Novel Approaches to Enhance Techno-functionality of Extruded Pulse Flours: Effects of Air Injection and Feed Particle Size

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INTRODUCTION

- Industrial applications of pulses depend on their techno-functional properties.
- Extrusion has great potential to fine-tune ingredient techno-functionality due to its capability for precise control of the temperature, pressure and shear during processing, and thus the changes in food polymers (e.g., starch gelatinization, protein denaturation).
- Feed particle size is particularly important for pulse-based foods due to lack of well-defined particle size criteria for pulse flours.
- Novel techniques such air injection during extrusion can be utilized to further develop techno-functionally superior pulse ingredients. In this context, oxygen in air acts as an oxidizing agent during extrusion cooking.

OBJECTIVES

(1) To investigate the relationship between yellow pea flour particle size, extrusion temperature profile and end-product techno-functionality.

(2) To assess the potential of a novel extrusion cooking technique, i.e., air injection assisted extrusion, to enhance end-product techno-functional properties.

MATERIALS AND METHODS

Yellow pea (*Pisum Sativum L.*)

A rotor beater **mill** (Retsch SR 300, Retsch GmbH, Haan, Germany) with mesh sizes of (i) **0.75 mm** to obtain flour with relatively smaller particle sizes (referred to as '**small**'), and (ii) **2.0 mm** to obtain flour with relatively larger particle sizes (referred to as '**large**') was used.

