ENZYME-ASSISTED TALLOW FRACTIONATION: THE POTENTIAL FOR ADDED-VALUE PRODUCTS

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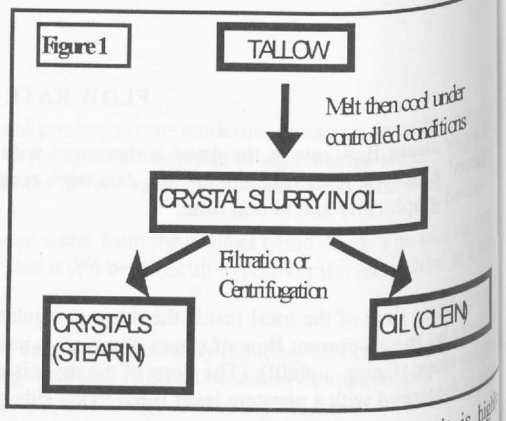
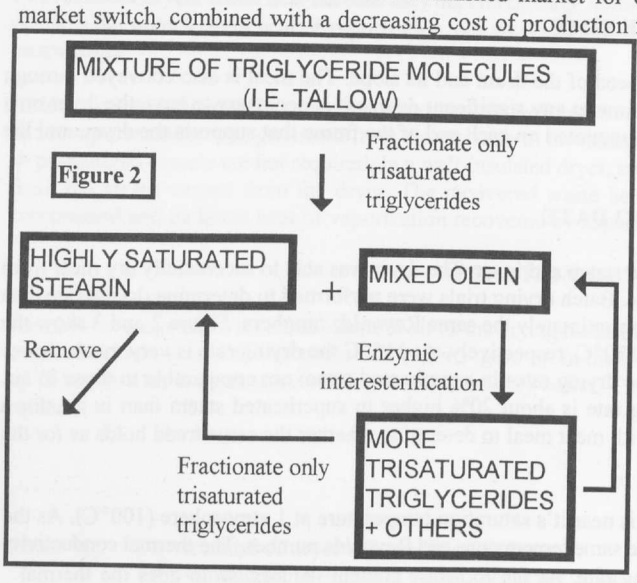
INTRODUCTION

Tallow is one of the major by-products of the meat processing industry. Beef tallow, in particular is valued for its distinctive flavour and its stability when used in frying. Tallow, however, contains a much larger proportion of saturated fats than vegetable oils (palm oil excepted). Since these have been linked with high blood cholesterol and coronary heart disease, major users of frying fats (notably fast-food chains) have switched from using tallow or tallow/vegetable oil blends to vegetable oils (1). This has resulted in a much diminished market for edible tallow. This market switch, combined with a decreasing cost of production for palm oil has put downward pressure on the value of tallow.



Since there is little the meat industry can do to reduce tallow production, it is highly desirable to find ways to add value by improving the properties of tallow for end-use applications. One way to do this is to reduce the saturated fat content of tallow while retaining its valued properties as a frying fat, and/or by modifying its melting profile to create products useful in other areas of the food industry.



Fractionation is currently used industrially to alter the melting profiles of fats (2) (Figure 1). Tallow is made up of triglyceride molecules, which contain three fatty acids linked to a glycerol molecule. Tallow triglycerides molecules (in common with those of other fats) mostly contain a mixture of saturated and unsaturated fatty acids, so separation of intact triglycerides is a poor method for enriching fractions in saturated or unsaturated fatty acids.

