Cal Poly Pomona

All Natural Extruded Cheese Snacks

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Background

Extrusion Technology

Extrusion is a unique food processing technology that combine, thermal, mechanical (Thermo-mechanical) energy, shear force, and pressure to convert food ingredients (biopolymers) into edible foods.

Extrusion cooking advantages:

- High flexibility with respect to processing conditions.
- High throughput.
- Allows for (semi-)continuous processing.
- Low processing costs; medium capital investment.
- Fully sterilized and ready for packaging.

Background

Extrusion Technology

Food and feed products

Direct expanded products

- Breakfast cereals
- Snacks
- Petfood
- TVP

Indirect expanded products

(puffed by frying, toasting)

- Breakfast cereals
- Snacks

Formed products

- Pelletized foods
- Petfood
- Aquafeed

High-moisture protein extrudates

- Meat analogues
- Processed cheese

Dense products

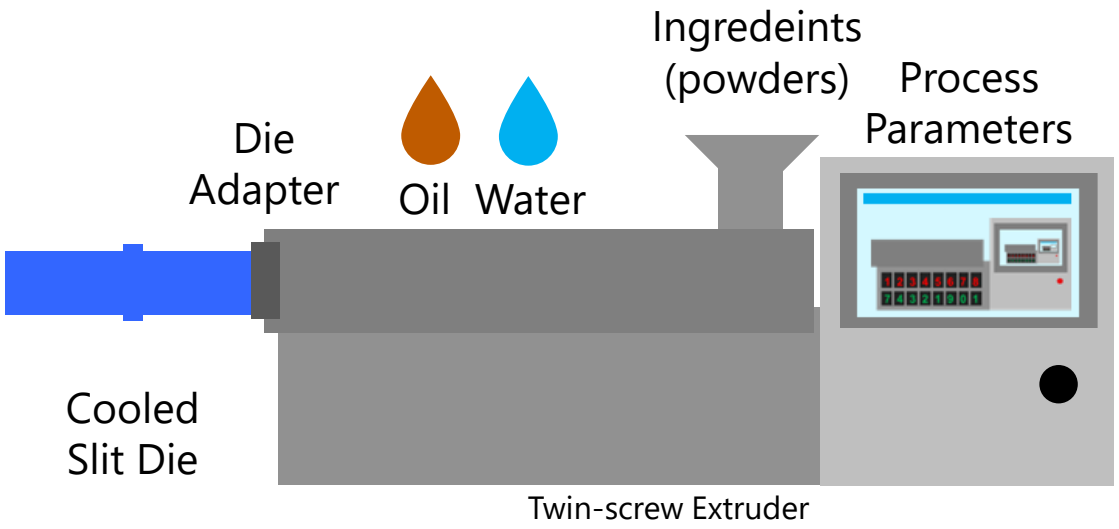
- Pasta & pasta analogues
- (Rice) noodles
- Controlled release systems

