Ball Milling Effects on the Properties of Stabilised Oat Bran Protein Concentrate Powder

Kurnia Ramadhan [a,b] and Tim J. Foster [a]

[a] Division of Food Sciences, University of Nottingham, Sutton Bonington Campus, Leicestershire LE12 5RD, United Kingdom
[b] Department of Food Science and Technology, Universitas Bakrie, Jl. H. R. Rasuna Said Kav C22, Jakarta 12920, Indonesia

EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN Food

Introduction

Stabilised oat bran protein concentrate (SOBPC) is the bran fraction of oat that had undergone enzymatic and thermal processes, hence the protein was concentrated to half of its dried weight, and large amount of carbohydrate and lipid were preserved. This heat treatment denatures the proteins within cereal bran.

Ball milling has been used to pulverise materials into fine particle size powder. Diminution of particle size will increase the surface area, hence affecting hydrophilic properties and improve dispersibility of particles in food systems. At the molecular level, ball milling is able to change conformation of carbohydrates and proteins to some extent.

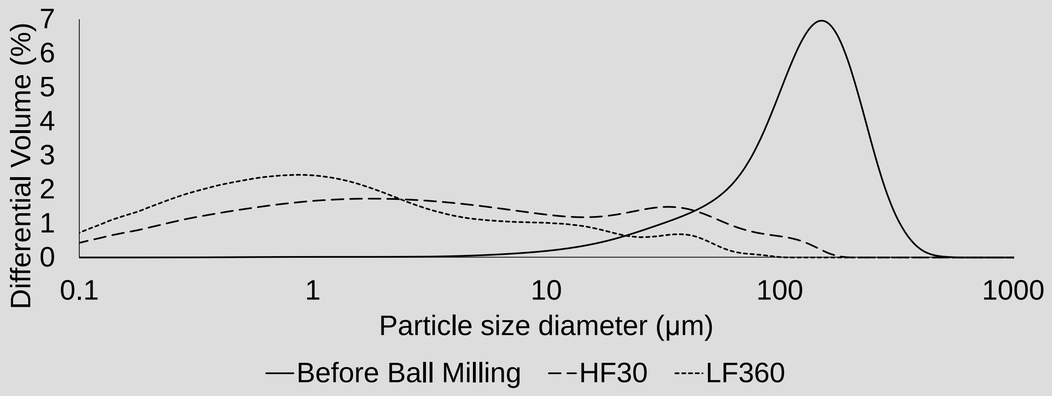
The predominant parameters of ball milling that cause changes in material properties are milling frequency and time. The present study aims to investigate the effects of different ball milling frequencies on the physical, infrared spectral, and thermal properties of stabilised oat bran protein concentrate powder.

Materials and Method

Stabilised Oat Bran Protein Concentrate (SOBPC) was commercially available as PrOatein® and supplied by Tate & Lyle Oat Ingredients (Kimstad, Sweden). It is declared to have ca. 94% dry matter, which contain 54% protein, 17% fat, 18% carbohydrate, and 2% fibre on dry basis.

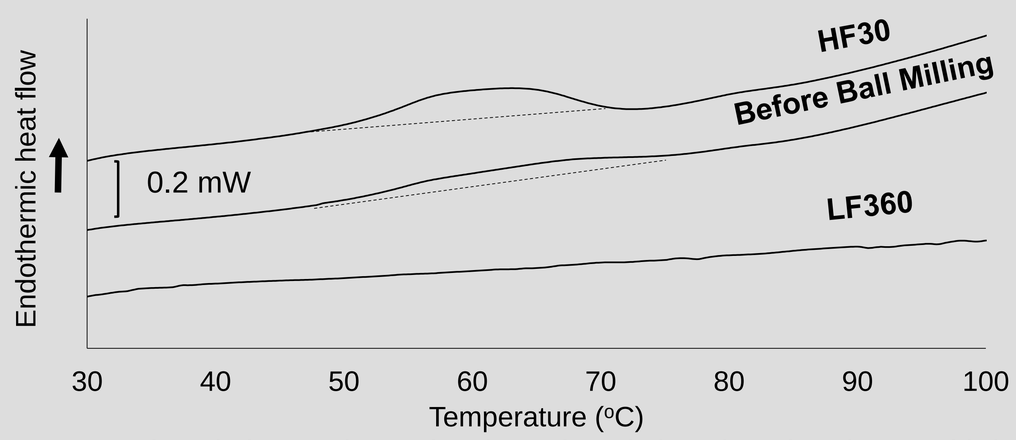
Sample	Milling frequency (rpm)	Milling time (min)	Milling operation
HF10	800	10	1 min milling and 10 min pause
HF20	800	20	
HF30	800	30	
LF120	200	120	5 min milling and 5 min pause
LF240	200	240	
LF360	200	360	

