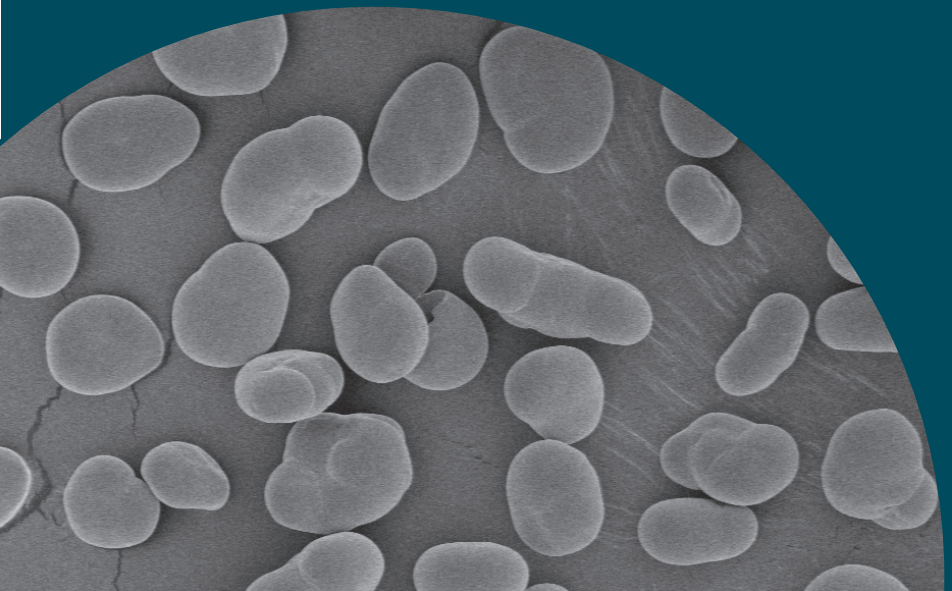
PULSE CANADA

Pulse Starch

Technical Overview

Starch represents the major component of pulse seeds, ranging from 40-50% of the dry seed weight. Starches naturally occur as granules that are composed of chains of glucose units linked together to form the two building blocks of starch: amylose and amylopectin. The ratio of amylose to amylopectin plays an important role in functionality. Compared to many other naturally occurring starches, pea, lentil and bean starches contain high levels of amylose (31-49%) and contain low concentrations (<1%) of minor components such as lipids or proteins.

Pulse starches can be produced using dry or wet processing methods. Dry fractionation is typically applied to dehulled pulse flours in which the flour is separated based on size and density into a starch-rich flour (60-85%db) that will contain residual levels of protein and fibre. During wet processing, pulse starches are produced as the by-product of protein solubilization and are commercially sold as a wet slurry or dried to produce a white, powdered isolate (>85% db). Hybrid methods combining dry and wet processing are also being explored, in addition to new technologies, for example, tribo-electrostatic separation.



Compared to common commercial starches, pulse starches show:

- Higher amylose contents (31-49%)
- Lower gelatinization temperatures
- Greater retrogradation rates
- Lower peak viscosities and higher final viscosities
- Greater resistance to high-temperature processing
- Stronger gelling ability
- Greater enzymatic resistance in a raw, granular state

(Li et al., 2019; Liu et al., 2019)

Special thanks to Dr. Yongfeng Ai (University of Saskatchewan) for providing data, images and valuable insight.

Pulse Starch
Structure

The majority of pulse starch granules appear oval, spherical or kidney in shape and with an average size of 15–28 um (Ren et al 2021). Irregularities such as fissures or scratches as well as processing-induced physical damage have been reported on an otherwise smooth granule surface. These granules display a C-type x-ray diffraction pattern and semi-crystalline structure. The relative crystallinity and B-polymorphic content ranges from 21–36% and 22–55% for pea, 19–33% and 28–36% for lentil, and 20–29% and 17–26% for faba bean pulse starches, respectively (Ren et al 2021).

