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APPLICATION OF DIFFERENTIAL SCANNING CALORIMETRY (DSC) TO CHARACTERIZATION OF COMPONENTS IN RENEWABLE RESOURCES

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SUMMARY

The differential scanning calorimetry has entered the investigation of components in material of plant origin due to its speed and simplicity (ref. 1). In addition to the application of plants in food and textile industries their importance as a substitute for fossile resources increases steadily (ref. 2). The DSC is able to characterize the functional properties of plant components. The results of DSC measurements allow predications on the suitability of these components as an energy resource or as basis for industrial synthesis.

INTRODUCTION

In this study we have used differential scanning calorimetry to characterize functional properties of components in material of plant origin like proteins, carbohydrates or fats. Measurable are phase changes, disintegration e.g. of secondary structures and sorption phenomena. In particular we studied water sorption, swelling behaviour of gluten and starch, gelatinization of starch and reorganization of starch structures (retrogradation).

The DSC thermogrammes give information about:

- characteristic temperatures of the thermal transition (e.g. start and range of starch gelatinization)
- endothermic or exothermic nature of the reaction
- quantity of the heat flux

MATERIAL AND METHOD

As renewable resources we chose potatoes, cereals and legumes. Their main fractions are starch, gluten, sugar and fat. A Mettler DSC 20 TA 3000 and a Netzsch DSC 444, two heat flux DSC instruments, have been applied to the measurements.

RESULTS

A main problem concerning the determination of gluten quality for industrial paper coating is its purity. The gluten is edulcorated from starch. Starch residues affect the quality of the gluten seriously. So it is of great importance to

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detect the starch fraction quantitively. A simple way to realize this offers the gelatinization enthalpy of starch, determined by DSC. Fig. 1 shows the thermogrammes of two gluten of different purity. The area of the gelatinization peak represents the concentration of the starch fraction.
An important value of native substances is the amount of free water. It is responsible for the water activity inside of the material which affects e.g. the growth of micro-organism. The determination of the total water amount does not give sufficient information about water activity because of different kinds of water binding. An easy way to estimate the amount of free water offers the determination of freezable water. Fig. 2 shows the melting peak of frozen water in a starch/water mixture. The second run demonstrates that some water has been bound during the gelatinization which has taken place in the first run of the heating programme.
In recent years starch industry has asked for starches with high amylose content. According to this agriculture has raised new kinds of legumes. One of the major criterions concerning the manufacturing of starch is its gelatinization behaviour. The usual determination of this property by Brabender-viscogramme fails with this legume starch. Here DSC proves to be proper method, too (Fig. 3 and 4).
A problem during the processing of starch containing material is its ability to age. This ageing phenomenum influences the product quality seriously. In Fig. 5 the disintegration of starch structures, built up during ageing, is compared with the gelatinization of native potato starch. The area of the peak represents the degree of the ageing, often called retrogradation.
Another phenomenum which influences the properties of starch is caused by annealing. Starch/water mixtures which are kept at temperatures close to the beginning of gelatinization show a shift of the gelatinization range to higher temperatures (Fig. 6).
Fig. 7 shows amylose/lipid complexes in cereal starch after extraction with alcohols (methanol, ethanol, isopropanol). The complexes interfere the processing of the starch. So the raw material has to be purified before. DSC can detect the amount of complex residues which represents the starch contamination.
The seven figures given in this study are part of poster, presented at the 7^{th} Ulm Calorimetry Conference and may serve as selected examples.

CONCLUSION

The Heat Flux DSC is a sensitive method, completing other non calorimetric methods. The recognition of this potentiality by the interested researches will result in a greatly expending activity.

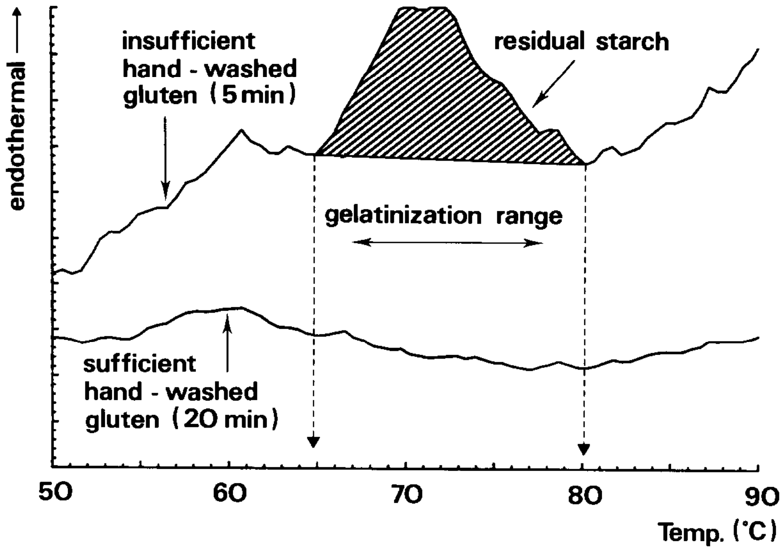

Fig. 1. DSC-thermogrammes of gluten after different times of starch extraction. The gelatinization peak represents the starch concentration.

