓ In terms of the bread made with different proportions of maize and rye flours and with different types of milling, the results did not provide evidence of significantly distinct characters, although the type of mill used led to a few distinct chemical properties, as seen before