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Canada



DEVELOPING PURPLE WHEAT AS A SOURCE OF ANTHOCYANIN PIGMENTS FOR FOOD AND NON-FOOD APPLICATIONS

El-Sayed M. Abdel-Aal

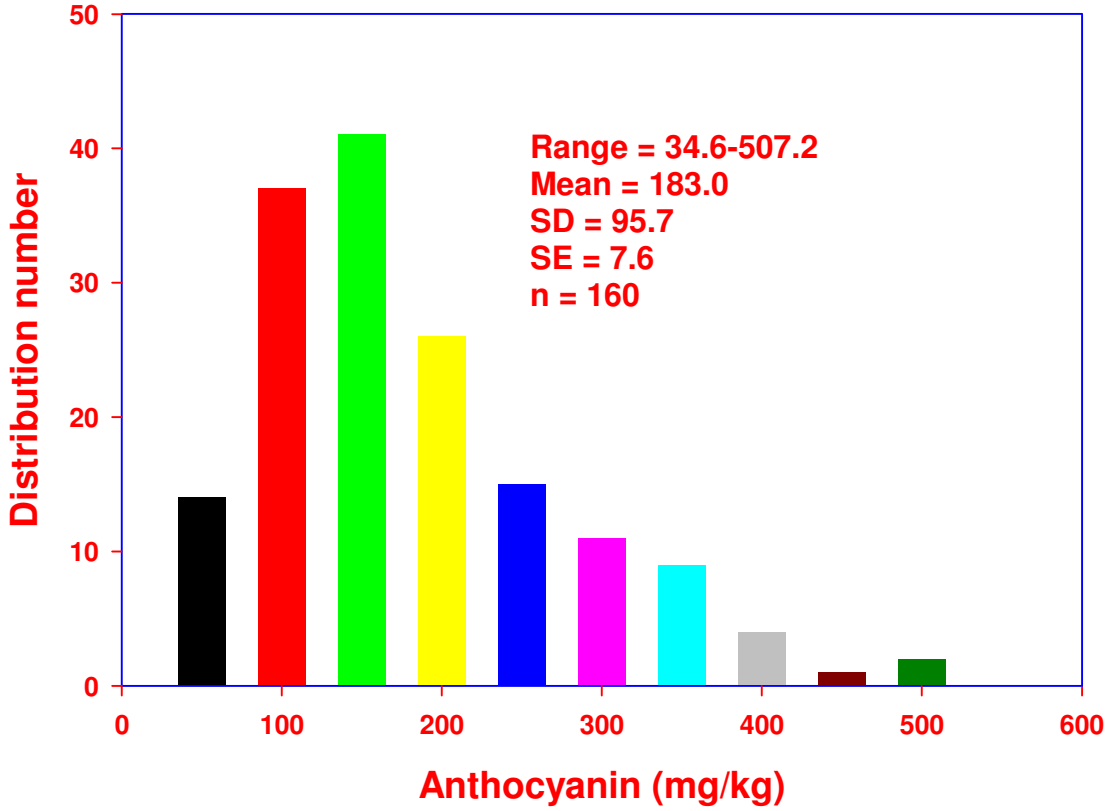
[1]Guelph Food Research Centre, Guelph, Ontario, Canada