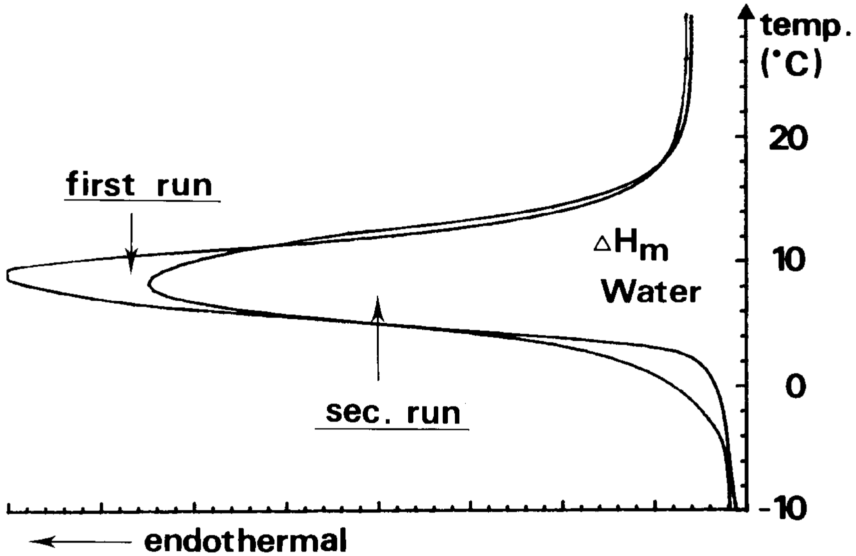

Fig. 2. Determination of free water by the melting enthalpy of freezable water. The second run shows that some amount of water has been bound during gelatinization in the first run.

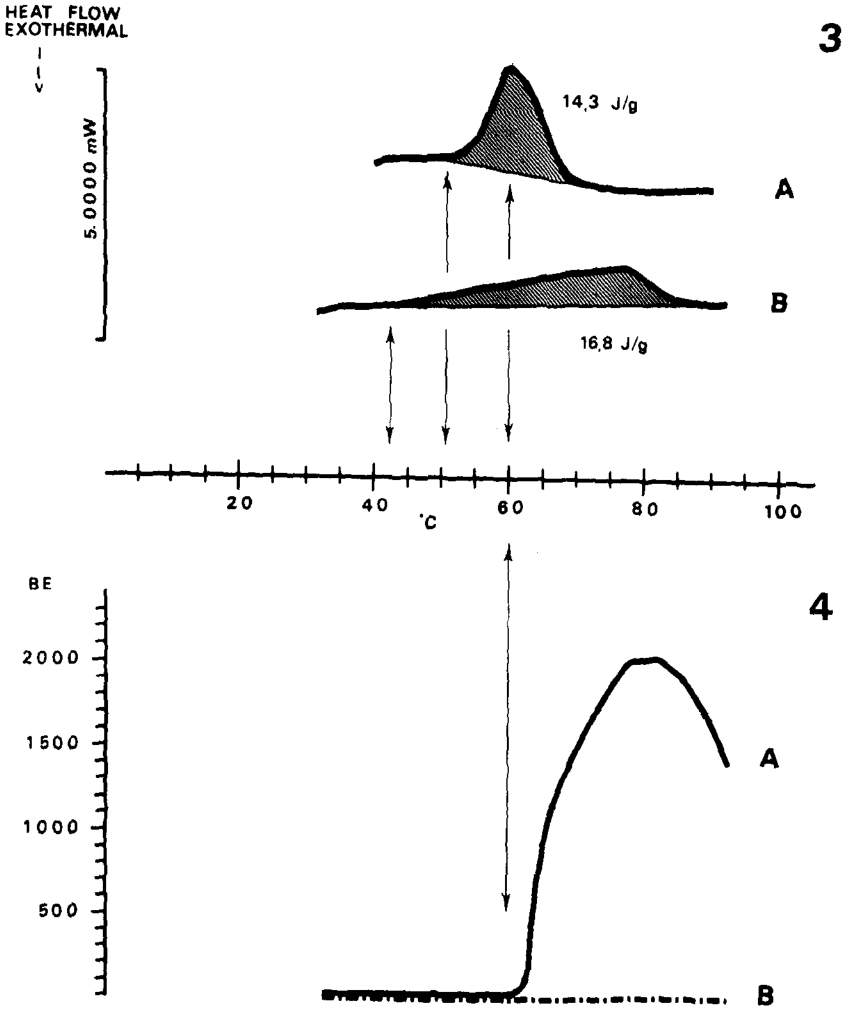

Fig. 3 and 4. Comparison of starch gelatinization DSC(3) and Brabender-viscogramme(4). The curves show potato starch (A) and a legume starch with high amylose content (B).

