University of Manitoba

Canola fibre: How to upcycle it into bioactive and beneficial prebiotic components?

Bogdan A. Slominski[1], Yanxing Niu[1], Rob Patterson[2], Martin C. Nyachoti[1], and Anna Rogiewicz[1]

[1] University of Manitoba, Winnipeg, Manitoba, Canada

[2] CBS Bio Platforms, Calgary, Alberta, Canada

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In quest of alternatives to antibiotics

- With the negative consumer reaction and public health concerns, the use of antibiotics as growth promoters has been proposed to be replaced by various antibiotic alternatives.

In quest of alternatives to antibiotics

Research Hypothesis:

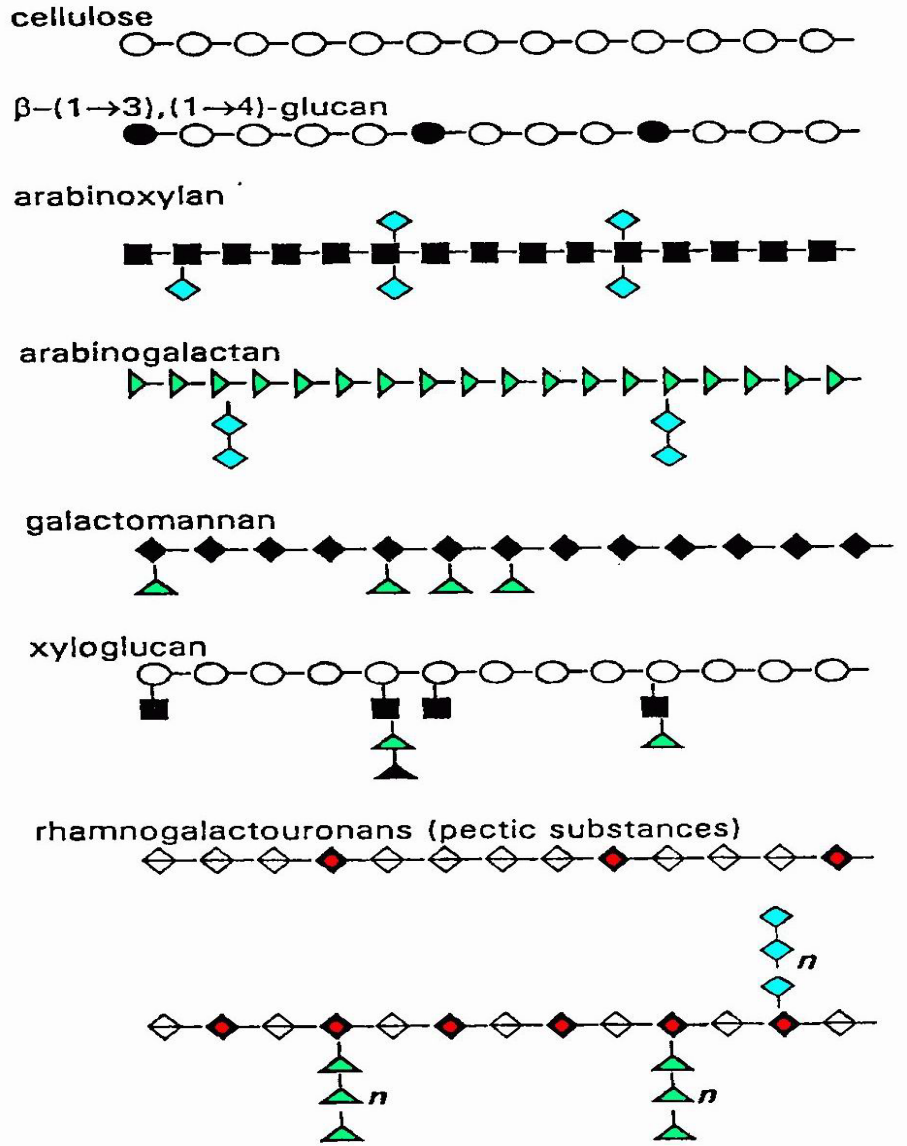
Enzymatic degradation of canola fibre will contribute to the production of **hydrolysis products** which may have a prebiotic effect in improving gut development, health, and function.

