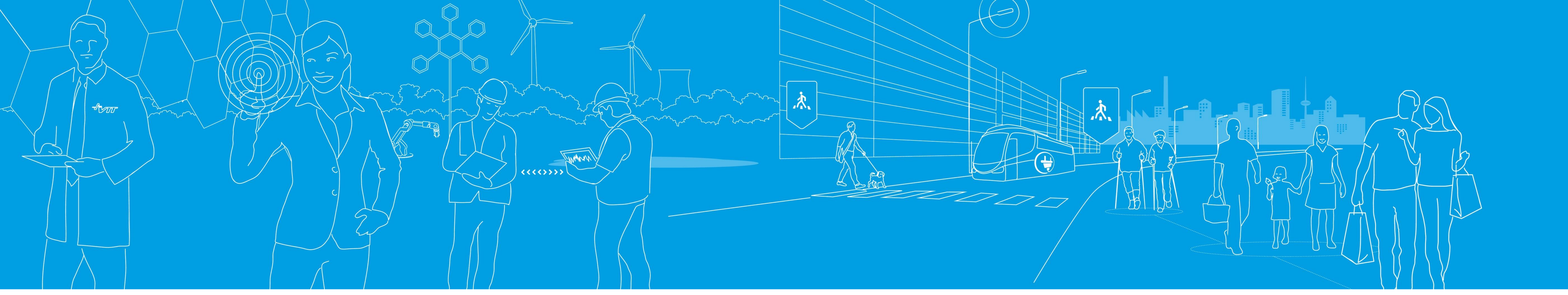

TECHNOLOGY FOR BUSINESS

Effects of structural and mechanical properties of brittle cereal foams on disintegration of food during mastication

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INTRODUCTION / BACKGROUND

Structural and textural differences of solid cereal foams influence their breakdown during mastication. Bolus formation and digestibility are also affected by the composition and proportion of the dietary fibre to starch. The aim of this study was to investigate how the structural differences of solid cereal foams (puffs vs. flakes) affect mastication properties and *in vitro* starch digestibility.

MATERIALS AND METHODS

Raw materials and recipes

Four extruded puffs and flakes were produced from endosperm rye flour (RF) by extrusion processing with or without 10% rye bran (RB) addition. Samples were prepared by a twin screw extruder (APV MPF 19/25, Baker Perkins Group Ltd, Peterborough, UK) and 3 mm die with a constant feed rate 60 g/min. Temperature profile was 80-95-110-120 °C (sec. 1 to die) and screw speed were 345 and 260 rpm for puffs and flakes, respectively.

Texture analysis

The puffed (Fig. 1a) samples were mechanically characterized in uniaxial compression by TA.XT 2i Texture Analyzer (Stable Micro Systems, UK) using a protocol by Alam et al. (2014). Flake samples (Fig. 1b) were analysed by using 5-blade Kramer shear cell with a 250 kg load cell. Samples were deformed at 25% strain with cross head speed of 1 mm/s. The hardness (F_{max}) and crispiness values were derived from the force-deformation curves.

Figure 1. *Mechanical characterization of puffs and flakes*

X-ray tomography

Samples were scanned by using x-ray microtomography (XMT, Skyscan 1172, Belgium) at 40 kV / 250 µA using a protocol by Alam et al. (2014). After scanning, reconstructed images were further analysed for porosity (%), cell wall thickness (mm) and cell diameter (mm) by Ctan (v. 1.12, Skyscan, Belgium) image analysis software.

Starch hydrolysis index

In vitro starch hydrolysis index (HI) was measured using a method described by Sozer et al. (2014). Powdered puffs and flakes samples were incubated for 180 min with porcine pancreatic α-amylase. The area under the curve (A_{uc}) was calculated using Sigmaplot 10.0 (Systat Software Inc., Point Richmond, CA, USA) with the preloaded macros. Incremental A_{uc} was calculated using the formula of trapezoidal area e.g., at 0 min = ½ × (abs_0 + abs_{30}) × (t_{30} – t_0) followed by 30, 60, 120 and 180 min. HI values were calculated at 1h, 2h and 3h and the results reported as mean ± SD value.