Background

Extrusion Technology

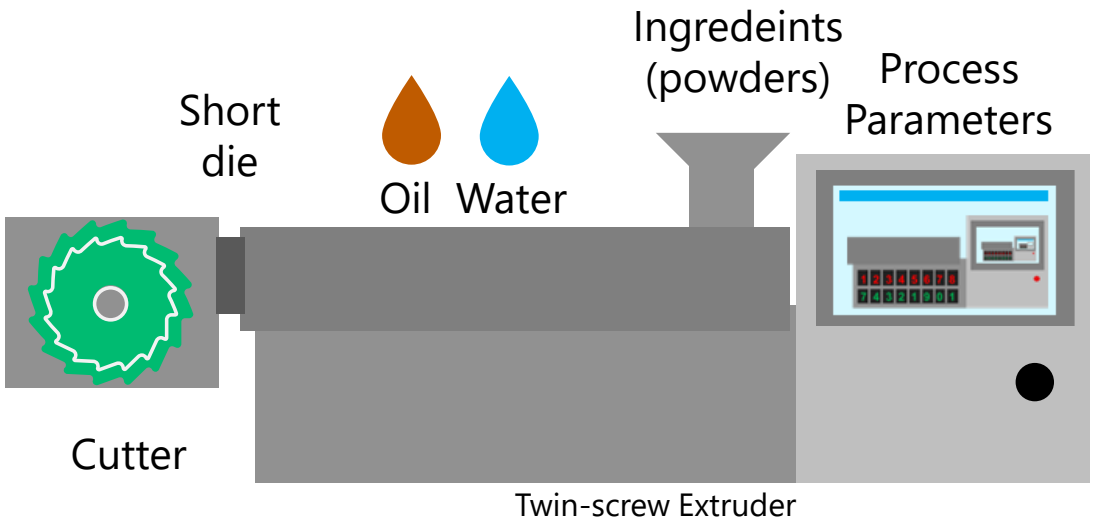
High Moisture Extrusion

Product: moist, soft product, cooled or frozen storage required (fresh snacks).



Low Moisture Extrusion

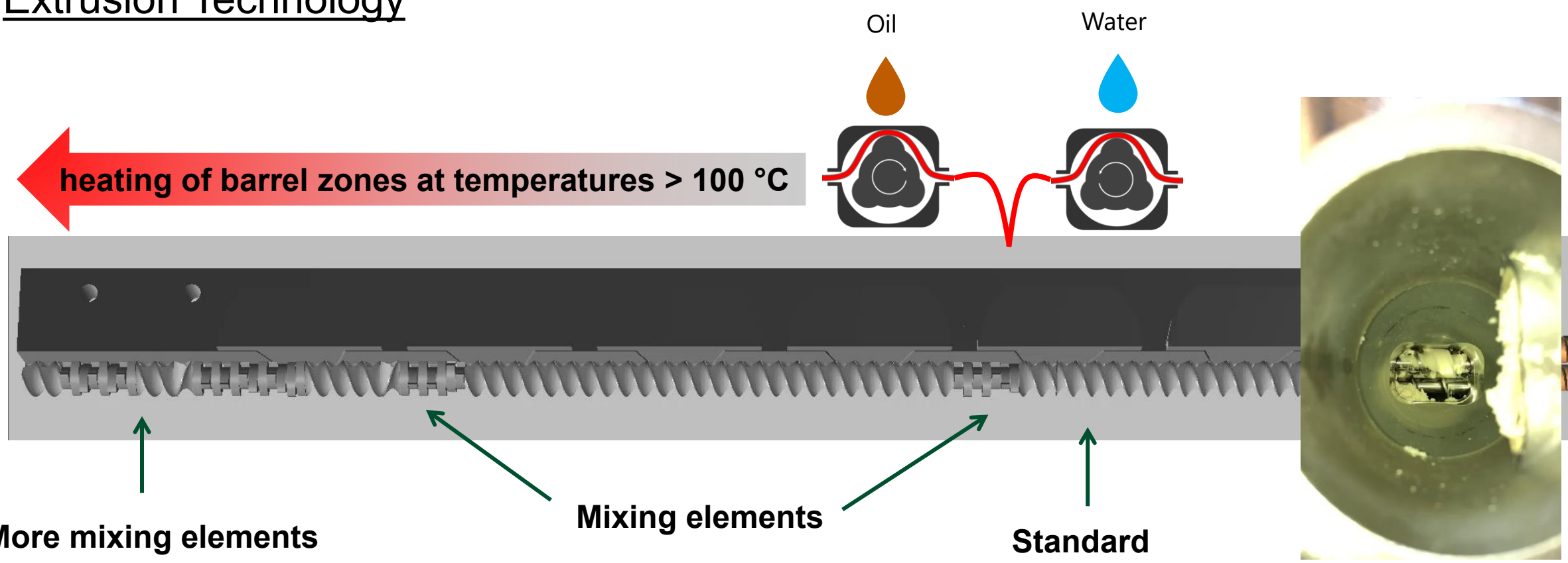
Product: dry, brittle product and long shelf-life (puffed snacks).



