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Review

Stability of phytochemicals as sources of anti-inflammatory nutraceuticals in beverages — A review

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ABSTRACT

Recently phytochemical constituents have attracted a lot of interest as sources of functional ingredients in food product formulations. However, before being incorporated into foods or beverages the stability of these bioactive constituents during post-harvest preservation procedures, in food matrices and during processing and storage must be considered. This review will focus on the stability of phytochemical constituents of herbs with anti-inflammatory properties, including chamomile, meadowsweet, feverfew and willow. These herbs contain a relatively high content of phenolic compounds in comparison to common fruits and vegetables. They have been traditionally used to make teas or infusions that are consumed as a remedy for pain and inflammation. Effects of preservation and extraction conditions on the level of bioactive constituents will be reviewed. The storage conditions (temperature) and thermal processing at pH levels encountered in food products will also be examined.

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1. Introduction

Phytochemicals have received much attention in recent years due to their many health benefits, including antioxidant and anti-inflammatory activities. Medicinal herbs contain a high level of phytochemicals, including phenolic compounds, (Cai, Luo, Sun, & Corke, 2004; Katalinic, Milos, Kulisic, & Jukic, 2006; Butt, Nazir, Sultan, & Schroën, 2008) and therefore would be ideal ingredients for inclusion in functional beverages. Before formulation of fortified beverages is possible, the stability of these bioactive compounds during all the processing steps necessary to their inclusion into foods and beverages must be determined. This includes stability during post-harvest preservation of the plant material (drying, freezing, etc.), preparation of plant extracts, heat processing of model fortified foods and beverages containing these extracts and storage of these model foods. This review will focus on the effects of processing and storage

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on the phytochemical compounds in herbs including chamomile (*Matricaria recutita*), feverfew (*Tanacetum parthenium*) meadowsweet (*Filipendula ulmaria*) and willow (*Salix alba*) (Fig. 1). These herbs have a high content of phenolic compounds in comparison to other food sources i.e. fruits and vegetables (Table 1).

Chamomile, feverfew, meadowsweet and willow are all indigenous to Europe and have been traditionally used due to their anti-inflammatory properties (Blumenthal, Goldberg, & Brinckmann, 2000; Mills & Bone, 2000). Chamomile flowers are one of the most commonly used ingredients in herbal teas and are also widely used in cosmetics (e.g. dyes and shampoo), alcoholic beverages and baked foods (McKay & Blumberg, 2006). Chamomile contains flavonoids including flavone glycosides (e.g. apigenin-7-glucoside) and flavonols (e.g. quercetin glycosides and luteolin glucosides). Apigenin-7-glucoside (Fig. 2) was found to be the most abundant flavonoid in chamomile flowers and as such has become the standard flavonoid to establish extract potency (European Pharmacopoeia, 2004). Caffeic and ferulic acid derivatives have also been detected in the flowers of chamomile (Mulinacci, Romani, Pinelli, Vincieri, & Prucher, 2000). Chamomile contains a volatile oil which is blue in colour. The main components of chamomile essential oil are sesquiterpenes, including matricin/chamazulene, (−)-α-bisabolol and bisabololoxides A and B (Medić-Šarić, Stanić, Maleš, & Šarić, 1997). Pharmacopeial grade chamomile consists of the fresh or dried flowers of the plant (Blumenthal et al., 2000). The health benefits associated with chamomile flowers have been recently reviewed by McKay and Blumberg (2006).

The constituents in feverfew with pharmacological activity are sesquiterpene lactones, which include parthenolide (Fig. 2). Pharmacopeial grade feverfew must contain at least 0.2% of parthenolide (European Pharmacopoeia, 2004).The biological activity of feverfew is also due to its content of phenolic compounds including apigenin, luteolin and tanetin (Pettit, Hoard, Doubek, Schmidt, Pettit, Tackett et al., 1996; Williams, Harborne, Geiger, & Hoult, 1999; McVean, Xiao, Isobe, & Pelling, 2000; Wu, Chen, Wang, Kim, He, Haley-Zitlin et al., 2006). Traditionally feverfew leaves were used fresh, but preparations made from dried feverfew are more common today in the form of teas, tablets and capsules (Piela-Smith & Liu, 2001).