Mastication trial

Fifteen young female volunteers were recruited. Mean age of volunteers was 24.6 ± 4.4 years and their BMI was 22.0 ± 1.4 kg/m^2. Mastication process was characterised by measuring the electrical activity of facial muscles using electromyography (NeurOne system, Mega Electronics, Kuopio, Finland). Bipolar Ag/AgCl electrodes were placed on the masseter and temporal muscles on both sides of the face of the volunteers. Data recorded and later analysed for number of bites, chewing time, duty cycle, total work and work/bite.

Particle size analysis of bolus

The bolus samples were diluted into 100 ml of water, mixed with magnetic stirring for 25 min and let stand for 5 min in order to get bigger particles settled in the bottom of petri dishes. Digital images were taken of each petri dish. Particle areas were determined using Cell^P imaging software (Olympus, Germany).

REFERENCES
Alam et al. (2014), Food and Bioprocess Technology, 7(7), 2121−2133.
Sozer et al. (2014), Journal of Cereal Science, 60(1), 105−113.

RESULTS

Mechanical properties

Puffs were less hard and crispier (Fig. 2) than flakes regardless of bran addition. Bran addition increased hardness and reduced crispiness.

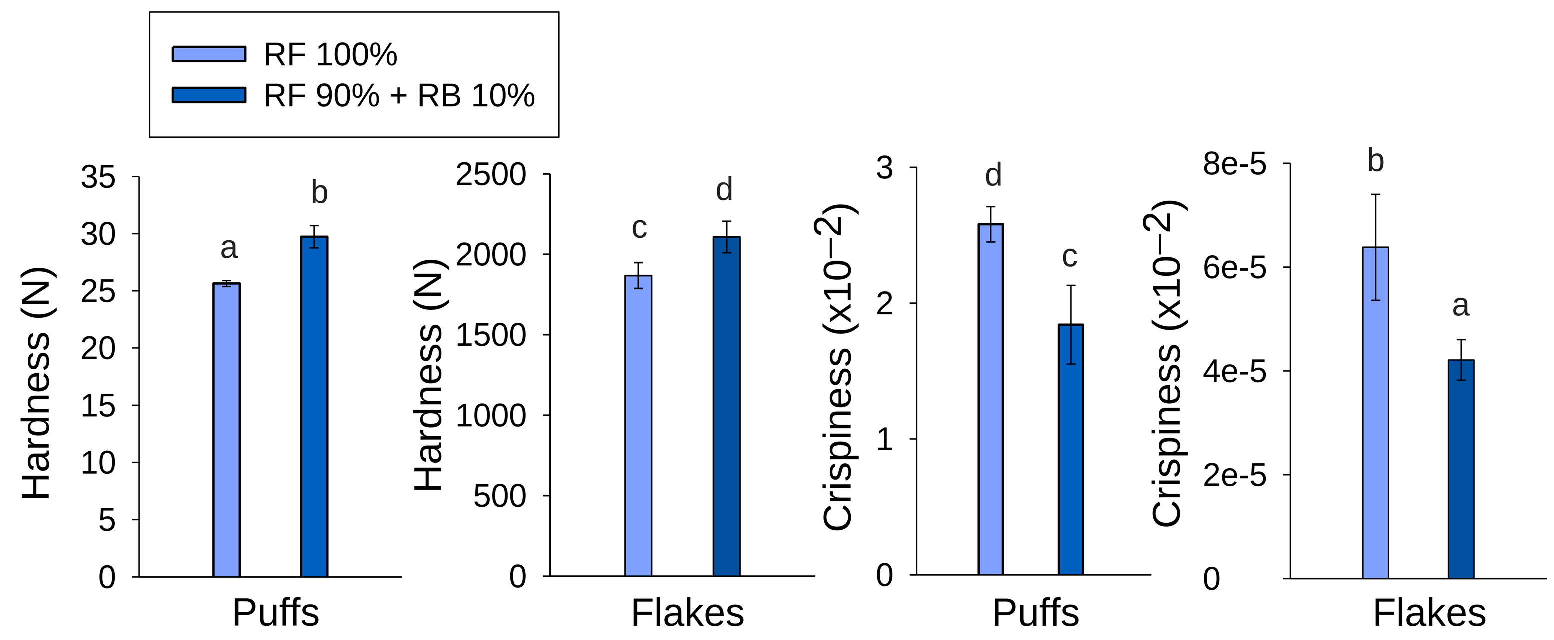

Figure 2. *Mechanical properties of extruded rye puffs and flakes. Bars followed by different letters in each figure were significantly different (P < 0.05)*

Structural characterisation

Bran addition did not change the microstructural properties such as porosity, average cell diameter and cell wall thickness (Fig. 3). Puffs were porous with less avg. cell wall thickness compared to the flakes.

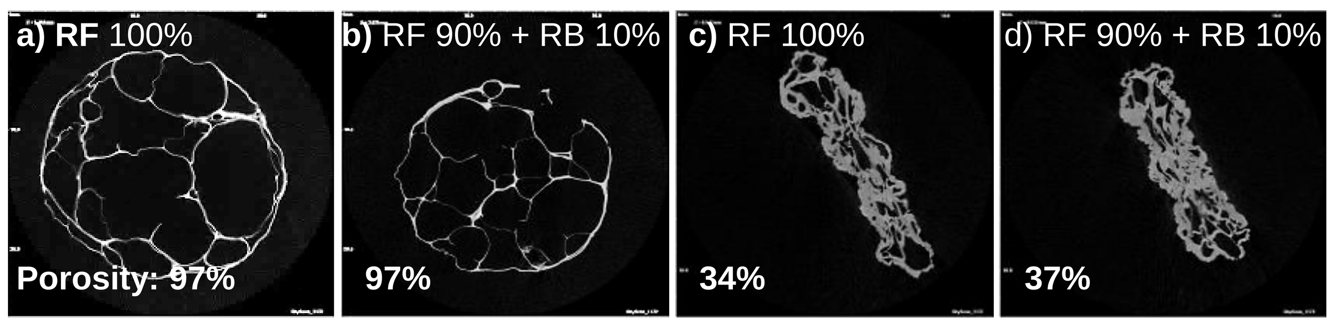

Figure 3. *XMT images of rye puffs and flakes*

Mastication properties

Mastication of puffs required less total work and less chewing time than flakes (Fig. 4). Bran addition did not change mastication properties (e.g., number of bites, chewing time, total work and work/bite) of either type of product.

