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STUDY OF (SSD) BISCUIT BAKING BY DYNAMIC THERMAL ANALYSES (DMTA, DSC, TGA).

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1. INTRODUCTION

The baking process of sheeted short dough (SSD) biscuits involves the transformation from a viscoelastic dough into a cellular solid, with a final texture. This process is induced by the expansion of the material submitted to the vaporization of water and gases from leavening powders. Meanwhile, rheological properties of the matrix, which are modified by water losses, thermal denaturation and melting of dough components, reduce the impact of the expansion phenomenon. The objective of this work is to relate the changes of rheological properties of biscuit dough during thermal treatment to structural modifications of the product from molecular level to macroscopic scale.

2. MATERIAL AND METHODS

2.1 Sample preparation

Ingredients provided by LU (La Haye-Fouassière 44-Nantes) - wheat flour, fats, sugars and leaveners - are mixed at desired levels and sheeted in order to manufacture 19 model doughs. Their respective composition is indicated in the following Table in % of hydrated wheat flour.

dough#	water	sugar	fat	leavener
1	26	-	-	-
2-8	16-26	7-45	-	-
9-11	26	-	6-16	-
12-14	26	-		1
15-18	16-26	45	16	1
19	-	45	16	1

Sample #1 represents the basic dough, sample # 19 the actual composition of the biscuit whereas dough #18 has the same composition as #19 with 16% of added water. Other samples are tested to provide information on the influence of each component (#2-14) and their interaction between one another (#15-17). Water content has sometimes to be adjusted to ensure dough sheetability.

2.2 Rheological and thermal methods

A DMTA Mk III (Rheometric Scientific, Loughborough, UK.) was used in the compression mode at a frequency of 5 Hz with a deformation amplitude of 10 µm. Assuming that the static force, applied (0.045N) to the sample in order to keep contact with the plates, can be neglected, the variation of the sample height was also recorded as a function of temperature. The rise is defined as the ratio of the height variation to the initial height ($\Delta h/h_0$) with h_0 = 2mm.

The weight loss of samples (30 mg) was measured as a function of temperature on a thermogravimetric analyser TGA7 (Perkin Elmer, Norwalk, CT, USA). From these results, a weight loss rate was calculated.

DSC experiments on doughs were performed on a DSC 121 (SETARAM, Caluire, France), using 170 mg samples sealed in stainless steel pans. The reference cell contained 105 mg of alumine. Temperature and enthalpy calibrations were carried out with indium.

Runs were carried out in duplicate from 20 to 160°C at the same heating rate of 3°C/min for all 3 types of experiments and average values are reported.

3. RESULTS AND DISCUSSION

3.1 Basic dough

Figure 1 presents a typical sketch of experimental curves gained with the 3 methods, in the case of dough #1. Events observed on DSC thermogram refer to starch melting in low hydrated medium. Their characteric temperature [70, 101, 122°C] are just above those of wheat starch (Burt and Russel 1983): that may be attributed to the presence of other hydrophilic components, like gluten for instance.

Temperature range corresponding to the rise observed with DMTA ($\Delta h/h_0$~150% on the interval [132°C, 144°C]) and the one corresponding to weight loss obtained from TGA, [135°C, 151°C] overlap. Storage modulus E' is always higher than dissipative modulus and its value at rise onset is 40kPa. For expansion observed in the DMTA oven, air incorporated into the dough during mixing and steam formed by evaporation of dough water are the driving forces of the rise of the basic dough sample.

3.2 Influence and interactions of components

Characteristic values of thermal events noted in Fig.1 are systematically quoted for every dough tested. Detailed results are reported elsewhere (Chevallier et al. 1998).

