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DSC-STUDIES OF FLOUR CONFECTIONERY*)

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Abstract

In this study heat flux DSC (NETZSCH DSC 444) has been adapted to investigate both the thermal characteristics of wheat starch gelatinization and the endothermic melting transition of retrogradated pastry crumb in order to evaluate the degree of staling. Particular attention has been paid to the pastry ingredient sugar, which has a greater affinity to water than starch. Sugars, in general, raise the phase transition temperature of starch gelatinization. Based on a competing effect to the available water sugar lowers the degree of starch gelatinization during baking, influencing the crumb properties. Different sugars may lead to different endothermic phase transition resulting in altered keeping behaviour of the pastry crumb. For instance, lactose leads to less energy uptake (endothermic) compared to sucrose or glucose/fructose after the same period of storage respectively. This points to retarded retrogradation with lactose whereas the rate of retrogradation (lactose : sucrose) remains almost the same at a given moment. DSC results correspond to sensoric results. The positive effects of lactose is subject to further investigations with the aim of optimizing baking techniques.

1. INTRODUCTION

Starch as a major constituent in bread and sweet yeasted pastries is undoubtely considered to be very important in relation to the overall quality and especially to the keeping behaviour of the pastry. The conformational structure of cereal starch and its functionality during and after baking determines the pastry quality. Depending on the water content (water availability respectively) raising temperature causes irreversible conformational alteration of the starch structure accompanied by water absorption and starch gelatinization. During aging (keeping period of the pastry) the amorphous state of gelatinized starch molecules sets back to aggregates of crystalline condition (retrogradation). This is

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considered to be the major cause of the so called staling of the pastry crumb (hardening, loss of elasticity without loss of water content).

2. EXPERIMENTAL

The principles and methods of DSC thermoanalysis are described in other publications (ref. 1, 2). For the present study, a NETZSCH heat flux DSC 444 was used (3). All scans were performed at heating rates of 3°C/min with Al_2O_3 as reference, using sealed stainless steel crucibles. The temperature ranged between 40 and 130°C. The DSC was used to produce thermal events of unbaked (DSC-simulated "baking") samples or to evaluate the character and the intensity of a pre-induced treatment (baking or aging). In particular the degree of gelatinization of starch-water-sugar systems and doughs and the aging effects of partly gelatinized starch (retrogradation) in crumbs has been investigated.

The standard formula of sweet yeasted breads was 100/10/10/49/6/1.25, wheat flour (0,55 % ash content)/oil/sugar/water/yeast/salt. The standard baking test included 30 min baking at 200°C, rectangular tins, floor oven, final centre crumb temperature 98°C. The volume yield of standard loaves were 730 ± 20 cm^3 volume per 100 g flour. The crumb centre (where samples were taken from) water content was 37 ± 0,3 %.

3. RESULTS

Heating wheat starch in the presence of excess water results in an irreversible endothermal conformational change at an onset temperature of 50°C. Many researchers have investigated those typical gelatinization characteristic of starches by DSC (refs. 3-6). The degree of the phase transition to a loosely bound network (gel condition) depends on water availability. As moisture levels of starch/water systems are reduced, the melting of starch crystallites shifts to increasingly higher temperatures and the degree of gelatinized starch drops to lower values (Fig.1).

In further experiments no endothermal transitions were seen below a water content of 22,5 %. In this case no remarkable thermal event occurs in the expected range of 50 to 98°C (upper approximate temperature limit of inner crumb during baking).

Due to the limited water availability in doughs a high degree of starch gelatinization will not appear in breads and pastries. With regard to the higher water affinity of sugars further inhibition of gelatinization occurs depending on sugar content and the kind of sugar (Tables 1 and 2). The diminished energy required for the melting of crystalline zones of starch indicates the competing effects with regard to the available water (Figs. 2 and 3). These effects also results in different mechanical properties of crumb.