Euro Food June 2015

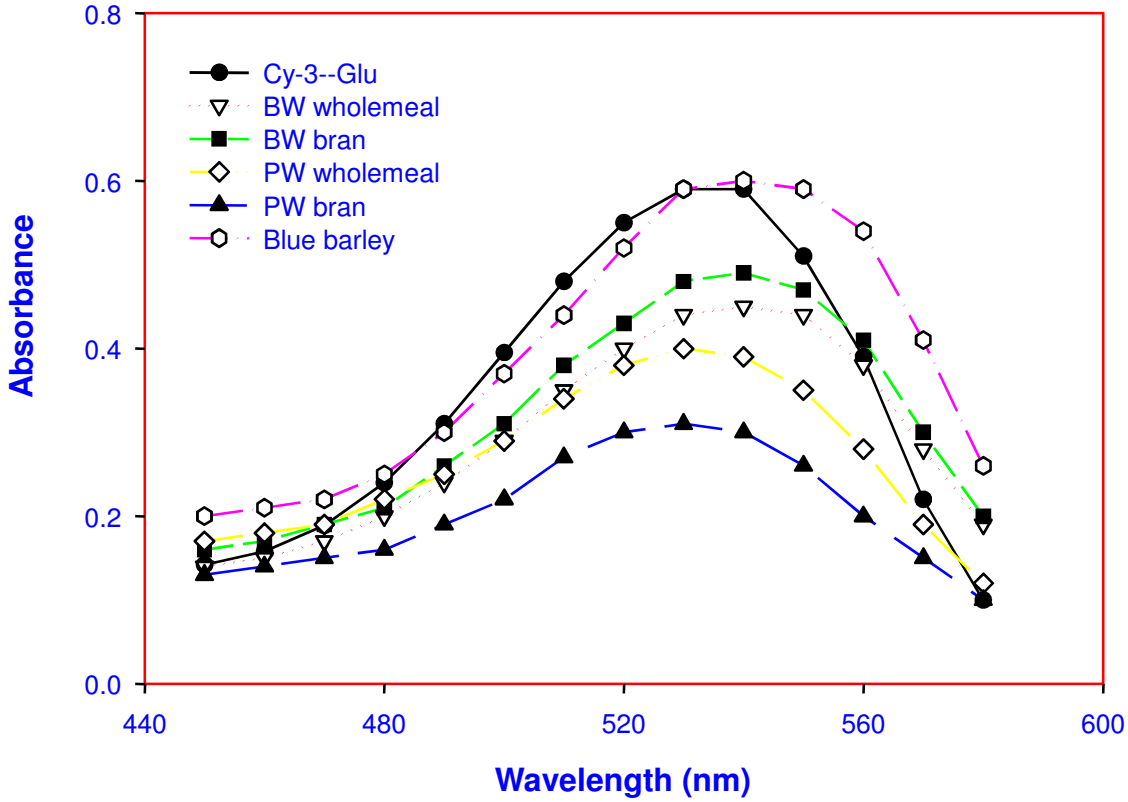
OUTLINE

- Development of colorful wheat and food
  - Anthocyanin in purple wheat
    - Role of anthocyanin in life
      - Purple wheat as a source of anthocyanins
        - Antioxidant properties of anthocyanins
          - Preparation for human studies
            - Conclusions