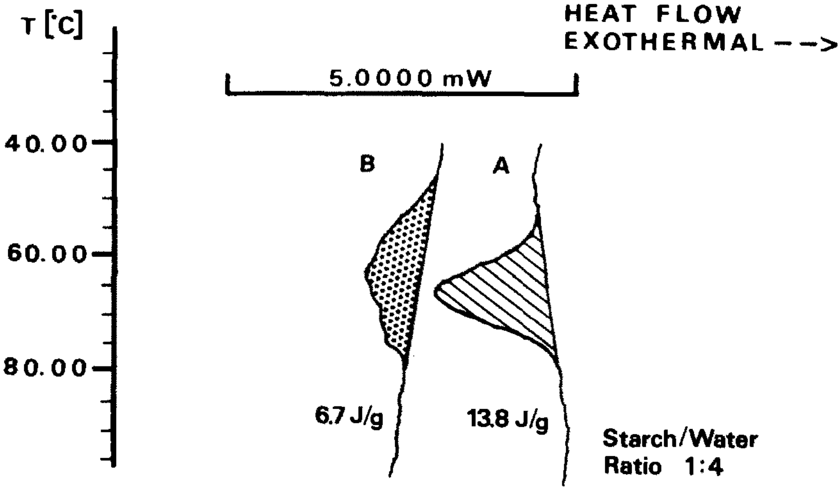

Fig. 5. DSC-curves of native potato starch (A) and potato starch gel after 4 freeze-thaw-cycles (B).

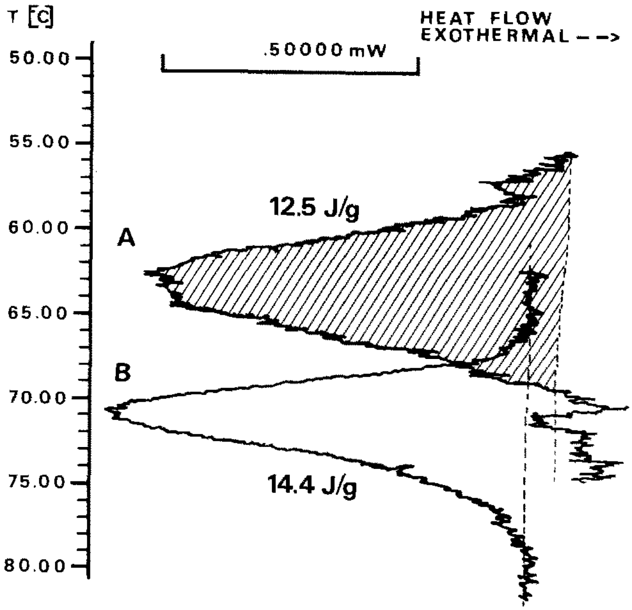

Fig. 6. Shift of the gelatinization range of potato starch to higher temperatures (A - B) after annealing at 325K for 72h. The gelatinization enthalpy increases and the peak appears more sharply.

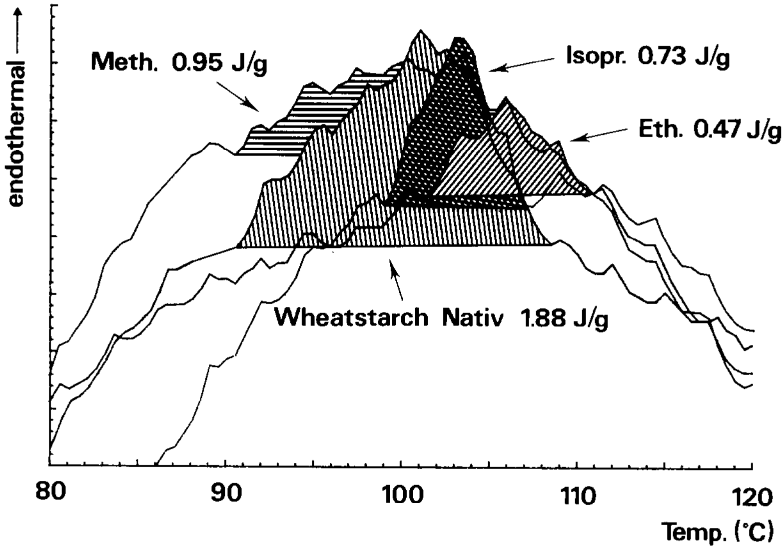

Fig. 7. DSC-curves of wheat starch after extraction with alcohol/water mixtures. The thermogrammes show the decrease of the amylose/lipid complex.

References

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