Component Structure and Content

	Amylose				Amylopectin					Minor Components	
	Content (%)	Number-Average DP	Weight-Average Molecular Weight (g/mol x 107)	Radius of Gyration (Rg, nm)	Average Chain Length	Branch Chain Length Distribution (%) DP 6-12	DP 13-14	DP 25-36	DP ≥ 37	Lipid (%)	Protein (Nx6.25, %)
Pea	31-49	1300-1400	5-24	171-347	17-20	20-24	54-60	13-16	9-10	0.28-0.52	0.13-0.5
Lentil	32-39	1400	33-38	249-398	17-21	20-27	54-58	14-16	9-10	0.03-0.83	0.10-0.38
Faba Bean	31-40	1400	-	-	20-21	19-21	54-56	13-15	10-12	0.17-0.23	0.20-0.44
Corn	26-31	500-1000	49-103	312-324	20-23	22-27	49-52	12-14	9-15	0.70-0.75	0.30-0.35
Tapioca	16-31	2660-3000	70	191	19-28	17-34	40-47	10-16	8-27	0.10	0.0-0.10

Table adapted from Ren et al. (2021)
DP = degree of polymerization

Pulse Starch Functionality

Pulse starches display an absence of amylose-lipid complex formations and thus lower pasting temperatures compared to corn starch. When heated (≤95°C) under excess moisture conditions, pulse starches display 1) lower peak and breakdown viscosities, but 2) higher final and setback viscosities compared to normal maize and tapioca starches. This is due to the effect of 1) amylose on restricting granular swelling to maintain its integrity during heating as well as 2) the subsequent reassociation of leached amylose during cooling, respectively. This reassociation of amylose upon cooling and storage further acts to suspend the remaining granules in solution, entrap water, and reinforce the three-dimensional gel network that is formed; resulting in a firm, elastic gel network. When heated at temperatures greater than 95°C, pulse starches experience thixotropic breakdown and thermal degradation. This has not been reported to affect peak viscosity, but is related to greater breakdown viscosity and decreased setback and final viscosities under pasting conditions as well as decreased gel strength (Liu et al. 2019). Pulse starches will generally display greater resistance to high temperature processing than other commercial starches.

Thermal Properties

	Gelatinization Onset	Gelatinization Peak	Gelatinization Conclusion	ΔH	Retrogradation
	T_o (°C)	T_P (°C)	T_C (°C)	(J/g)	(%)
Pea	58-60	64-70	72-81	8.4-14.1	50-62
Lentil	60-63	65-70	73-85	8.4-13.5	46-64
Faba Bean	59-66	64-71	72-78	7.8-12.4	52.4
Corn	59-66	66-70	73-84	14-15	31.5
Tapioca	60-63	64-70	72-80	12.8-18	7.1