DEVELOPMENT OF COLORFUL WHEAT AND PURPLE WHEAT FOODS

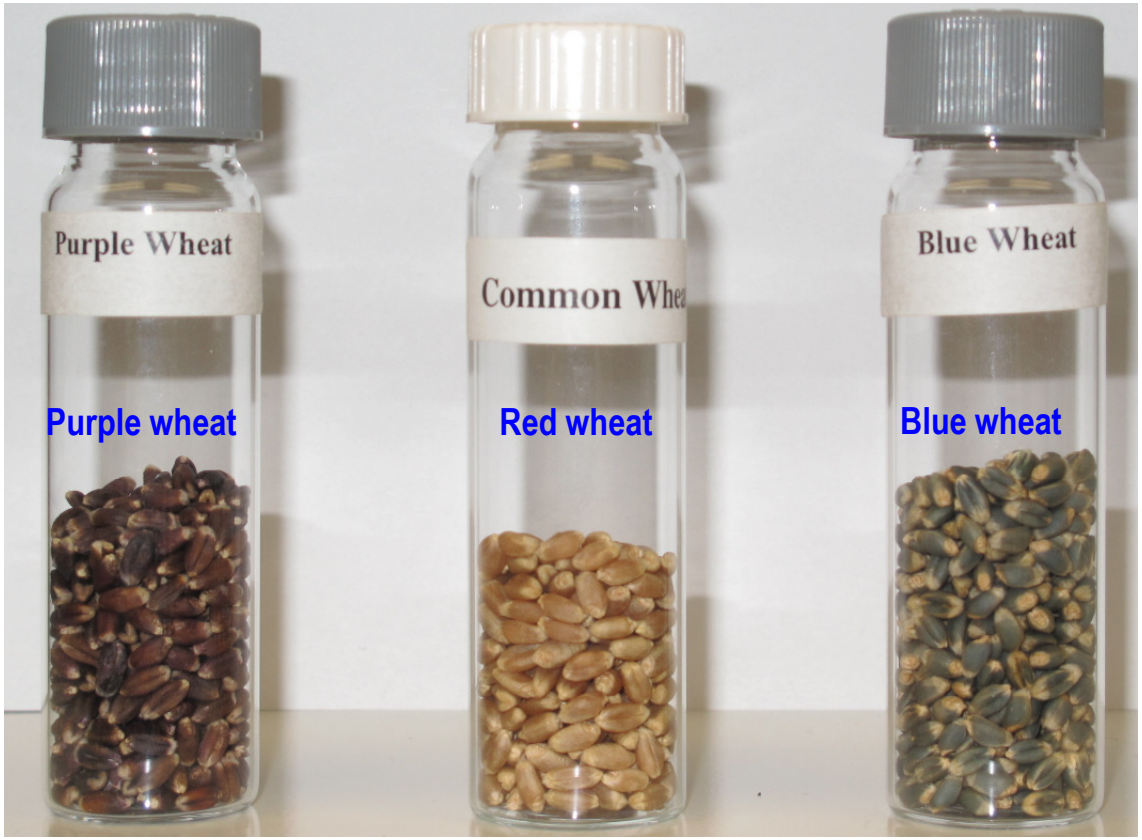


Abdel-Aal and Hucl, Cereal Chemistry, 1999, 76, 350



Absorbance spectra of Cy-3-Glu and wheat extracts

Abdel-Aal and Hucl, Cereal Chemistry, 1999, 76, 350

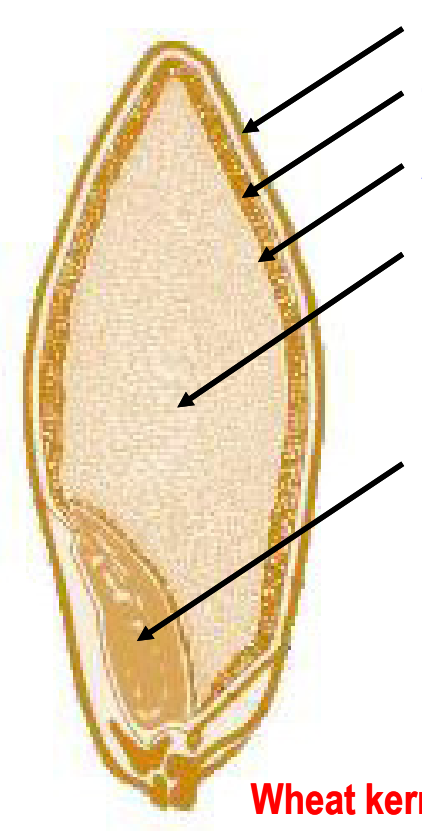

Purple Wheat
Common Whea
Blue Wheat
Purple wheat
Red wheat
Blue wheat

CDC Primepurple wheat
2013



AnthoGrain™

Wheat Milling Fractions

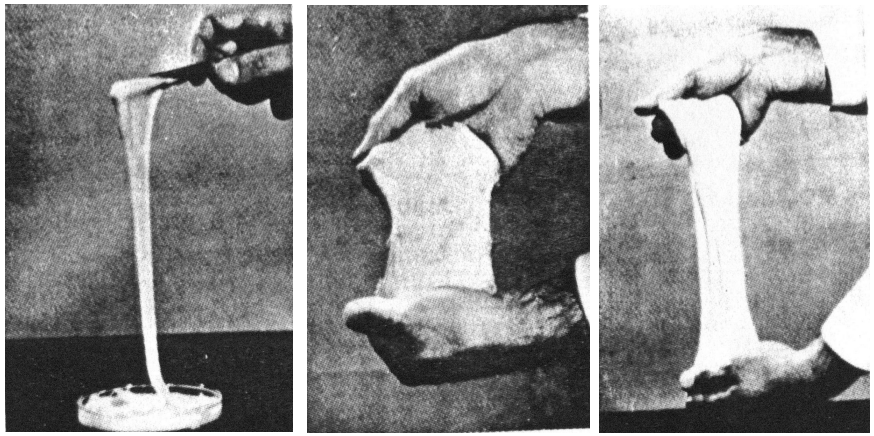


Wheat kernel

Yield, %	ACNs, mg/kg
