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A framework for an economic model of novel process for the fractionation of Dried Distillers Grain with Solubles

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ABSTRACT

Background
Bio-refining is the concept of utilising byproducts of first generation biofuels such as bioethanol, to generate new revenues from them. Dried Distillers Grain with Solubles (DDGS) is a byproduct from bioethanol production plants and distilleries that is currently used as an animal feed. In the UK the mass of DDGS produced is predicted to increase from 250 to 960 kg/annum1,2. Collaborative research by the Universities of Reading, Bath, Birmingham and UCL aims to valorise DDGS by extracting its component fractions.

Project Description
A framework was developed for a decisional tool and economic model of a large-scale DDGS fractionation process, designed to assess the economic viability of such a process. The Excel-based model uses experimental data, to generate mass balances, and assumptions from decisional tools developed at UCL for the biopharma industry, to scale-up and analyse process costs.

Industrially relevant case studies were used to highlight the tools developed at UCL for the biopharma industry, to scale-up and based fractionation process extracting its component fractions.

AIMS AND OBJECTIVES

• Predict a large-scale DDGS fractionation process and use experimental small-scale data to conduct a mass balance on the oil and protein extraction steps.
• Accurately model the costs of the unit operations to predict the overall cost of the process.
• Create a user interface that allows key information to be easily inputted into the model and provides a visualisation and dynamic analysis of process performance and associated costs.
• Run a series of industrially relevant case studies to assess the effect of initial DDGS load mass (1 - 100 tonnes) and moisture content (11% - 70%) on the costs of the process.
• Identify limitations and bottlenecks within the process and assess sensitivity of process costs to changes in key process parameters.

CASE STUDY RESULTS

Effect of increasing initial DDGS load mass on total annual costs (£/year)

100 tonnes (11% moist.)

Labour Costs 9%

Other Indirect Costs 3%

Depreciation Costs 34%

Raw Material Costs 42%

Other Direct Costs 12%

100,000 tonnes (11% moist.)

Labour Costs 0%

Other Indirect Costs 1%

Depreciation Costs 40%

Raw Material Costs 47%

Other Direct Costs 12%

• Labour cost is most significant at smaller scale (operators control multiple pieces of equipment)
• Raw material costs and depreciation become more significant at larger scale
• 100,000t is the most realistic case from industry

Breakdown of total annual cost per unit operation with scale-up

100 tonnes (11% moist.)

Oil Ext 1.4 x 10^6

Protein Ext 2.6 x 10^6

Sugar Ext 3.2 x 10^6

100,000 tonnes (11% moist.)

Oil Ext 3.8 x 10^6

Protein Ext 6.0 x 10^6

Sugar Ext 7.8 x 10^6

• The model shows oil extraction to be the most expensive step, irrespective of scale
• The main driver of the increased cost when scaling up is depreciation i.e. the equipment cost (FCI)
• Sugar step becomes significantly less expensive in comparison at 100,000t

CONCLUSIONS

• An initial framework has been created, modelling the three steps of the fractionation process. The model showed that increased DDGS load mass and lower moisture content caused higher COGs/year due to increased equipment and raw material costs. Further analysis identified the centrifugation step to be the main driver behind the high equipment cost. Therefore an alternative filtration system must be found.
• The model highlights how larger scale impacts cost, however it is difficult to draw accurate conclusions because of the limitations of the model.
• The model has the ability to evaluate the effect of different types of DDGS on costs, further analysis is required to assess the true impact of variations in DDGS composition.
• An assessment of some revenue streams is included in the model, however additional potential high value products from protein need to be identified, such as glutamate derivatives which can be used to produce high value chemicals.

FUTURE WORK

• Make durations a function of material and capacity limits of equipment to improve the Batches per Year calculation.
• Create DoE equations suitable for large-scale predictions.
• Link to optimization and program in C#.

REFERENCES

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2. Weightman A. Adding value to DDGS. HGCA. 2013.