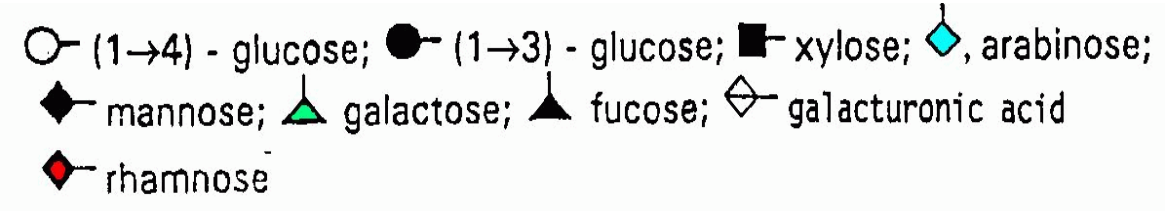
Fibre components of canola meal (% DM)

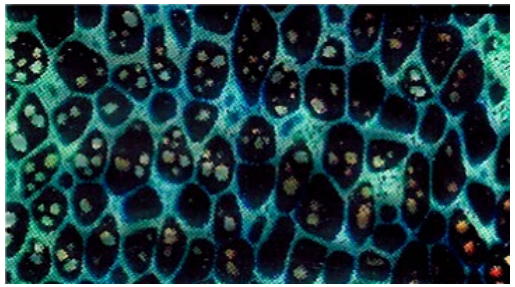
Component	Mean value[1]
Non-starch polysaccharides	22.5
Lignin and polyphenols	10.7
Glycoproteins	5.3
Total Dietary Fiber	38.5

[1] Average of 13 crushing plants over 7 years

Non-starch polysaccharides (NSP)

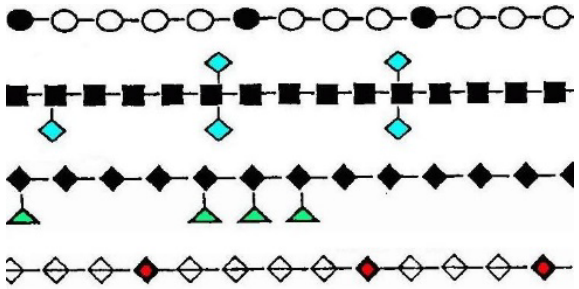






Canola embryo cross section

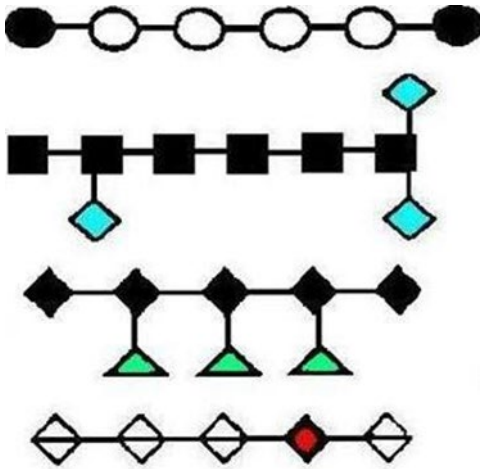
Production of prebiotic NSP hydrolysis products