7.1	818
22.6	495
66.8	32
100	212

Abdel-Aal et al., J. Agric. Food Chem., 2006, 54, 4696

Wheat Flour Uniqueness



Gliadin

Glutenin

Gluten

>30 gliadins

4-6 HMW & 15 LMW

50 protein subunits

Purple Wheat Food Applications

- Breads
- Breakfast Cereals
- Snacks
- Noodles
- Crackers
- Pancakes







Purple Wheat Foods



Pancake



Bread



Flakes



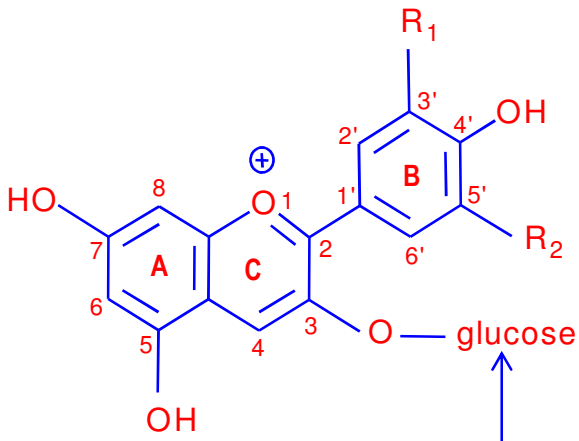
Noodles



Muffin

ANTHOCYANINS IN PURPLE WHEAT

Anthocyanin Structures



Organic acid (aliphatic or phenolic)