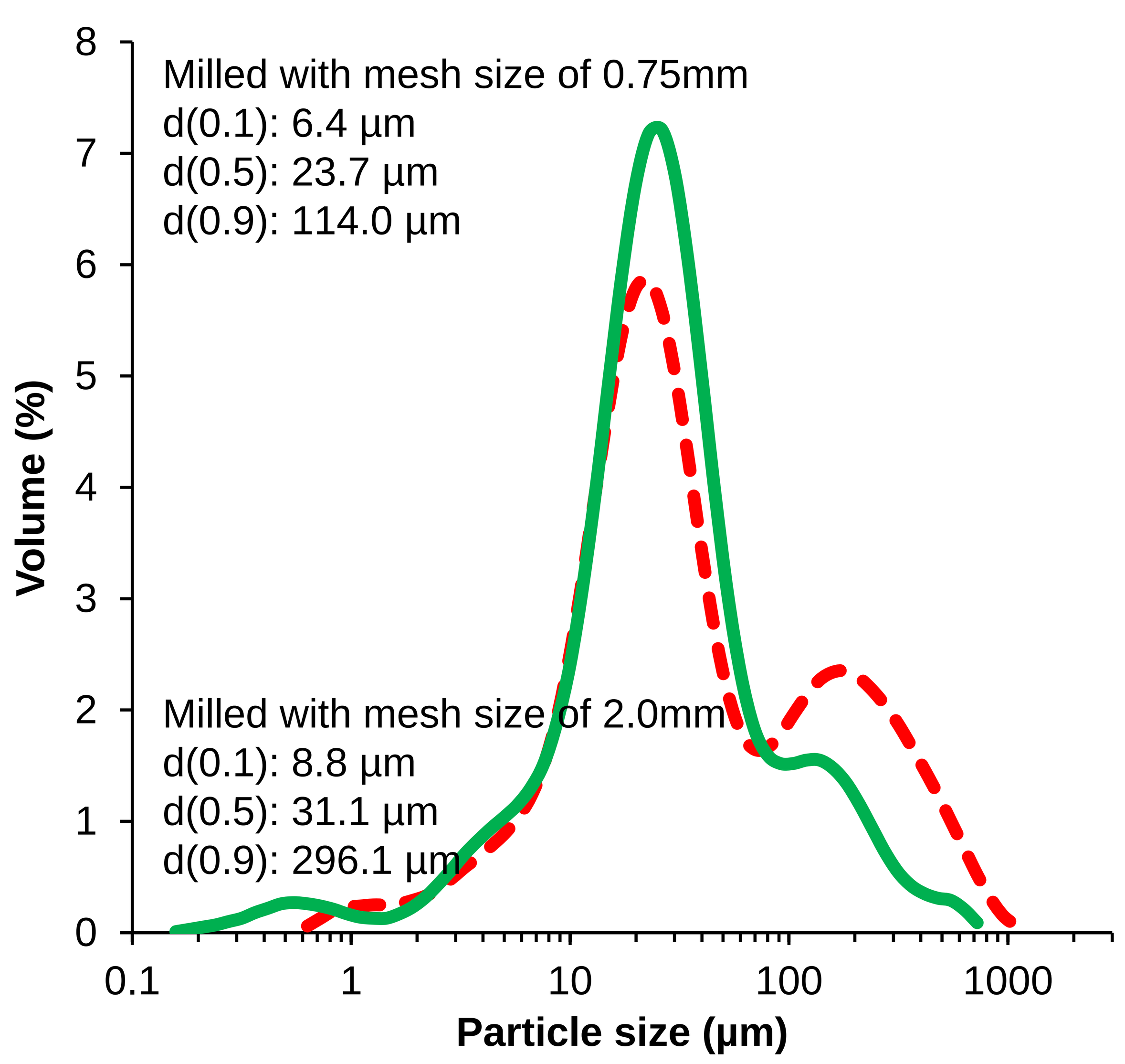

Fig. 1 Particle size distribution of pea flour milled with mesh sizes of 0.75 mm (solid line) and 2.0 mm (dashed line).

A laboratory-scale co-rotating twin-screw **extruder** (MPF19, APV Baker Ltd., Peterborough, UK) with a circular die (diameter: 2.3 mm) was used at a screw speed of 220 rpm.

Emulsion capacity (EC) was measured according to Stone et al. (2015) by conductivity meter.

Emulsion stability (ES) was measured following the method of Stone and Nickerson (2012) where the emulsions were allowed to separate for 24 h at room temperature.

Pasting properties was measured by a Rapid Visco Analyzer (RVA 4, Newport Scientific, Warriewood, Australia).

Water solubility (WS) and **water binding capacity** (WBC) were calculated based on weight of supernatant and precipitate in a mixture of flours and distilled water (10% w/v) following Masatcioglu and Koksel (2019).

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial support from the University of Manitoba Collaborative Research Program, New Investigator Operating Grant of Research Manitoba, AGT Food and Ingredients for supplying yellow pea and Richardson Centre Food Technology and Research (Winnipeg, MB, Canada) for milling and particle size analysis.

RESULTS and DISCUSSION

Table 1 Torque, die pressure, specific mechanical energy (SME), emulsion capacity (EC) and emulsion stability (ES). (± standard error).

	Air pressure (kPa)	Torque (%)		Die pressure (kPa)		SME (Wh kg^{-1})		EC (g oil/ g protein)		ES (%)	
Die T (°C)		Small	Large	Small	Large	Small	Large	Small	Large	Small	Large
120	0	35±0	25±0	6500±100	6700±100	319±2	230±2	41.2±0.1	41.0±0.2	68.5±1.0	75.0±2.9
	150	31±0	25±0	6950±250	6450±50	285±2	230±2	41.2±0.1	43.0±0.0	71.5±1.5	70.0±0.0
	300	29±1	26±0	7650±150	7100±0	263±1	236±0	41.3±0.1	42.1±0.5	67.5±1.5	73.8±2.4
140	0	29±0	21±0	5250±150	5100±0	263±4	196±6	40.8±0.7	39.7±0.2	70.5±2.1	70.0±2.0
	150	23±0	17±0	6000±0	5000±0	215±2	155±0	39.1±1.4	41.7±0.2	67.0±3.0	72.5±3.2
	300	23±0	14±0	6600±0	4150±50	213±0	126±2	41.1±0.5	40.3±0.1	75.8±2.2	76.3±2.4
160	0	25±0	18±0	5150±50	3100±0	227±2	165±2	41.7±0.3	43.5±0.1	70±0.0	70.0±0.0
	150	24±0	15±0	4600±0	3950±50	221±0	138±2	42.0±0.3	40.1±0.0	75.8±2.2	62.5±1.4
	300	24±0	18±0	4850±50	4250±50	223±2	165±2	44.9±0.3	39.9±0.2	69.3±1.5	77.5±1.4