Meadowsweet contains a high content of tannins, phenolic acids and flavonoids (Blumenthal et al., 2000). It also contains salicylates, which are thought to be responsible for the medicinal properties of the herb. The flavonoids present in meadowsweet leaves (Papp, Apati, Andrasek, Blazovics, Balazs, Kursinszki et al., 2004; Krasnov, Raldugin, Shilova, & Avdeeva, 2006) and flowers (Lamaison, Carnat, & Petitjean-Freytet, 1991) have been analysed. All studies found that the main flavonoids present were derivatives of quercetin and kaempferol, including spiraeoside, rutin, quercitrin, quercetin-3-O-β-glucuronide, hyperoside, avicularosid and kampferol-4′-O-glucoside. Spiraeoside was the main flavonoid present in both the leaves and flowers.

Table 1
Content of total phenols in a range of plant material.

Plant material		Total phenols (mg/g)
Fruit	Strawberry	3.64–17[a,b]
	Raspberry	23.9[b]
	Mulberry	15.15[a]
	Blackcurrant	20.3[b]
	Apple	12.1[b]
	Oriental plum	6.7[a]
Vegetable	Beetroot	1.6–2.57[a,b]
	Onion	2.17–2.5[a,b]
	Red onion	2.53–3.1[a,b]
	Red pepper	1.8[a]
	Green pepper	2.06[a]
	Pea	0.4[b]
	Potato peel	2.5–4.3[b]
Herbs	Meadowsweet	26.8–119[b,c,f]
	Nettle	8.8[c]
	Chamomile	12.7–24.5[b,c,d]
	Willow	27–83[b,f]
	Thyme	17.1[b]
	Feverfew	32[e]
Cereals	Oats	0.3–0.7[b]
	Wheat	0.2–1[b]
	Rye	0.5–1.3[b]

[a] Lin and Tang (2007).
[b] Kähkönen et al. (1999).
[c] Trouillas et al. (2003).
[d] Harbourne et al. (2009a).
[e] Marete et al. (2009).
[f] Harbourne et al. (2009).

Pharmacopeia grade meadowsweet must consist of the dried aerial parts (flower, leaf, and steam) harvested when the plant is in bloom (Blumenthal et al., 2000).

White willow contains condensed tannins, flavonoids and glycosides of phenolic acids. Like meadowsweet, willow contains derivatives of salicylic acid, namely salicin, salicortin and tremulacin. Pharmacopeial grade willow bark must consist of the dried bark from young branches of willow and must contain at least 1% salicin (Blumenthal et al., 2000). Setty and Sigal (2005) reviewed the clinical studies which have been conducted using this herb.

2. Post-harvest preservation of the plant material

Preservation of herbs is a key factor during the preparation of the raw material as a source of natural ingredients for potential use in functional foods and beverages. The level of active ingredients in medicinal plants may be affected by the preservation technique applied (Harbourne, Marete, Jacquier, & O'Riordan, 2009). It is therefore important to carry out preservation procedures that maximise the retention of the desired chemical constituents.

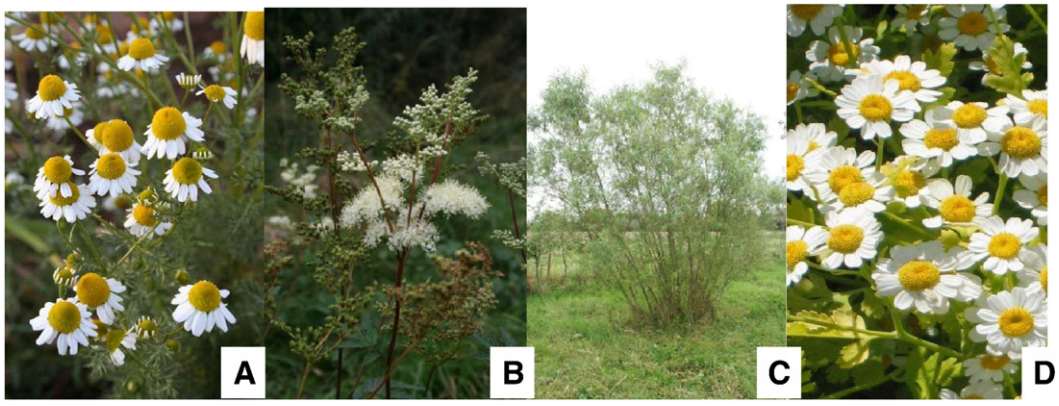

Fig. 1. Image of chamomile (A), meadowsweet (B), willow (C) and feverfew (D).