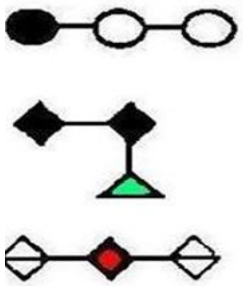
Multi-carbohydrase

NSP hydrolysis products

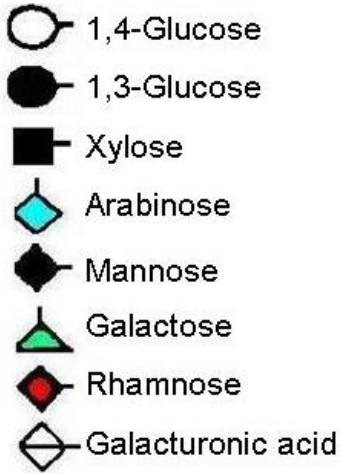
Low-molecular-weight polysaccharides



Oligosaccharides



Simple sugars



Production of bioactive CM fibre products

Laboratory scale → Industrial scale

48h at 40˚C

CM

Enzyme

Freeze-drying

ECM

CM

Enzyme

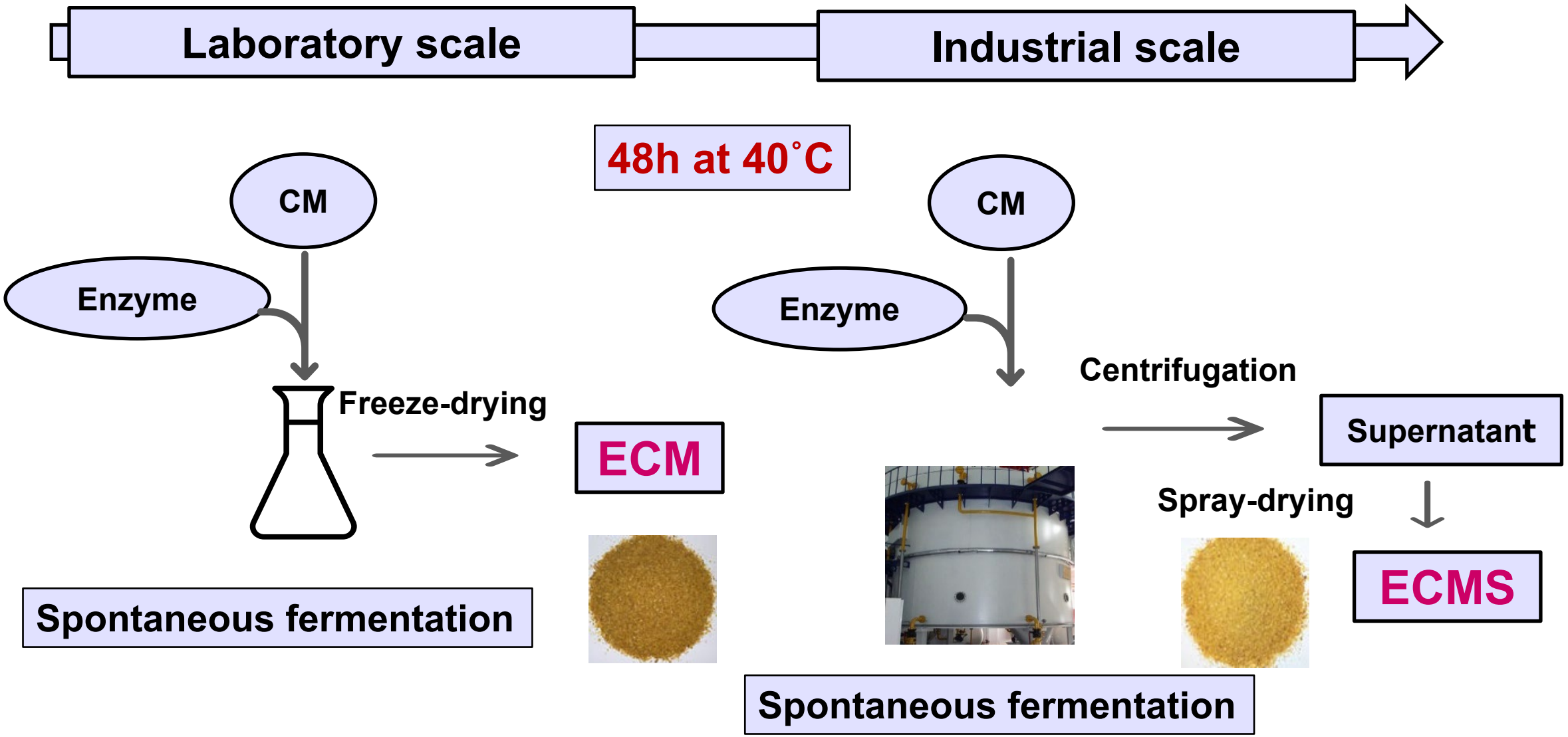
Centrifugation

Supernatant

Spray-drying

ECMS

Production of bioactive CM products



Chemical composition of CM, ECM and ECMS

(%, as-is basis)

Component	CM	ECM	ECMS
Crude protein	39.3	41.4	48.2
Carbohydrates			
Sucrose	6.7	0.8	0.9
Oligosaccharides	3.4	0.0	0.0
Phytate	2.2	0.0	0.0
Total dietary fiber (TDF)	34.1	28.1	4.0
Non-starch polysaccharides (NSP)	**21.3**	**13.6**	**3.9**
NSP hydrolysis products	**-**	**7.8**	**15.9**
Lactobacillus spp.[1]	1	304	8
Lactic acid	0.0	5.7	14.3
pH	5.8	4.0	3.9

[1] Measured through qPCR and analyzed using the $2^{-\Delta\Delta CT}$ method by normalizing the expression of *Lactobacillus spp.* to that of total eubacteria present in CM (i.e., =1).