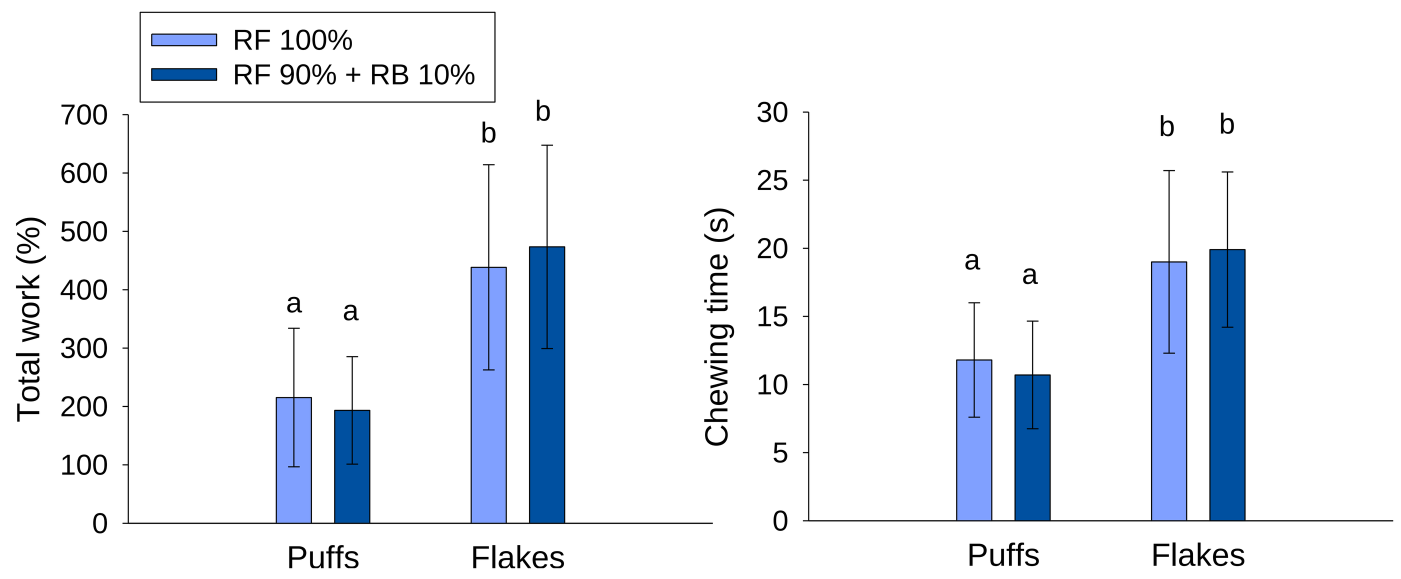

Figure 4. *Mastication properties of rye puffs and flakes. Bars followed by different letters in each figure were significantly different (P < 0.05)*

HI of puffs and flakes and particle size of their bolus

Puffs were degraded to smaller particles than flakes during mastication (Fig. 5). No significant (p < 0.05) differences observed between puffs and flakes (86.4 vs 85.1) in terms of HI. Bran addition increased hydrolysis only for flakes (94.5, significant p < 0.05) but not for puffs (89.7, not significant).

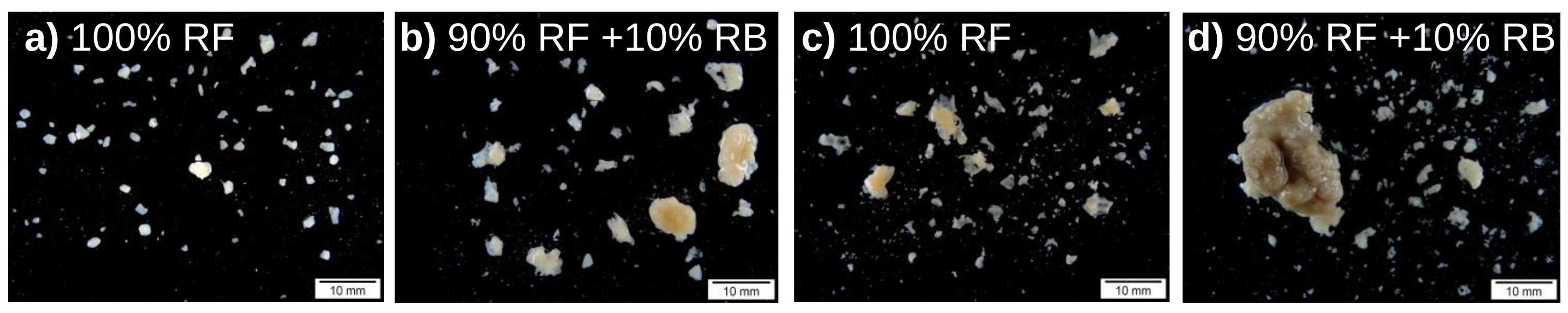

Figure 5. *Bolus particle size distribution of rye puffs (a, b) and flakes (c, d)*

CONCLUSIONS

- Extruded puffs were more porous, less hard and crispy compared to the flakes.
- Mastication of puffs required less work/bite, chewing time and number of bites than that of flakes.
- Although rye bran addition increased instrumental hardness and reduced crispiness, its effect on structural and mastication properties was not significant.
- The hydrolysis rate of puffs and flakes were not significantly different despite the significant differences in structure, texture and disintegration processes.

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