Source: Thermo Fisher Scientific

Background

Extrusion Technology



Cooking zone: Heating of barrel and shearing of screws leads to change in molecular structure and rheological properties

Source: Thermo Fisher Scientific

Background

Extrusion sizes

11 mm Thermo Fisher Scientific extruder

0.2-2.5 kg/h, lab scale testing

Background

Extrusion sizes

20/40 mm Brabender extruder

0.5-20 kg/h, pilot scale

Background

Extrusion sizes

32 mm Buhler extruder

5-50 kg/h, pre-commercialization scale

Background

Extrusion sizes

175 mm Buhler extruder, 500-2500 kg/h, full commercialization

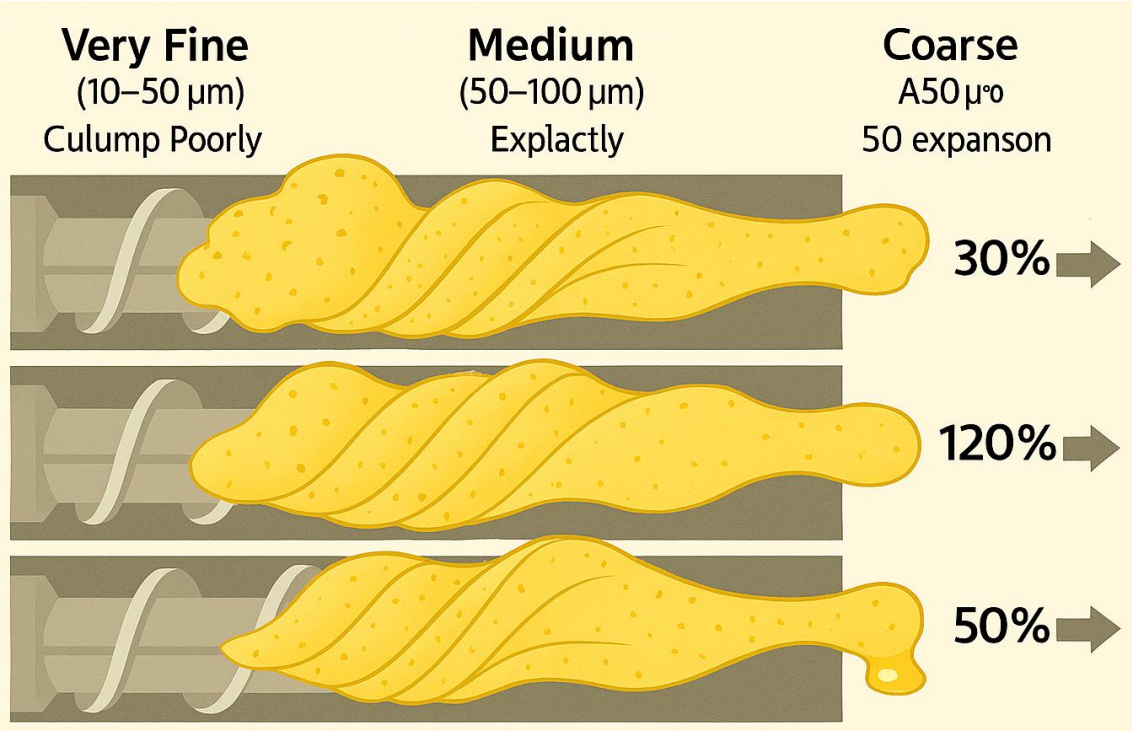
Methods

Cheese preparation

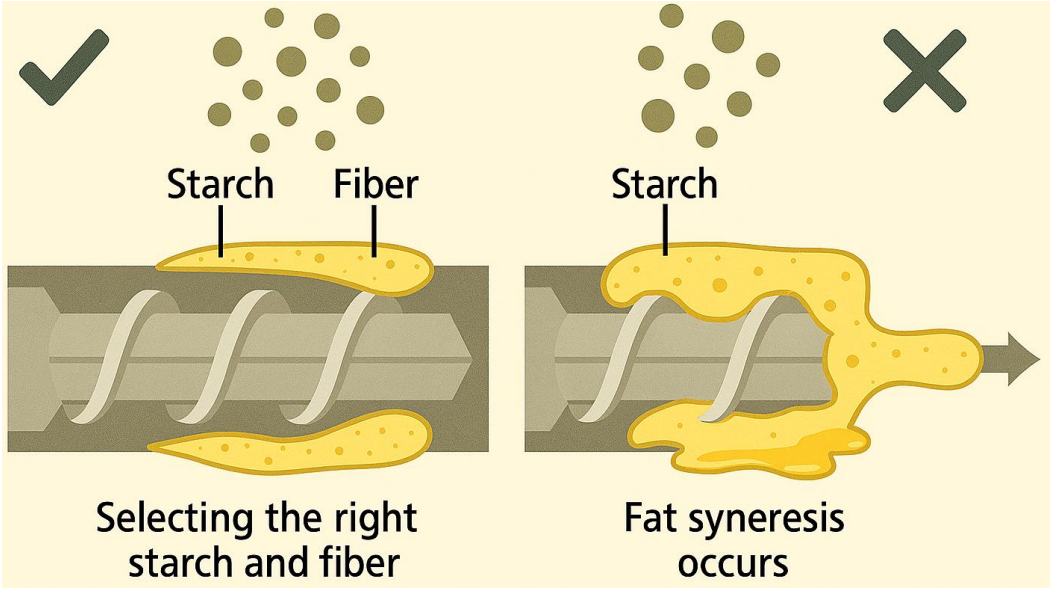
Methods

Cheese preparation

Choosing the right particle size, starch compatibility, and fiber level is key to achieving good expansion in extruded fresh cheese and minimizing fat leakage.



Cheese high fat content.
Selection of the right ratio of fiber and starch to prevent fat syneresis!



Methods

The extrusion design (variables)

The extrusion processing conditions applied to identify the best parameters evaluated through appearance and expansion ratio.

Condition	Cheese (%)	Moisture (%)	Screw speed (rpm)	Temperature (°C)
1	25	20	400	120
2	30	20	400	120
3	35	20	400	120
4	40	20	400	120
5	45	20	400	120
6	50	20	400	120
7	25	20	400	120
8	25	20	400	125
9	25	20	400	130
10	25	18	400	125
11	25	20	400	125
12	25	22	400	125
13	25	18	400	125
14	25	18	500	125
15	25	18	600	125

