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Almond skins (*Amygdalus communis* L.) contain high-value components, such as dietary fibre and polyphenols. Here we describe the bioaccessibility of phytochemicals from almond skins during gastrointestinal (GI) digestion and the role of cell walls in regulating bioaccessibility. A Dynamic Gastric Model of digestion which simulates the physical-chemical processing of the stomach and accurately mimics both the transit time and the luminal content of the upper human gut was used to digest almond skins *in vitro*. No significant changes were observed in the sugar composition of the cell walls of almond skin after *in vitro* gastric or *in vitro* gastric + duodenal digestion, suggesting that no degradation of the dietary fibre had occurred. The decrease in the concentration of the major phenolics and flavonoids within the almond skins after digestion was used as a measure of their bioaccessibility in the GI tract. Under UV light, blue autofluorescence was emitted from the phenolics within the walls of the sclerenchyma cells, the lignified cells of the xylem, and from the cuticle overlying the nucellar layer. Phytochemicals from almond skins are bioavailable in the GI tract. The high dietary fibre content could be exploited for the potential health benefits of non-glycaemic carbohydrate functional food preparations, mainly for gut health.

Almond skin digestion: release of phytochemicals and gut health

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Almond skins (*Amygdalus communis* L.) are industrially produced by blanching and represent 4-8% of the weight of the nut. They are currently considered by-products from the almond processing industry with little economic value. However, almond skins still contain potentially added-value compounds, such as polyphenols and dietary fiber. In this study we describe the release of polyphenols from almond skins during simulated upper gastrointestinal (GI) digestion. The effect of a food matrix on this release and on skin fiber is also reported. The work is relevant to modulation of gut microbiota and upgrading an almond by-product.

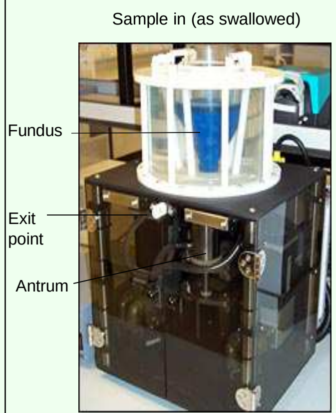
1 Almond skins

- Blanched almond skin powder (**BS**) was prepared by hot water extraction and supplied by the Almond Board California.
- In order to investigate the effects of food matrix on nutrients and phytochemical bioaccessibility, **BS** were subjected to simulated GI digestion in water (baseline) and baked cookies.

Cookies with **BS**

- Handmade cookies with the following composition:
- 6.2 g protein, 21.9 g fat, 64.3 g carbohydrate in 100 g biscuits (~463 Kcal).
- 25 g portion containing 2 g **BS** (~115 Kcal) for simulated digestion.

2 Simulated GI digestions



Dynamic Gastric Model:

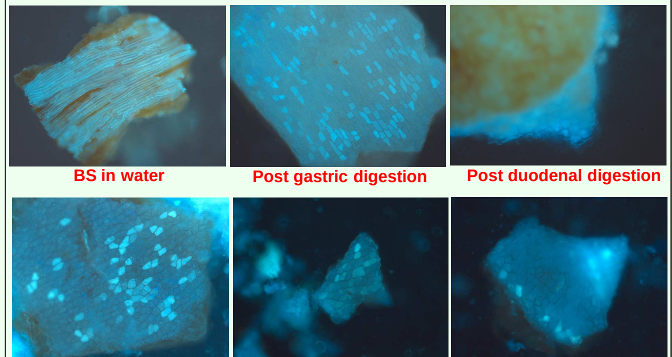
- Simulates the *in vivo* physical and biochemical processing.
- Dynamic gastric additions.
- Simulated delivery to small intestine.

Duodenal digestion:

- pH 6.5, bile salts (8 mmol/l), $CaCl_2$ (11.7 mmol/l), trypsin (104 U/ml), chymotrypsin (5.9 U/ml), colipase (3.2 mg/ml), pancreatic lipase (54 U/ml).

3 Microstructural analysis

- In order to investigate effects of digestion on overall structure of **BS**, fragments were examined under UV light to reveal autofluorescence components.