Particle Size Distributions



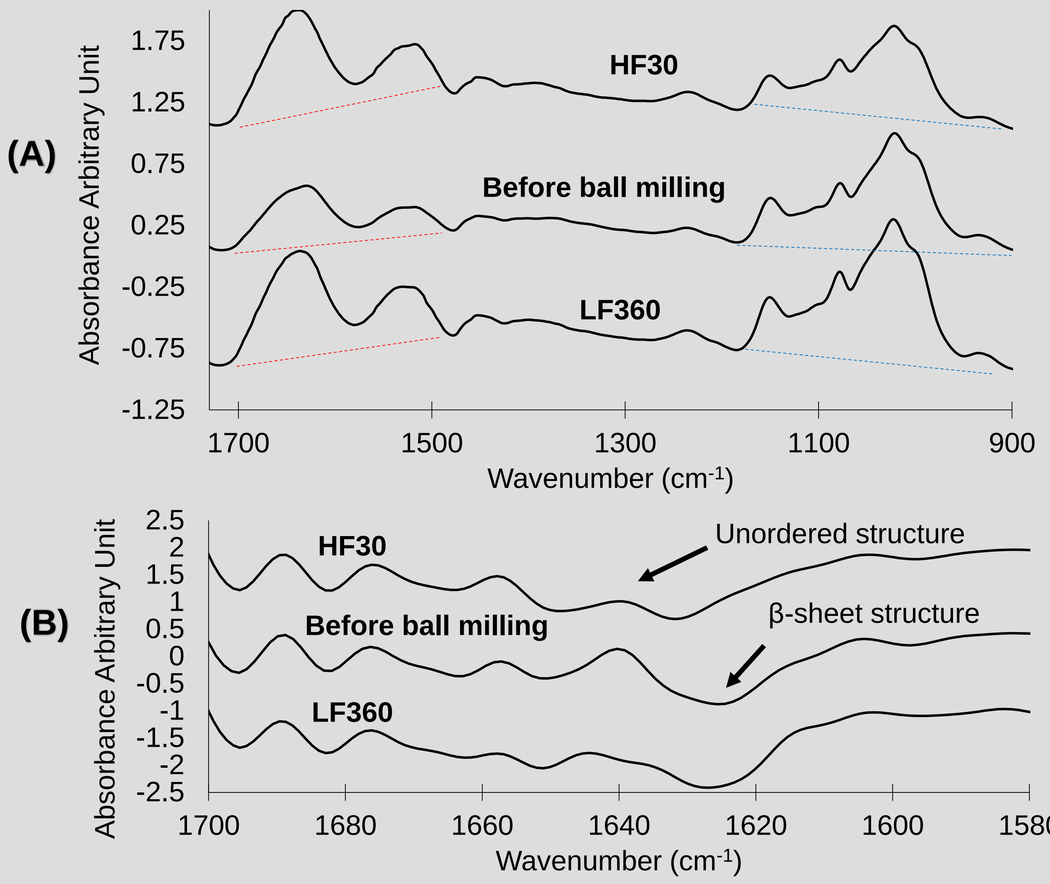
Particle size distributions of SOBPC powder, dispersed in water and measured using light scattering particle size analyser. Ball milling at low frequency resulted in a narrower range of particle size distributions.