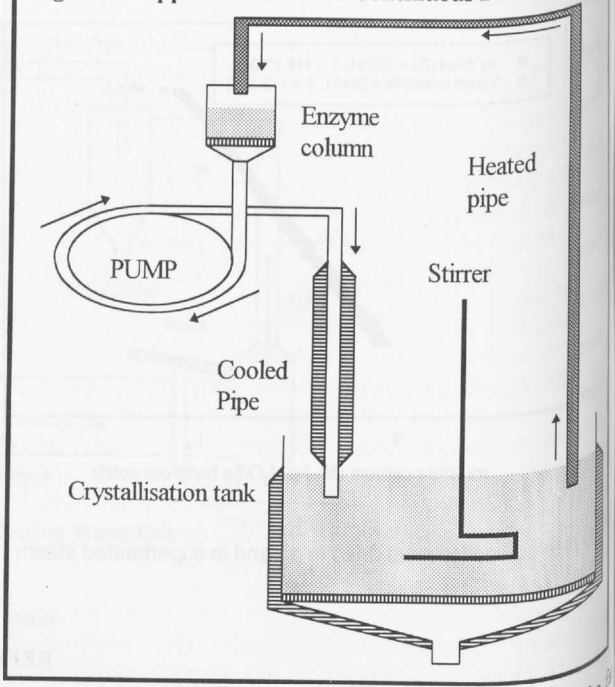
Redistribution of the fatty acids by interesterification of the triglycerides, *during the fractionation process*, is required to achieve this (Figure 2). As the cycle progresses, more (predominantly) trisaturated stearin is produced and the olein becomes more unsaturated. The process can be continued until the olein has the desired properties.

The use of lipase-directed interesterification would make it possible to produce products such as:

- A predominantly monounsaturated olein which would be low in polyunsaturated fatty acids and would retain the desirable tallow flavour; this would be ideal for industrial frying.
- A source of oleic acid for the oleochemical industry,
- Food ingredient fats with precisely tailored melting profiles,
- A highly saturated stearin which could be used as a hardening agent if blended with vegetable oils, thus avoiding hydrogenation.

The goal of this project was to explore the practical limits of this concept.

Figure 3: Apparatus Used for Continuous Fractionation



EXPERIMENTAL

Materials: The enzyme used in most experiments was immobilised *C. antarctica* lipase (Novozym 435) from Novo, Denmark. The substrate was Chef Royale, a refined and partially fractionated tallow product from Bakels Edible Oils, New Zealand.

Batch Fractionation: Typically, Chef Royale was weighed into a stoppered conical flask, acetone added (30% w/w, if desired) and the mixture melted. The molten mixture was then shaken in a water bath at the desired temperature. The crystals that formed were removed by suction filtration in jacketed filter funnels at the fractionation temperature. Acetone was removed (if required) from the oil fraction by rotary evaporation.

Continuous Fractionation: Chef Royale (up to 600 g) was circulated through the apparatus in Figure 1. The crystallisation tank was water jacketed at the desired crystallisation temperature. Tallow was heated to 50°C in the heated pipe before passage through the enzyme column and then cooled back to crystallisation temperature before return to the crystallisation vessel. The process was continued until sufficient crystals had formed in the crystallisation vessel and then the stearin and olein were separated by filtration.

Analysis: Stearins and oleins were analysed by gas chromatography for fatty acid profile and free fatty acid (FFA) content. Melting profiles were determined by differential scanning calorimetry.

RESULTS AND DISCUSSION

The important parameters that will determine the practicality of the enzymic fractionation process are the ability to:

- Make large changes in fatty acid composition and melting profile of fractions in a single fractionation step,
- Keep FFA formation within acceptable limits (below 2%),
- Demonstrate a long enzyme lifetime under realistic reaction conditions,
- Develop a practical apparatus for enzymic fractionation.

Results illustrating these requirements are shown below.

Changes in Fatty Acid Composition: Enzymic interesterification in a batch process (in the presence of 30% acetone) was able to produce significant increases in the percentage of unsaturated fatty acids in the olein, compared with no-enzyme controls (Figure 4). We expect to improve on these results with further development.

FFA Formation: The FFA levels varied but were around the 2% limit that was considered acceptable (Figure 5). It appears that the amount of enzyme is the main determinant of FFA formation. Further development should reduce these levels.

Effect on Melting Profiles: The melting profiles of samples from the experiment described in Figures 4 and 5 were taken a different times and compared with the starting material (Figure 6). Significant changes were observed, relative to no-enzyme controls.