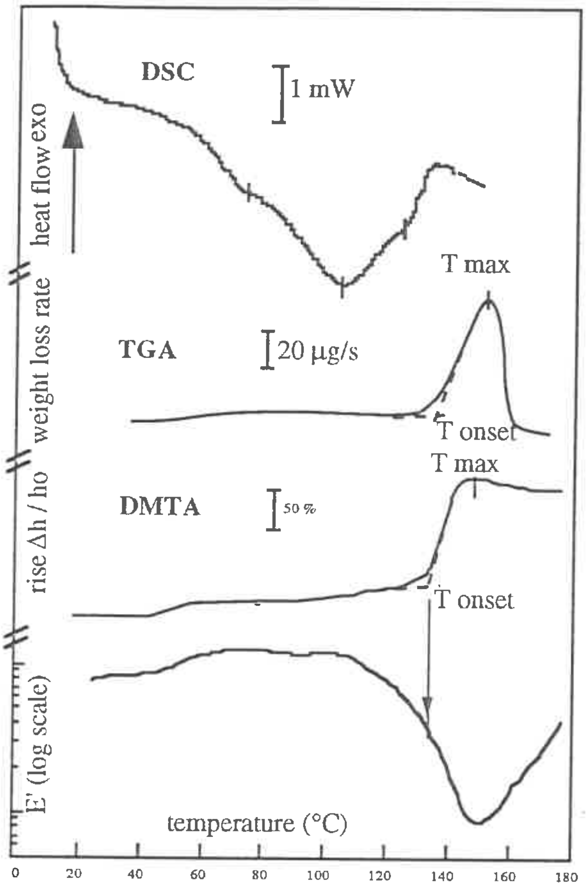

Fig.1: Typical thermogram records for basic dough (#1).

To summarize, sugars increase storage modulus, up to 200 kPa, starch melting temperature, up to 113°C. This last effect, proportional to sugar concentration, may be attributed either to water activity decrease or starch -sucrose interactions (Lelièvre 1976). Fats, by their melting phase transitions, may play a role in the stabilisation of gas cells in doughs (Brooker 1996) and reduce the rise during baking for largest concentration . Phase transitions of starch, even though they have no straightforward influence on the rise, may influence the biscuit texture through the state of cell walls. The only interaction identified with regard to phase transitions is the influence of sugars on thermal transitions of starch. As far as the other ingredients are concerned (fats and chemical leaveners), the system can be considered as additive.

3.3 Biscuit texture development

Rise of all doughs can be represented as function of the elastic modulus E' by DMTA. Indeed, variations of E' over the complete temperature interval of study (20 to 160°C) are very difficult to interpretate mainly because of bubbles expansion. Therefore, values reported for E' correspond to the rise temperature of samples (Fig.2). For doughs with no chemical leaveners (#1 to #10), the lower the rise, the higher the elastic modulus. This variation illustrates that thermomechanical properties of doughs, expressed here by their rigidity increase, preclude expansion of dough samples. Moreover, for a given value of the elastic modulus, rise is more important for doughs with chemical leaveners than doughs with sugars or fats. For the same rigidity, gas produced by chemical leaveners will therefore enhance expansion of dough samples.

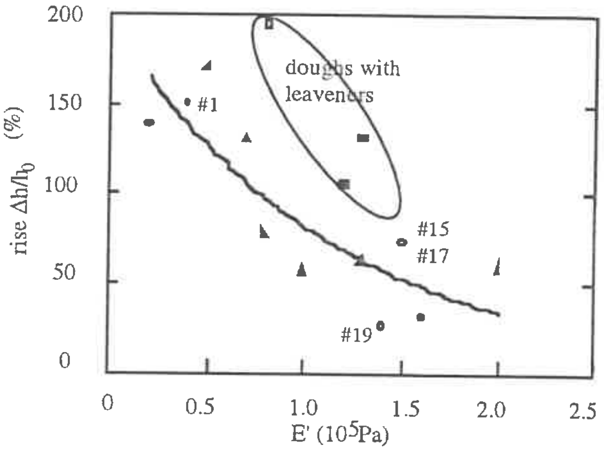

Fig.2: Variations of rise with storage modulus E'

As for extruded foams (Della Valle et al. 1997), final texture of the biscuit is thus governed by two antagonistic phenomena: gas production, function of temperature and water content and matrix viscoelastic properties which are a function of biochemical modification of components.

4. CONCLUSION

The use of DSC, TGA and DMTA shows that thermal transitions, volume and mass changes can be interpreted altogether. This simulation helps the understanding of phenomena involved in SSD biscuit baking process.

However, experiments on such complex materials with reduced water content remain difficult to interprete completely. Roles of flour components, particularly starch and protein, need further studies such as pilot scale baking in order to better define hydrothermal path of the dough and compare the modifications observed to those identified in the present study at the lab scale.

5. REFERENCES

Brooker BE (1996) J. Cereal Sci. 24: 187-198

Burt DJ, and Russel PL (1983) Starch 35: 354-360

Chevallier S, Colonna P, Della Valle G, Lourdin D (1998) J. Cereal Sci. submitted

Della Valle G, Vergnes B, Colonna P, Patria A (1997) J. Food Eng. 31: 277-296

Lelièvre J (1976) Polymer 17: 854-860