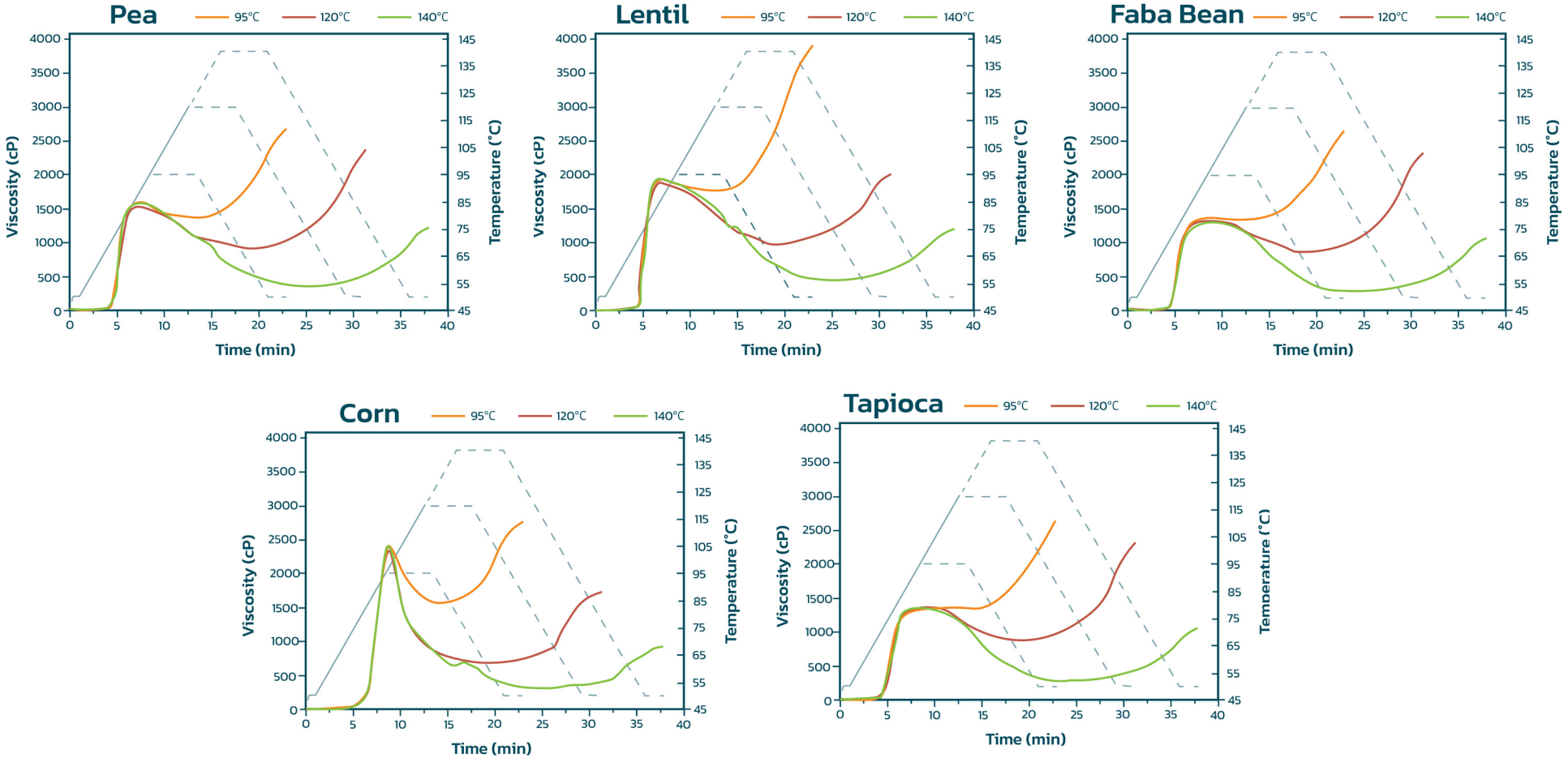
Table adapted from Ren et al. (2021)
DP = degree of polymerization

Figures curtesy of Dr. Yongfeng Ai, University of Saskatchewan

Pulse Starch

Pasting Properties

Pasting profiles of 7.82% (w/w) starch slurries in distilled water determined using a Rapid Visco Analyzer (RVA 4800). Samples were held at 50°C for 1 min, heated at 6°C/min to target holding temperature (95, 120 and 145°C) which was maintained for 5 min following cooling to 50°C at 6°C/min. Paddle rotation set to 960 rpm for first 10s and 160 rpm for remainder of test.