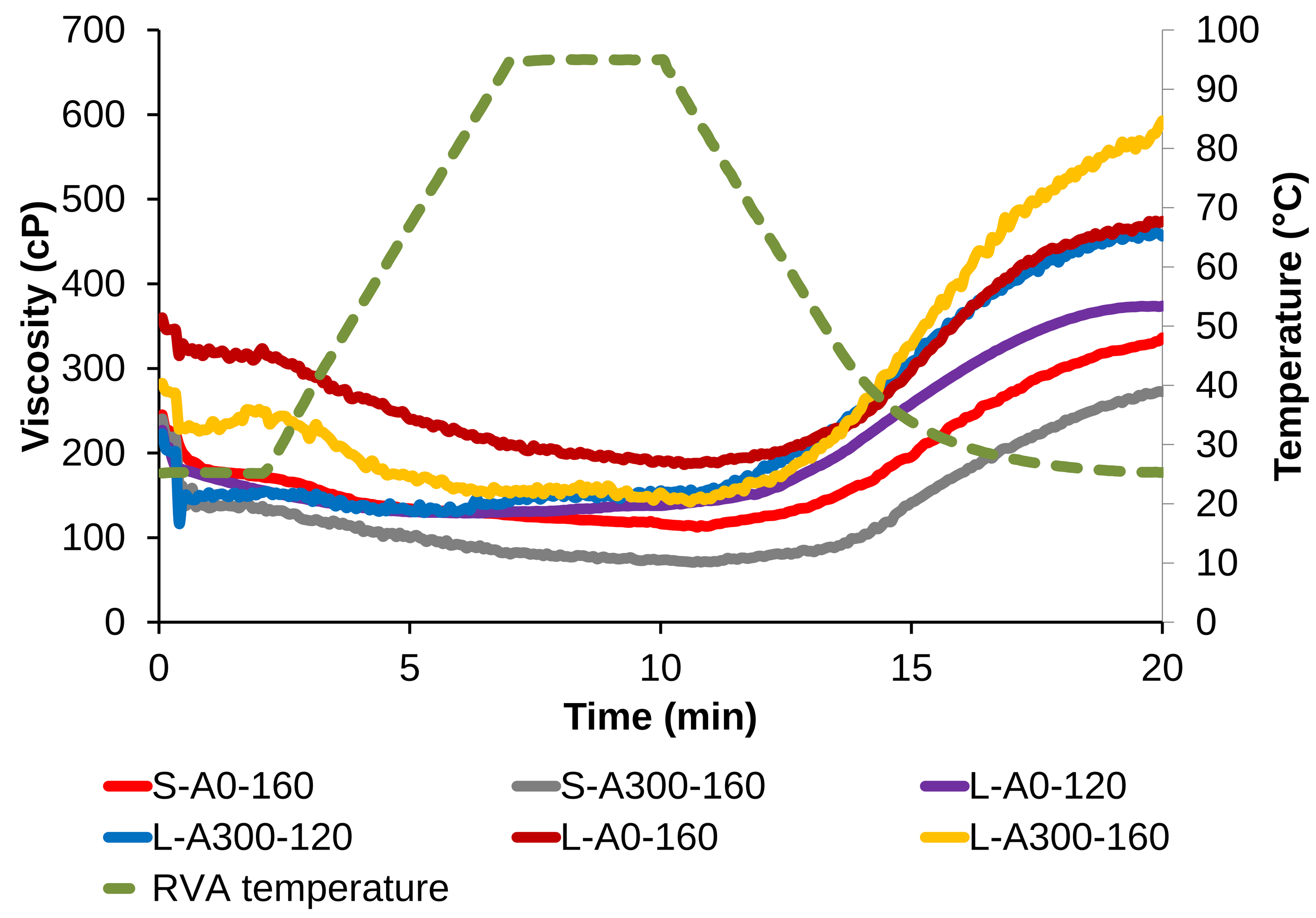

Fig. 2 Pasting properties of extrudates with two flour particle sizes, i.e., small (S) and large (L), air injection at 0 kPa and 300 kPa, i.e., A0 and A300, and two die temperatures, i.e., 120 and 160 °C.

- An increase in feed particle size generally caused decrease in torque, die pressure and SME during extrusion, meaning that larger particle size flour required less energy input to be processed.
- Feed particle size did not substantially affect EC. As particle size increased, ES generally increased, especially at higher air injection pressures. Larger particle size flours and higher air injection during extrusion therefore produced extrudates that are more suitable for meat extender applications (e.g., flexitarian burger patties, sausages, etc.)
- Overall, WS was the highest for the extrudates produced at the highest die temperature, making them more suitable for products such as sport drinks and protein shakes. There was not a clear trend for the effects of particle size, die temperature or air injection pressure on WBC.
- As feed particle size decreased, overall pasting viscosities of extrudates decreased. In addition, when the extrusion die temperature increased, extrudates exhibited a cold viscosity peak.