Methods

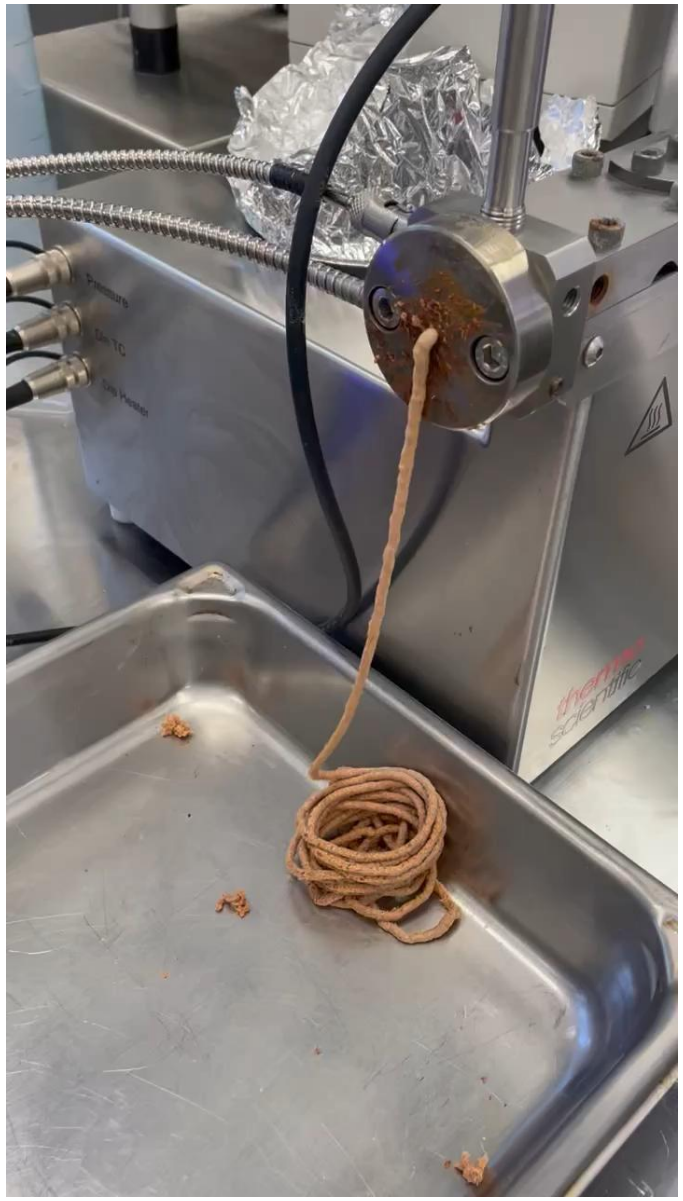
Selection of ingredients (protein vs starch)

Starch-based

Bubble nucleation starts in extruder die

High expansion ratio

No shrinkage



Protein-based

Bubble nucleation start in exruder die

Lower expansion ratio

Shrinkage

Results & Discussion

Higher cheese levels improved nutrition but reduced expansion due to fat acting as a lubricant.

Maximum expansion (~85%) achieved with 25–30% cheese, 18% moisture, 125 °C, and 400 rpm.

Expansion = Profit, Why?

The color of the extruded snacks. A) 25% cheese, B) 30% cheese, and C) 35% cheese. The processing conditions were 125 °C barrel temperature, 18% moisture content, and 400 rpm screw speed.