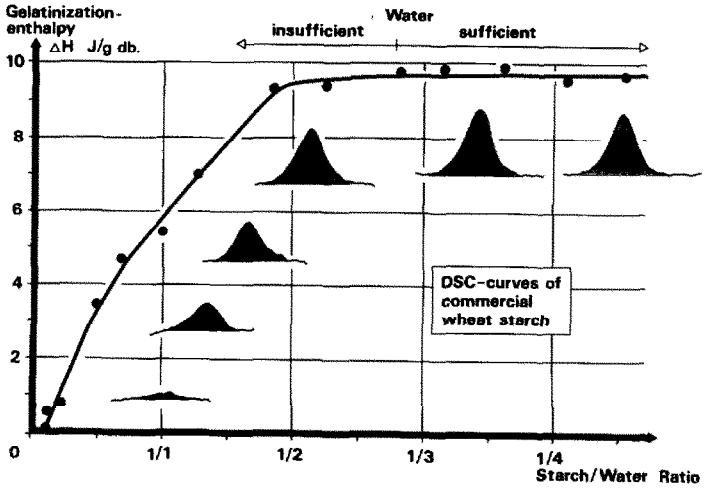

Figure 1. Degree of gelatinization of isolated wheat starch

Table 1
Degree of gelatinization of wheat starch/H_2O, determined by DSC

Sugar/water ratio (solution)	Starch/solution-ratio			
	1/4.6 (solution excess)		1/0.7 (consistent to bakers' practice)	
	Peak Temp. [°C]	Degree of gelatinization [%]	Peak-Temp. [°C]	Degree of gelatinization [%]
-/5 ("bread-like")	61	**100 (fixed)**	60	**44**
("sweet")				
1/5 LAC	67	**90**	67	**36**
GLU/FRU	65	**88**	64	**35**
SUC	67	**88**	66	**34**
("very sweet")				
1/2.5 LAC	73	**92**	75	**32**
GLU/FRU	69	**92**	68	**33**
SUC	72	**94**	74	**30**

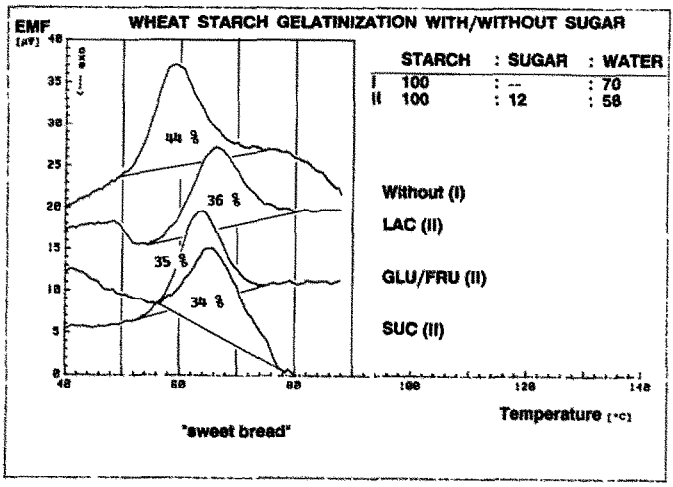

Figure 2. DSC-simulated "baking" of wheat starch ("sweet" level)

Table 2
Degree of gelatinization (%) of wheat starch in doughs (10 parts fat/100 parts flour), determined by DSC

	starch/water -ratio of dough	1. main peak-temp. [°C]	heating to 98°C (consistent to bakers' pract.)(%)
without sugar and fat ("bread-like")	1/0.99	71	27
10 parts sugar ("sweet")			
LAC	1/0.90	78	22
GLU/FRU	1/0.87	77	25
SUC	1/0.86	79	20
20 part sugar ("very sweet")			
LAC	1/0.96	82	19
LAC,pre-solved	1/0.82	88	5
GLU/FRU	1/0.86	79	21
SUC	1/0.79	86	8

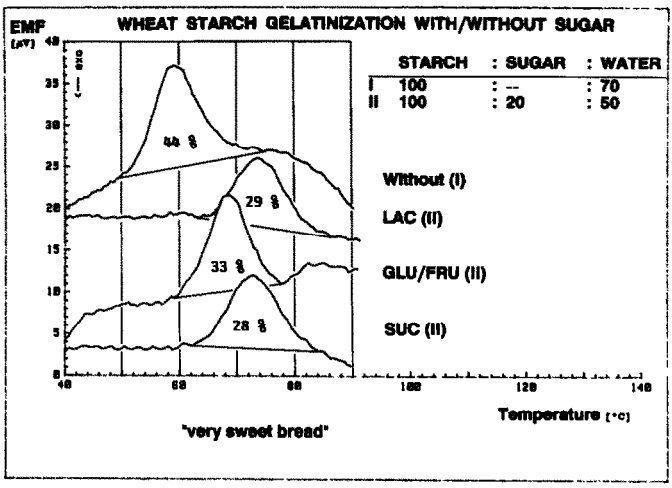

Figure 3. DSC-simulated "baking" of wheat starch ("very sweet" level)