Delphinidin-3-glucoside: R_1=OH, R_2=OH

Cyanidin-3-glucoside: R_1=OH, R_2=H

Petunidin-3-glucoside: R_1=OCH_3, R_2=OH

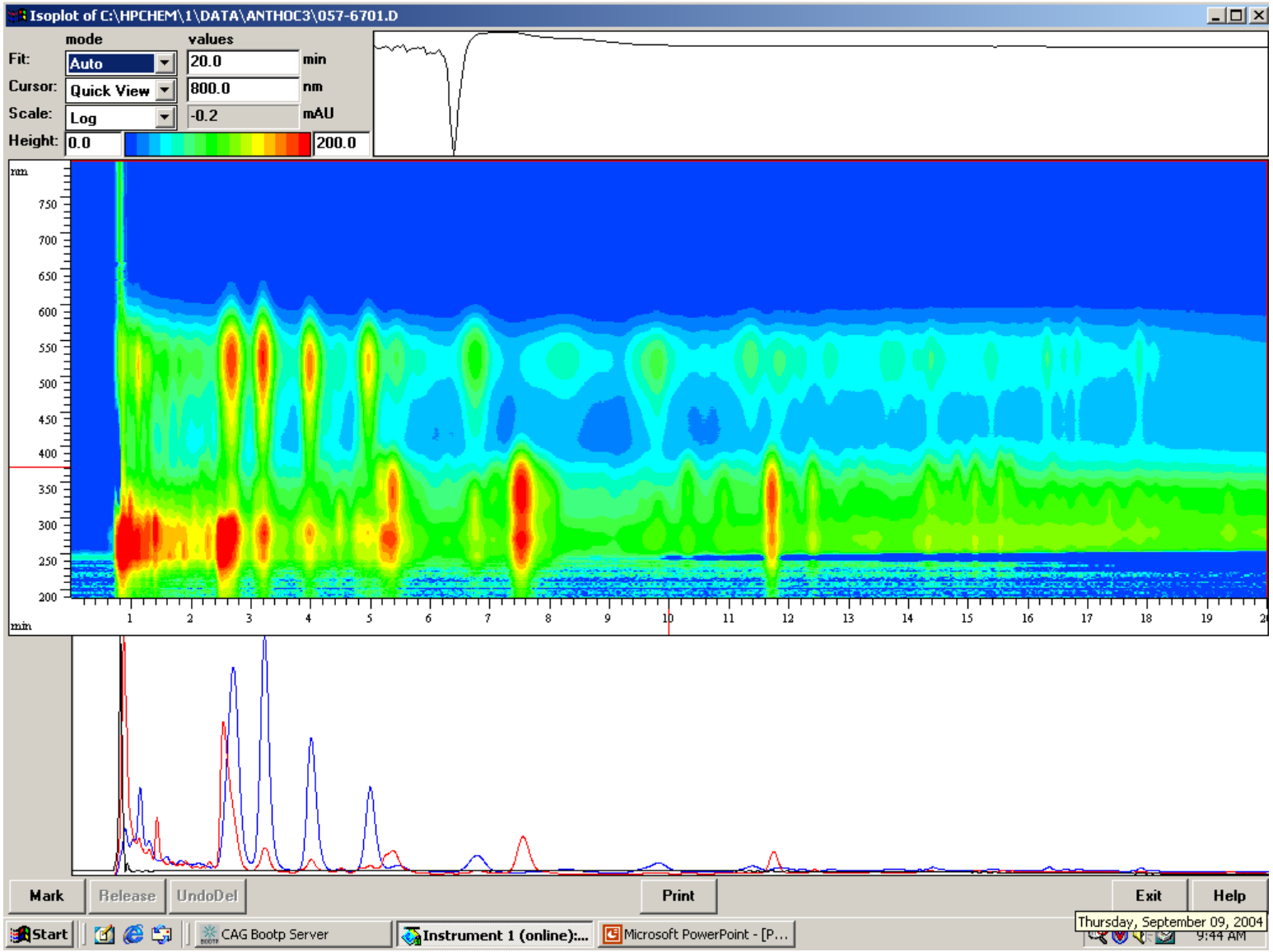
Pelargonidin-3-glucoside: R_1=H, R_2=H

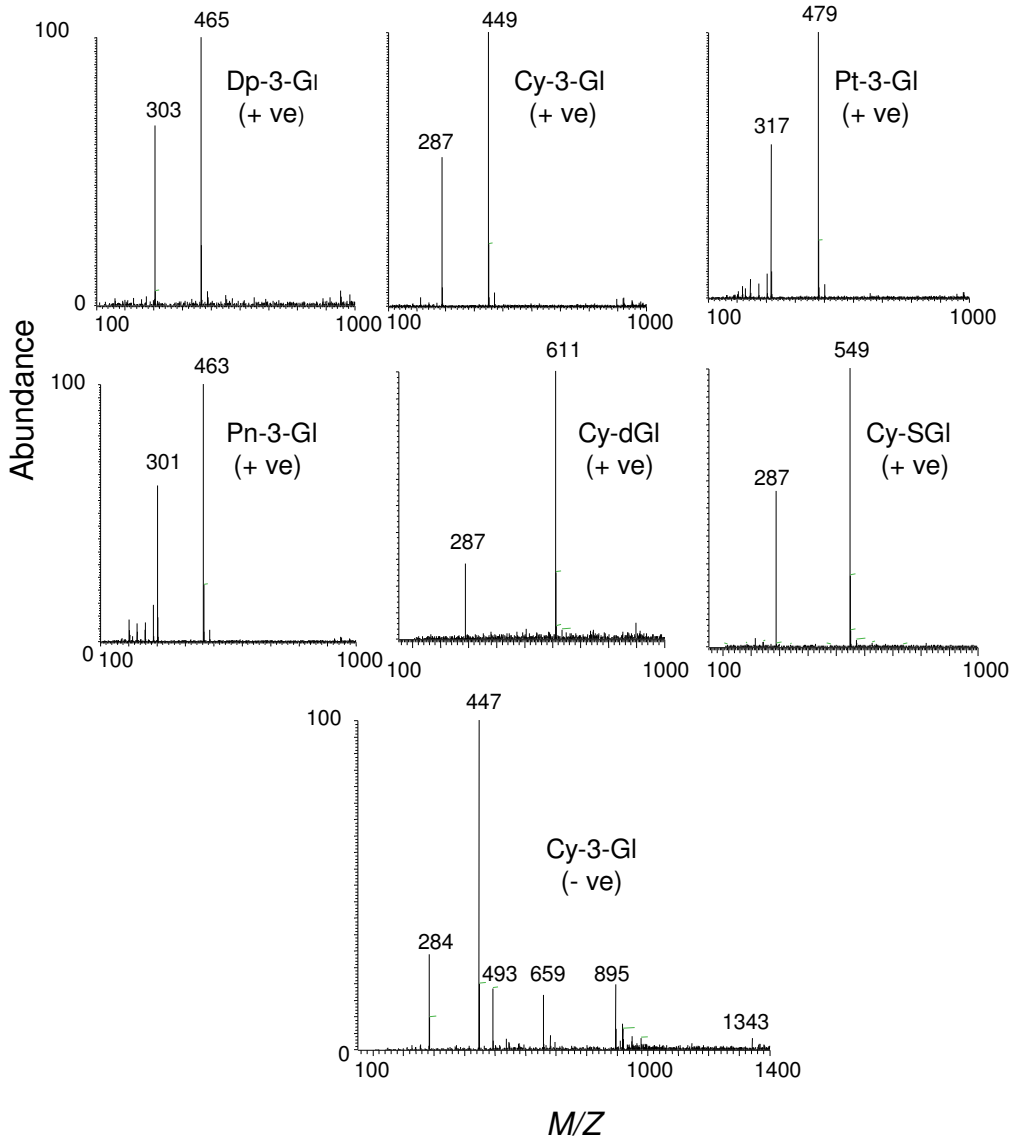
Peonidin-3-glucoside: R_1=OCH_3, R_2=H

Malvidin-3-glucoside: R_1=OCH_3, R_2=OCH_3

Characterization of anthocyanin compounds in purple wheat bran

Compound	Anthocyanin	# of isomeric compounds	Major ion pair	Concentration of anthocyanin (μg/g)
1	Cy-diGlu	9	611/287	1.67
2	Dp-3-Glu	1	465/303	0.09
3	Dp-3-Rut	4	611/303	3.67
4	Dp-MalGlu	5	551/303	3.54
5	Dp-SucGlu	3	565/303	tr
6	Cy-3-Glu	1	449/287	116.66
7	Cy-3-Rut	1	595/287	85.06
8	Cy-MalGlu	4	535/287	150.28
9	Cy-SucGlu	3	549/287	1.00
10	Cy-MalSucGlu	1	635/287	tr
11	Pt-3-Glu	2	479/317	0.19
12	Pt-3-Rut	1	625/317	0.05
13	Pt-MalGlu	1	565/317	3.23
14	Pg-3-Glu	1	433/271	0.91
15	Pg-Rut	3	579/271	0.35
16	Pg- MalGlu	3	519/271	1.17
17	Pg-SucGlu	3	533/271	0.19
18	Pn-3-Glu	4	463/301	27.37
19	Pn-Rut	3	609/301	7.38
20	Pn-MalGlu	6	549/301	18.38
21	Pn-Glu Succ	3	563/301	0.03
22	Mv 3 Glu	3	493/331	0.28
23	Mv Rut	2	639/331	2.55
24	Mv Glu Mal	4	579/331	0.53
25	Mv Glu Succ	3	593/331	1.28
26	Mv Glu Mal Succ	1	679/331	0.16
Total		75	-	426.02


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Abundance
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Cy-SGl
(+ ve)
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Cy-3-Gl
(- ve)