Results & Discussion

Extruded samples

25% cheese
18% moisture
125 C

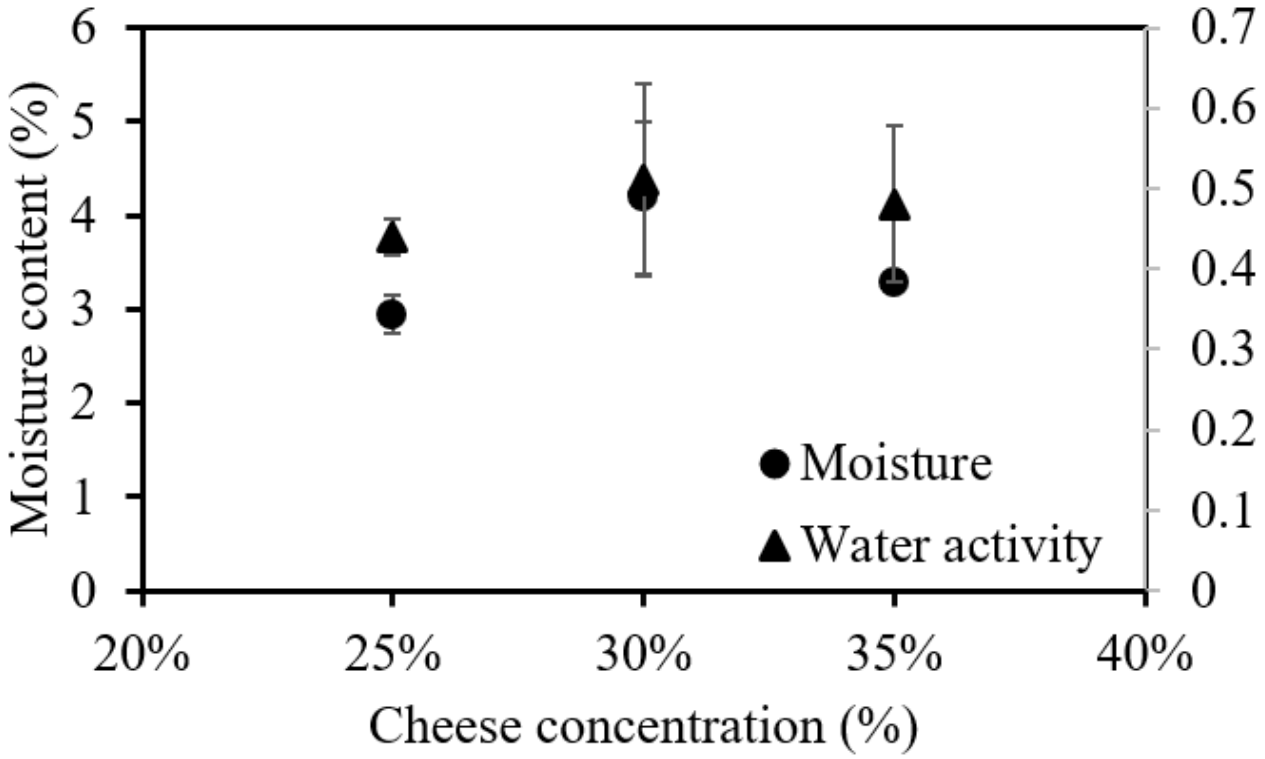
30% cheese
18% moisture
125 C

35% cheese
18% moisture
125 C

Results & Discussion

Drying at 72 °C for 4 h reduced moisture to 3–4% and aw 0.44–0.51, ensuring microbial safety and slowing chemical reactions.

Moisture control is critical for both safety and physical quality (expansion, bulk density).



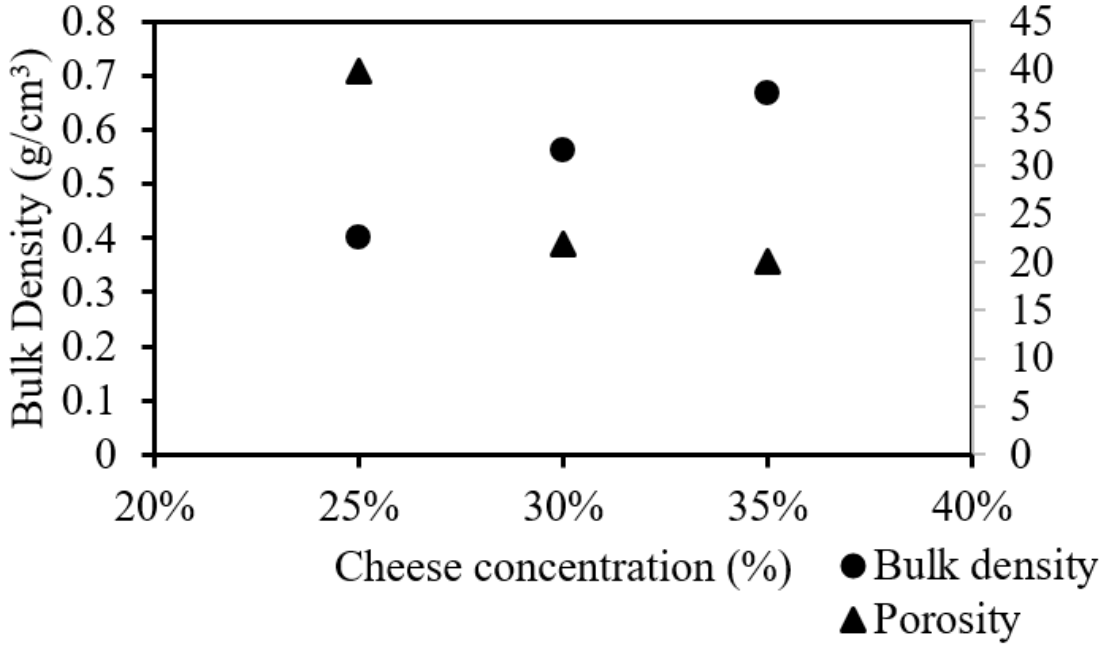
Moisture content and water activity. The processing conditions were 125 °C barrel temperature, 18% moisture content, and 400 rpm screw speed.