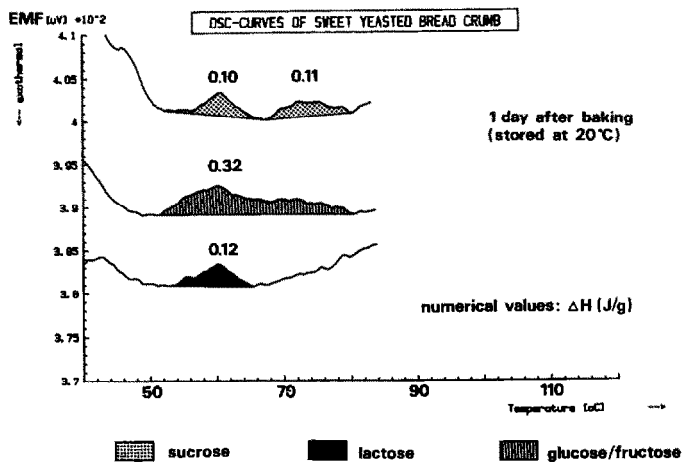

Figure 4. DSC-plots of sweet loaf crumbs after one day storing

As time passes, after gelatinization starch hardens by reassociation of the molecules comprising of gelatinized starch. This is called "retrogradation of starch". Retrogradation is a spontaneous exothermal alteration from a swollen, gel-like state to a more crystalline one. The undesirable staling phenomenon of bread during storage is partly caused

by this retrogradation. It has long been known that bread can be refreshened by heating (e. g. toasted bread). An endothermic transition would be observed when retrograded bread crumbs are heated (Figs. 4-6). As retrogradation progresses, the area of the endothermal melting peaks increase during storage time. Glucose/fructose (in Fig. 4) lead to higher melting enthalpies caused by retrogradation than sucrose. After the same period of storage lactose compared to sucrose or glucose/fructose results in lower endothermic curves (see fig. 5 and 6). This points to retarded retrogradation with lactose whereas the ratio of retrogradation remains almost the same at a given moment (5).

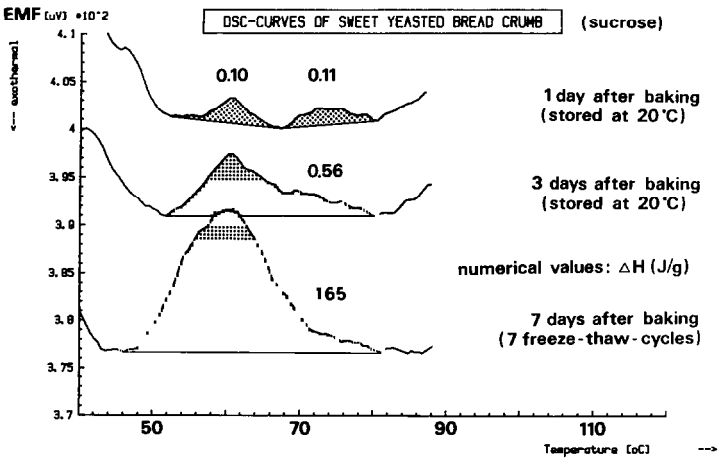

Figure 5. DSC-plots of sweet loaf crumbs (sucrose)

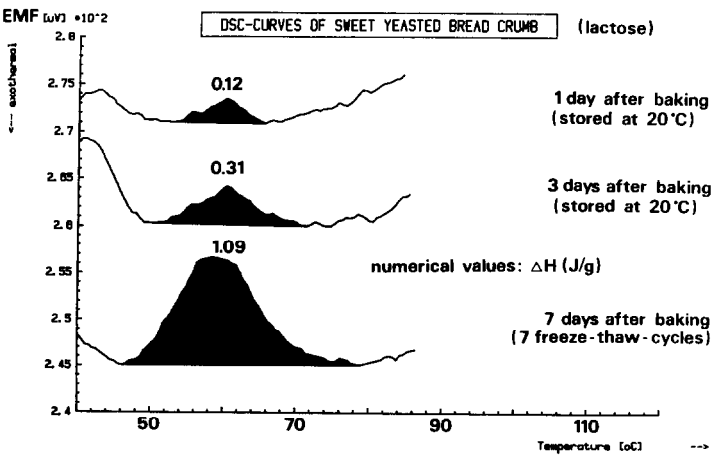

Figure 6. DSC-plots of sweet loaf crumbs (lactose)

4. CONCLUSIONS

The information obtained from our DSC-investigations are helpful in tracing the cause of improved crumb softness. The DSC data correspond to the sensoric properties of the crumb. The positive effects of lactose are subject to further investigations with the aim of optimizing baking techniques. As pronounced, DSC-interpretation can be helpful to the baking industry for recipe design and quality control.

5. REFERENCES

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