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M/Z

ROLE OF ANTHOCYANINS IN LIFE

Plants

- Pollination and seed dispersal
- Protection against UV
- Reduction of oxidative stress

Human Health

- Biological antioxidant
- Anti-cancer
- Anti-inflammatory effect
- Anti-diabetic effect
- Ocular effect

Food Industry

- Natural colorant
- Dietary antioxidant
- Functional ingredient

Cosmetic and healthcare Industry

- Natural colorants
- Natural antioxidants

Anthocyanin Consumption

Daily intake: 12.5 mg

of the total intake:
45% cyanidin
21% delphinidin
77% nonacylated
73% monoglucoside

Wu et al., J. Agric. Food Chem., 2006, 54, 4069.

PURPLE WHEAT AS A SOURCE OF ANTHOCYANINS



Purple Wheat Kernels

↓

Abrasive or Roller Milling

↓

White endosperm → Bakery products

Bran

↓

Aqueous ethanol extraction

↓

Purification — Column chromatography (amberlite XAD-7)

↓

Drying — Solvent proof oven

↓

Anthocyanin powder

↓

Characterization

Composition, color, stability antioxidant and biological properties



Purification by column chromatography

Average yield and anthocyanin concentration in isolates

Batch size	Yield (g/batch)	Yield (mg/g)	Concentration of anthocyanin (mg/g)	Concentration factor[a]
Purified-Amberlite				
10g	0.21	21.0	57.4	135
50g	0.79	15.8	38.9	91
100g	2.05	20.5	34.7	81
Purified-C18				
50g	0.75	15.0	33.9	80
Non-purified				
50g	1.17	23.4	13.7	32

[a]Ratio of anthocyanin concentration in powder to that in purple wheat bran.