Thermal Properties



Increase of enthalpy and acceleration of endothermic relaxation could be interpreted as molecular rearrangement induced by high frequency ball milling impact acting as energy activation that similar to annealing heat treatment.

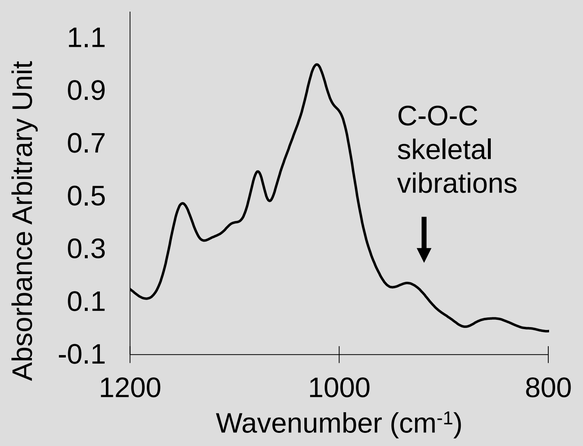
Infrared Spectral Changes



(A) Infrared spectra of SOBPC, measured using ATR-FTIR Spectroscopy, emphasising changes in integrated area under protein-assigned bands (1700-1500 cm^{-1}) relative to carbohydrate-assigned bands (900-1200 cm^{-1}). (B) Second derivative of SOBPC infrared spectra on protein-assigned bands showing protein conformational changes as affected by ball milling.

High frequency ball milling increased the integrated area of protein-assigned bands due to more heat was generated during milling.

Sample	Ratio of integrated area of protein to carbohydrate-assigned bands	Absorbance Intensity Ratio 935/1022
Before ball milling	0.98 ± 0.05	0.17 ± 0.00
HF10	1.75 ± 0.05	0.17 ± 0.01
HF20	1.82 ± 0.01	0.17 ± 0.01
HF30	1.95 ± 0.07	0.15 ± 0.00
LF120	1.18 ± 0.06	0.15 ± 0.01
LF240	1.19 ± 0.09	0.13 ± 0.01
LF360	1.31 ± 0.04	0.13 ± 0.00



Decrease of absorbance intensity ratio at 935 and 1022 cm-1 indicate a more severe depolymerisation of carbohydrate chain caused by low frequency ball milling

Conclusions

Ball milling was able to reduce particle size of SOBPC, a mixture of thermally processed insoluble protein and carbohydrate, to a micron size powder. Milling at high frequency would reduce milling time efficiently, noticing a temperature rise even at the shortest possible operation time, i.e. 1 min milling followed by 10 min pause. Temperature rise effects was observed from FTIR spectroscopy and calorimetry studies of SOBPC powder at low moisture.

References

- Gulzar, M., Bouhallab, S., Jeantet, R., Schuck, P., Croguennec, T., 2011. Influence of pH on the dry heat-induced denaturation/aggregation of whey proteins. Food Chem. 129, 110–116.
- Perez, O.E., Pilosof, A.M.R., 2004. Pulsed electric fields effects on the molecular structure and gelation of β-lactoglobulin concentrate and egg white. Food Res. Int. 37, 102–110.
- Van Craeyveld, V., Delcour, J.A., Courtin, C.M., 2008. Ball Milling Improves Extractability and Affects Molecular Properties of Psyllium (Plantago ovata Forsk) Seed Husk Arabinoxylan. J. Agric. Food Chem. 56, 11306–11311.
- Kim, Y.J., Suzuki, T., Hagiwara, T., Yamaji, I., Takai, R., 2001. Enthalpy relaxation and glass to rubber transition of amorphous potato starch formed by ball-milling. Carbohydr. Polym. 46, 1–6.

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Loughborough University

UNIVERSITY OF BIRMINGHAM