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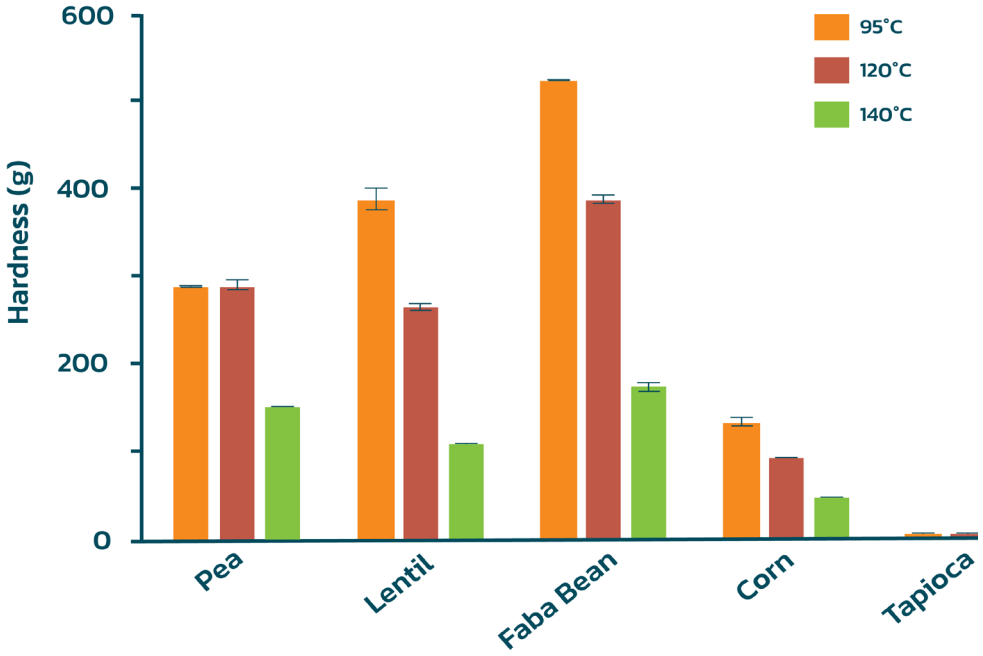
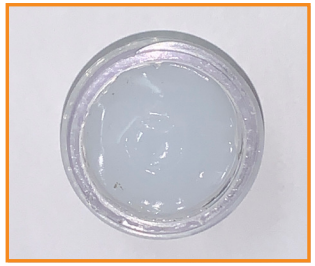
Pulse Starch
Gelling Ability

Hardness of starch gels prepared with pea, lentil, faba bean, corn, and tapioca starches after cooking at 95, 120, and 140°C. Starch gels produced from 7.82% (w/w) starch dispersion in distilled water and stored for 2 hr at room temperature after RVA test. Gel hardness was defined as the maximum compression force recorded using a TA.XT. Plus Texture Analyzer with Probe TA-10 (12.7mm diameter).

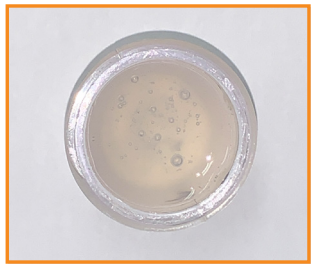



Pea Starch @ 95°C

Lentil Starch @ 95°C

Faba Starch @ 95°C

Corn Starch @ 95°C


Tapioca Starch @ 95°C

Figures curtesy of Dr. Yongfeng Ai, University of Saskatchewan

References:

Li, L. Yuan, T.Z., Setia, R., Raja, R.B., Zhang, B., Ai, Y. (2019). Characteristics of pea, lentil and faba bean starches isolated from air-classified flours in comparison with commercial starches. Food Chemistry: 276, 599-607. **https://doi.org/10.1016/j.foodchem.2018.10.064**

Liu, S., Yuan, T.Z., Wang, X.m Reimer, M., Isaak, C., and Ai, Y. (2019). Behaviors of starches evaluated at high heating temperatures using a new model of Rapid Visco Analyzer – RVA 4800. Food Hydrocolloids: 94, 217-228. **https://doi.org/10.1016/j.foodhyd.2019.03.015**

Ren, Y., Yuan, T.Z., Chigwedere, C.M., and Ai, Y. (2021). A current review of structure, functional properties, and industrial applications of pulse starches for value-added utilization. Comprehensive Reviews In Food Science and Food Safety: 1-31. DOI: 10.1111/1541-4337.12735

PULSE CANADA

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