ANTIOXIDANT PROPERTIES OF ANTHOCYANINS

DPPH scavenging capacity of blue wheat bran and powder

Product	µmole/g 10 min	µmole/g 30 min
Bran	40	46
Anthocyanin powder	1686	2526

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

ABTS scavenging capacity of blue wheat bran and powder

Product	µmole/g 3 min	µmole/g 10 min
Bran	23	57
Anthocyanin powder	1610	2925

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

Inhibition of human LDL cholesterol oxidation (µmole diene/g LDL/mg sample)

Product	2 hrs	8 hrs	12 hrs	24 hrs
Control (no antioxidant)	381	528	530	584
Bran	1	17	32	33
Anthocyanin powder	0.055	0.062	0.29	1.44

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

DPPH scavenging capacity of anthocyanins

Anthocyanin	µmole/g 10 min	µmole/g 30 min
Dp-3-Glu	792	831
Cy-3-Glu	1113	1232
Dp-3-Rut	567	613
Cy-3-Rut	3967	4346

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

ABTS scavenging capacity of anthocyanins

Anthocyanin	µmole/g 3 min	µmole/g 10 min
Dp-3-Glu	192	382
Cy-3-Glu	533	1015
Dp-3-Rut	232	430
Cy-3-Rut	1673	3261

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

Inhibition of human LDL cholesterol oxidation (µmole diene/g LDL/mg sample)

Compound	2 hrs	8 hrs	12 hrs	24 hrs
Control	381	528	530	584
Dp-3-Glu	0.042	0.119	0.263	0.244
Cy-3-Glu	0.308	0.695	0.720	0.928
Dp-3-Rut	0.047	0.092	0.272	0.267
Cy-3-Rut	1.251	3.130	3.196	4.018
BHT	19.4	23.0	30.5	36.6

Abdel-Aal et al., J Agric. Food Chem., 2008, 56, 11171

HUMAN STUDIES

Anthocyanin content of Purple Wheat anthocyanin-enriched products measured by spectrophotometric method

Products	Anthocyanin (µg/g)	
	Fresh weight basis	Dry matter basis
Wholegrain bread	65	101
Wholegrain muffin	49	78
Wholegrain pancake	96	167
Wholegrain flakes (uncooked)	120	135
Wholegrain flakes (cooked)	48	116
Wholegrain instant flakes (uncooked)	129	146
Wholegrain instant flakes (cooked)	30	116

Nutrient content of Purple Wheat anthocyanin-enriched Products (dry basis)

Products	Protein	Starch	Fiber	Fat
Wholegrain bread	18.0	56.8	11.9	6.4
Wholegrain bread + bran	16.5	55.4	16.4	5.1
Wholegrain muffin	9.2	19.6	18.1	14.5
Wholegrain flakes (uncooked)	16.2	60.6	12.6	2.1
Wholegrain flakes (cooked)	17.0	57.6	14.0	1.5
Wholegrain instant flakes (uncooked)	17.5	55.4	12.7	1.7
Wholegrain instant flakes (cooked)	18.8	61.2	13.6	1.3
Wholegrain pancake	16.8	36.0	20.7	7.9
Wholegrain flour	11.5	56.4	1.8	12.6

1st study: bioavailability of anthocyanins and phenolic acids & plasma antioxidant capacity

Foods:
Purple wheat wholegrain bread
Purple wheat flakes



Study participants:
Healthy individuals (18-55 Yrs, BMI 18-25)

Study design:
Randomized crossover acute meal study



2nd study: intervention study, oxidative stress and inflammation responses

Foods:
Purple wheat wholegrain bread
Purple wheat flakes





Study participants:
Individuals at risk

Study design:
Randomized placebo crossover acute meal study

Take Home Messages

- Purple wheat holds a promise for the development of natural colorants and/or natural antioxidants
- Purple wheat can be processed into a variety of staple foods for healthy diets
- Dry and wet separation technologies can be used to isolate anthocyanins from purple wheat
- More research is underway to evaluate bioavailability and health benefits of purple wheat products

Acknowledgments

Collaborators

- Dr. Pierre Hucl, U of S
- Dr. Amanda Wright, U of G
- Mr. Mark Pickard, Saskatoon

Partners & Grants

- InfraReady Inc, Saskatoon
- Canadian Food Innovation Cluster
- Agriculture Development Fund of Saskatchewan
- Agriculture and Agri-Food Canada

Research technicians

- Iwona Rabalski
- Marta Hernandez

Students

- Tamer Gamel, U of G
- Tyler O'Leary, U of G
- Riley DeForest, U of G
- Jacklyn Shipp, U of G
- Jessica Simons

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THANK YOU

Questions

AAFC Vision: Driving innovation and ingenuity to build a world leading agricultural and food economy for the benefit of all Canadians

AAFC Mission: to provide leadership in the growth and development of a competitive, innovative and sustainable Canadian agriculture and agri-food sector