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Growth performance of broiler chickens fed diets containing enzymatically-modified canola meal (ECM)

Preliminary growth performance trial

Diet	FI (g)	BWG (g/bird)	FCR (g/g)
Control	912	717	1.32
ECM (5% of diet)	929	730	1.30

P<0.05

4-21d of age

NSP, sialic acids, and dietary AMEn responses in broiler chickens fed diets containing (ECM)

Dose-response gut function trial

Diet	NSP digestibility, %	Sialic acids mg/100g	AMEn kcal/kg
Control	5.3^{b}	34.3^{a}	2943^{b}
Low ECM (5% of diet)	15.8^{a}	19.1^{b}	3009^{b}
High ECM (10% of diet)	18.9^{a}	16.0^{b}	3119^{a}

P<0.05

4-21d of age

Relative abundance of cecal microbiota in broiler chickens fed diets containing ECM

Item		Control	Low ECM	High ECM	*P* value
Day 14	*Firmicutes*	1.04	0.93	0.88	0.536
	Bacteroidetes	0.95	1.61	1.61	0.654
	Clostridium cluster IV	1.06	1.32	1.36	0.392
	Enterococcus spp.	1.06	0.77	0.31	0.288
	E. coli	1.08	0.85	0.41	0.054
	Lactobacillus spp.	1.10^{b}	254.22^{a}	321.79^{a}	<.000
	Bifidobacterium spp.	1.14	0.90	0.84	0.634
Day 21	*Firmicutes*	1.02	0.86	0.83	0.094
	Bacteroidetes	0.93	1.01	1.58	0.001
	Clostridium cluster IV	1.09	1.24	1.01	0.270
	Enterococcus spp.	0.91^{ab}	1.09^{ab}	0.04^{b}	0.037
	E. coli	1.00^{a}	0.61^{ab}	0.04^{b}	0.002
	Lactobacillus spp.	0.96^{b}	95.37^{a}	76.12^{a}	<.000
	Bifidobacterium spp.	0.99	1.34	1.10	0.640

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	Bifidobacterium spp.	0.99	1.34	1.10	0.640

Growth performance of broiler chickens fed diets containing enzymatically-modified NSP solubles (ECMS)

Preliminary growth performance trial

Diet	FI (g)	BWG (g/bird)	FCR (g/g)
Control	436[b]	371[b]	1.18
ECMS (2%)	468[a]	405[a]	1.16

P<0.05

1-14 d of age

Salmonella Enteritidis challenge study with lying hens

- Laying hens Hy-Line W-36 (24 weeks old): 12 hens per treatment, 2 hens per cage.
- Hens were challenged with *Salmonella* Enteritidis (SE) by oral gavage: dose 2×10^8 CFU.
- Samples of excreta and various organs were collected 3 and 8 days post infection for *Salmonella* enumeration.
- Experimental treatments:
  - Control, no SE challenge
  - SE challenge
  - SE challenge + 1% of ECMS

Salmonella Enteritidis counts in excreta and various organs *(log cfu/g)*

Days post infection	Organ	Treatment			P value
		NC	PC	PC + EMCS	
0	Excreta	0	0	0	n/a
3	Excreta	0	1.96[a]	0.82[b]	0.001
	Ceca	0	1.52[a]	0.00[b]	0.005
8	Excreta	0	0.93	0.38	0.095
P<0.05	Ceca	0	0.85	0.00	0.067
	Liver	0	0	0	
	Ovary	0	0	0	
	Spleen	0	0	0	

P<0.05

Salmonella Enteritidis counts in excreta and various organs *(log cfu/g)*

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		NC	PC	PC + EMCS	
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P<0.05	Ceca	0	0.85	0.00	0.067
	Liver	0	0	0	
	Ovary	0	0	0	
	Spleen	0	0	0	

P<0.05

Significant findings

- Replacing CM with ECM or ECMS can:
  - Improve energy utilization and growth.
  - Decrease sialic acids (mucin) production.
  - Increase the presence of *Lactobacillus spp. and* SCFA contents.
  - Decrease the abundance of *E.coli* in ileal and cecal digesta.
  - Reduce *Salmonella* counts and fecal *s*hedding in laying hens.

Take-home message

- Enzymatically-modified and fermented CM and its water-soluble fraction can improve gut function and health and support the antibiotic-free feeding programs in poultry nutrition.

Acknowledgements

Thank you!