Results & Discussion

Bulk density (0.4–0.66 g/cm³) and porosity (20–40%) were inversely correlated, consistent with published ranges.

Higher cheese content increases casein crosslinking during extrusion, creating tighter, high-density structures.

Higher porosity enhances texture and flavor release but reduces nutrient density per unit mass.



Bulk density and porosity of the extruded pet snacks containing different cheese concentrations. Need std dev error bars. The processing conditions were 125 °C barrel temperature, 18% moisture content, and 400 rpm screw speed.

Results & Discussion

The 25% and 30% cheese recipes showed similar nutrient profiles due to mixing/homogenization, while 35% cheese resulted in higher protein content.

The developed snacks provided a competitive protein level and a balanced mineral profile.

Iron content was <10% of the daily requirement.

Proximate analysis and mineral content for the extruded pet snacks. The processing conditions were 125 °C barrel temperature, 18% moisture content, and 400 rpm screw speed.

Test	25% cheese	30% cheese	35% cheese
Moisture	7.18%	6.87%	9.96%
Ash	1.30%	1.37%	1.49%
Protein	10.40%	10.90%	12.10%
Fat	9.40%	9.50%	11.20%
Carbohydrates	71.80%	71.40%	65.30%
Calcium	2270 ppm	2260 ppm	2810 ppm
Iron	7.4 ppm	6.81 ppm	8.98 ppm
Potassium	1460 ppm	1530 ppm	1350 ppm
Sodium	1530 ppm	1540 ppm	1920 ppm

Conclusion

Fresh cheese showed strong potential as nutrient-rich ingredients for extruded snacks, with 25–35% cheese successfully incorporated after optimizing extrusion conditions (18% moisture, 125 °C, 400 rpm).

Higher cheese levels improved nutrition but required careful processing; 35% cheese produced softer snacks, while 25% cheese produced harder snacks.

Future work should optimize drying for shelf life, acceptability, and expand formulation studies to support scale-up.

Future Project Funded by CDIC

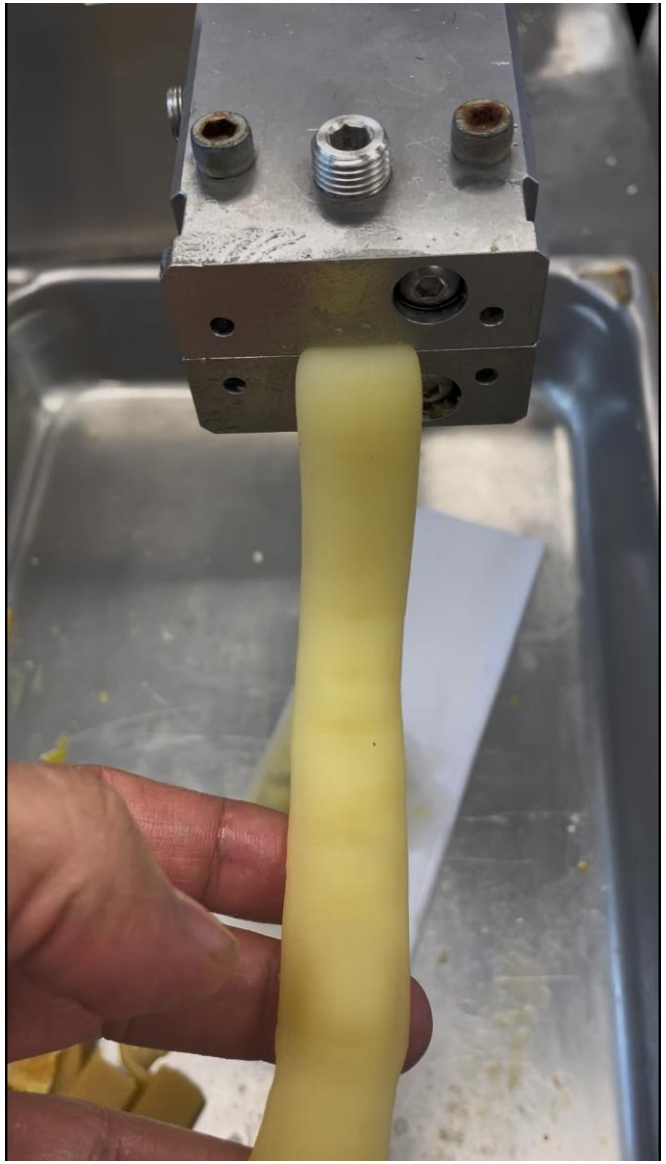
Establish database for commercially available starches and fibers!