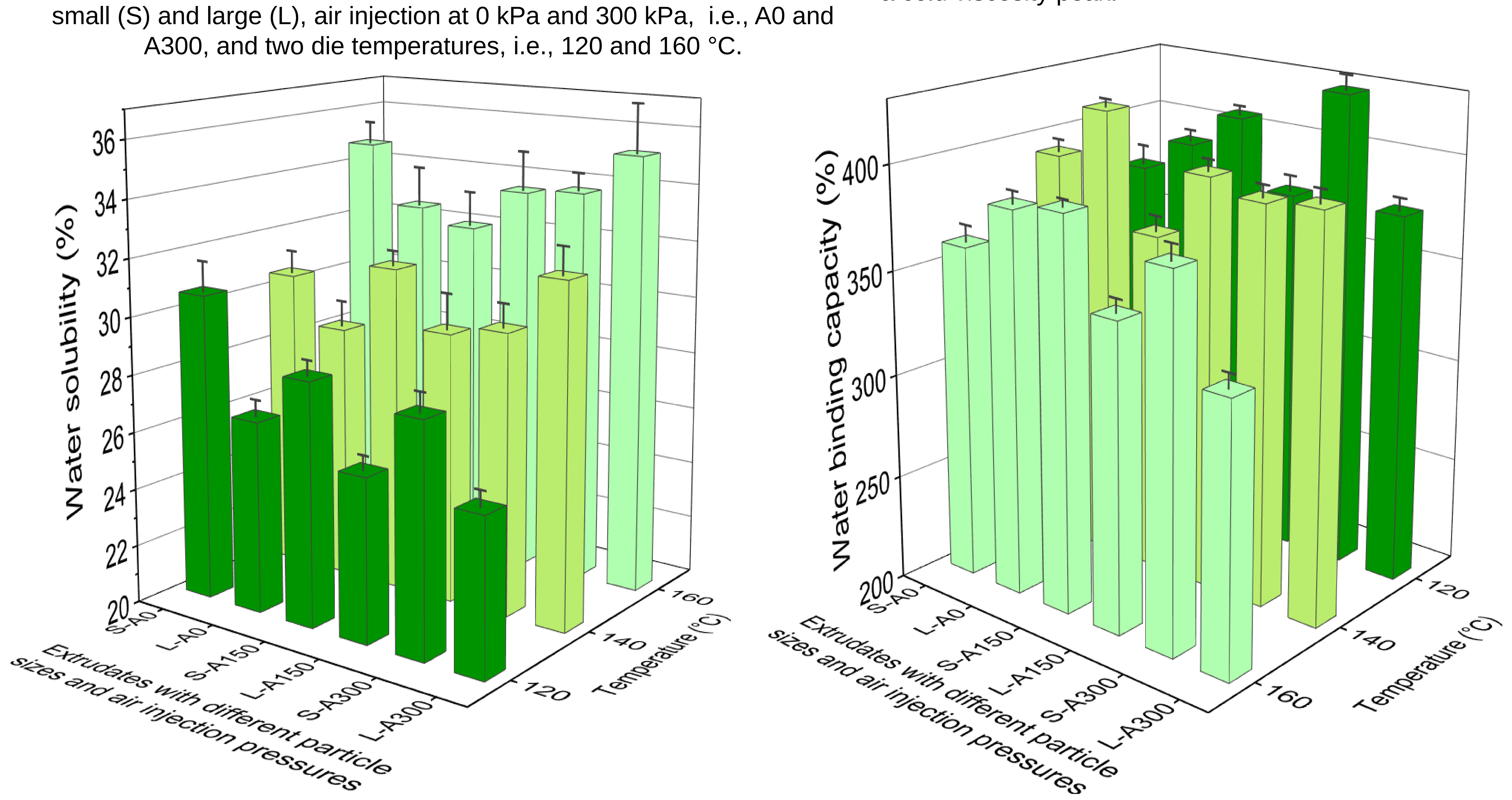

Fig. 3 Water solubility (WS) and water binding capacity (WBC) values of extrudates with air injection at 0 kPa, 150 kPa and 300 kPa, i.e., A0, A150 and A300, two different flour particle sizes, i.e., small (S) and large (L), and three die temperatures, i.e., 120, 140 and 160 °C. Error bars represent ± standard error (n=2 for extrusion and n=4 for WS and WBC).

CONCLUSION

- A novel extrusion technique (e.g., injection of air) combined with conventional modifications such as feed characteristics (e.g., particle size distribution) and processing conditions (e.g., die temperature) can be used to effectively manipulate techno-functional properties of extruded pulse flours.
- Injection of air, especially at high injection pressure (i.e., 300 kPa), is a powerful means of enhancing techno-functionality of pulse extruded flour.

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