Enzyme Stability: Enzyme was maintained at 50°C in Chef Royale and activity was monitored using an interesterification assay. There was no loss of activity over three weeks (Figure 7), in fact, activity actually increased. This may be due to slow diffusion of tallow into the pores of the enzyme support matrix.

Figure 4. Effect of Novozym on % Unsaturation of Olein

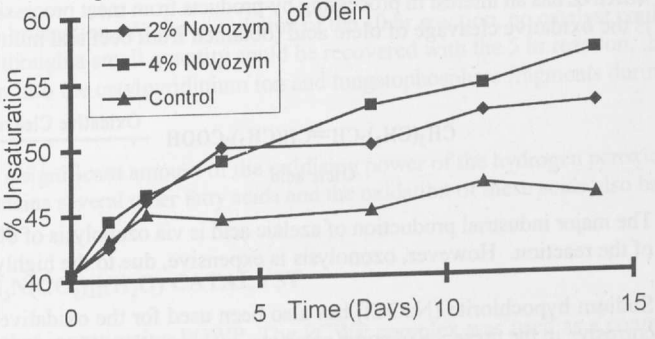


Figure 5. Effect of Novozym on FFA Formation

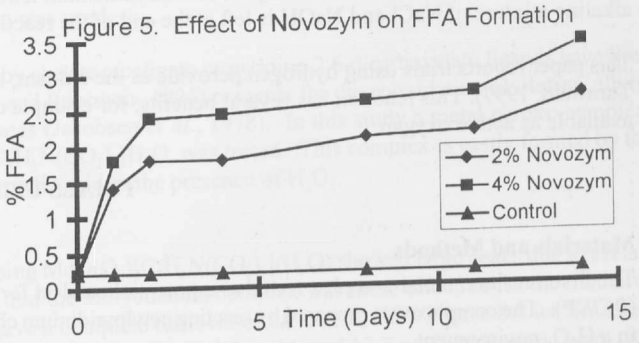
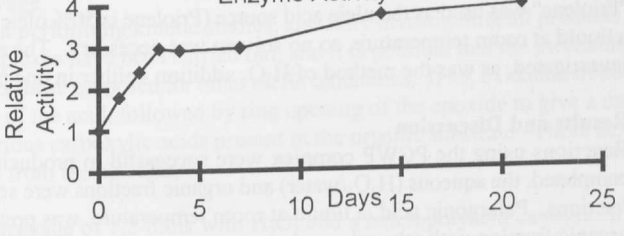


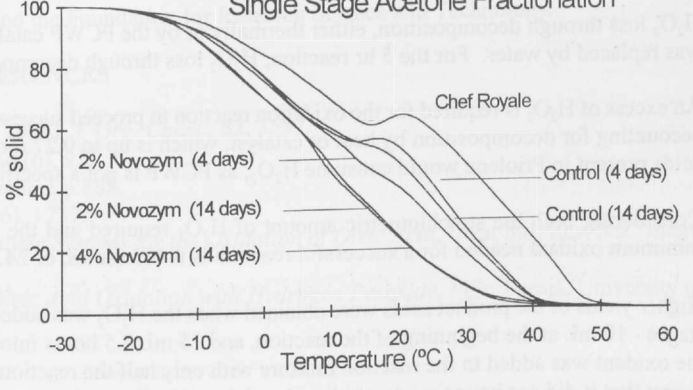
Figure 7 Effect of Reaction Conditions on Enzyme Activity



CONCLUSION

The continuous enzyme reactor is still under development and details cannot be given at this stage but results look very promising. These results show that fractionation in the presence of enzymes can achieve the requirements stated above and usefully increase unsaturated fatty acid content. Work is currently underway to further optimise the process and determine its practical limits. We intend to produce samples of fractions for evaluation; requests for these would be welcome.

Figure 6: Melting Profiles of Oil Fractions From Single Stage Acetone Fractionation



ACKNOWLEDGEMENTS

This project is supported financially by the NZ Meat Research and Development Council under contract # 95IR 104/2.2.

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