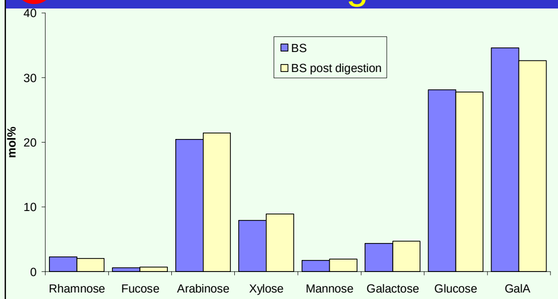


BS in water — Post gastric digestion — Post duodenal digestion

BS in cookies — Post gastric digestion — Post duodenal digestion

- Blue autofluorescent was emitted from the phenolics within the wall of the sclerenchyma cells, the lignified cells of the xylem, and from the cuticle overlying the nucellar layer.
- No significant structural differences were observed after digestion in either water or cookies.

4 Effect of digestion on dietary fiber



- Total dietary fiber (TDF): 46.3 %.
- 96% was insoluble dietary fiber (IDF), 4% was soluble dietary fiber (SDF).
- No changes in TDF composition after gastric plus duodenal digestion.
- Carbohydrate comprised 45% of the dry weight of **BS**. Glucose and galacturonic acid were the major sugars present, followed by arabinose and xylose. No significant changes in almond skin cell walls composition were observed post digestion.

5 Release of polyphenols

- The major almond skin flavonoids were catechin, epicatechin, kaempferol and isorhamnetin.

Compound	Water (% released)		Cookies (% released)	
	GD	DD	GD	DD
Protocatechuic Acid	65.6 ± 12	100.0 ± 12	59.0 ± 11	87.0 ± 11
Catechin	75.1 ± 9	95.0 ± 11	60.0 ± 11	-
Chlorogenic Acid	27.6 ± 13	40.3 ± 13	24.1 ± 4	27.2 ± 6
Vanillic Acid	100.0 ± 14	98.9 ± 12	38.4 ± 5	43.6 ± 4
p-hydroxybenzoic Acid	78.7 ± 17	88.1 ± 16	62.6 ± 8	74.9 ± 9
Epicatechin	89.0 ± 10	93.4 ± 11	27.0 ± 3	-
Trans-*p*-coumaric Acid	68.2 ± 7	73.6 ± 8	57.3 ± 8	69.1 ± 9
Eryodictiol-7-*O*-glucoside	30.0 ± 9	61.4 ± 10	19.3 ± 3	47.9 ± 5
Quercetin-3-*O*-rutinoside	58.9 ± 12	78.1 ± 12	60.9 ± 4	69.1 ± 6
Quercetin-3-*O*-galactoside	67.9 ± 8	80.0 ± 12	63.5 ± 7	75.3 ± 8
Quercetin-3-*O*-glucoside	51.1 ± 9	78.9 ± 13	49.3 ± 6	73.4 ± 4
Kaempferol-3-*O*-glucoside	58.5 ± 6	70.0 ± 12	41.8 ± 6	63.0 ± 4
Kaempferol-3-*O*-rutinoside	82.6 ± 11	89.3 ± 9	74.9 ± 6	79.1 ± 5
Isorhamnetin-3-*O*-rutinoside	74.9 ± 9	88.5 ± 10	60.0 ± 4	74.4 ± 4
Isorhamnetin-3-*O*-glucoside	48.9 ± 7	64.3 ± 10	45.6 ± 7	58.3 ± 3
Naringenin-7-*O*-glucoside	52.9 ± 12	77.5 ± 7	67.1 ± 8	69.5 ± 4
Eryodictiol	54.5 ± 8	87.5 ± 11	60.7 ± 5	85.7 ± 6
Quercetin	42.6 ± 11	61.2 ± 9	38.0 ± 2	55.0 ± 4
Isorhamnetin	47.1 ± 11	50.1 ± 11	32.2 ± 2	41.6 ± 1
Kaempferol	51.0 ± 11	56.0 ± 9	35.7 ± 4	52.0 ± 2
Naringenin	48.5 ± 11	71.0 ± 9	32.2 ± 1	63.0 ± 4

GD: post dynamic gastric digestion.
DD: post gastric plus duodenal digestion.
- not determined.

- The gastric plus duodenal digestion produced only a slight increase in polyphenols over that of the gastric compartment.
- Almond skin polyphenols are bioaccessible during GI digestion in water and cookies.

6 Summary

- Polyphenols are bioaccessible in the GI tract.
- No changes in dietary fiber were observed during digestion in water and cookies.
- Almond skins can be potentially used as added value food supplement.

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