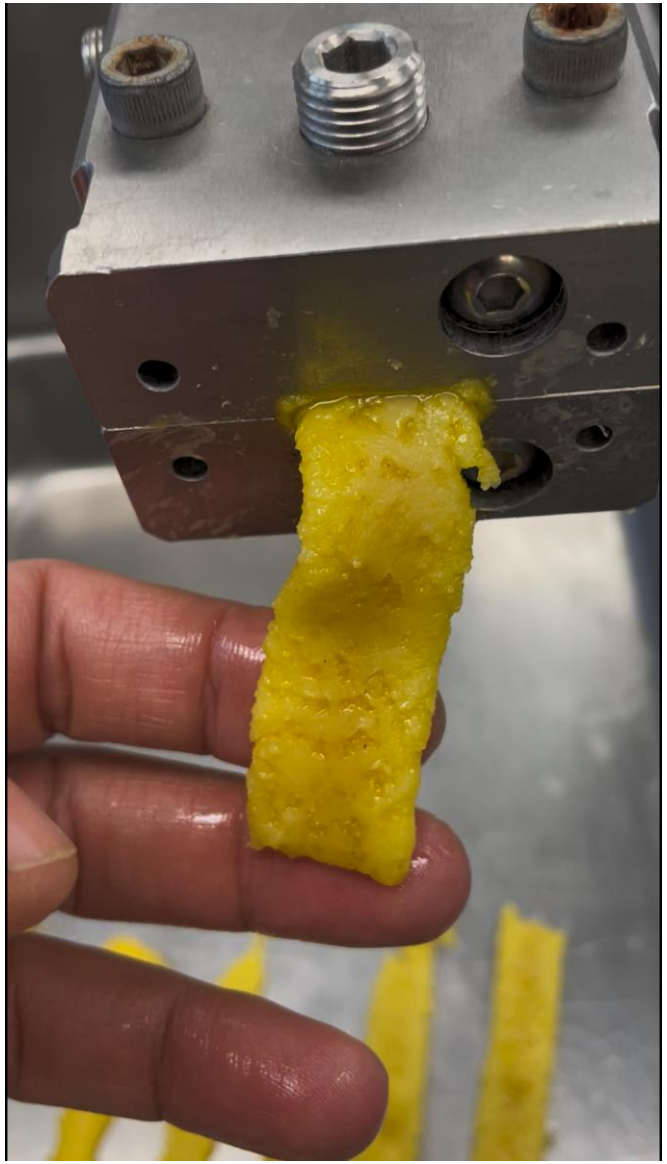
Future Work

Post-processing, flavors coating, examples!!!!

Future Work

Fresh cheese snacks (energy bars).





Thank You
Q&A

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