



Review

Are wild and cultivated flowers served in restaurants or sold by local producers in Denmark safe for the consumer?

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ABSTRACT

New Nordic Food has within the last decade received much media coverage with chefs of top restaurants using wild plants for foods. As part of a control campaign, the Danish Veterinary and Food Administration visited 150 restaurants and local food producers from May–October 2016 and investigated their use of plants picked from the wild, cultivated in private gardens or market gardens. Among the species used were the flowers from 23 plants. Here we present a safety evaluation of these flowers based on published phytochemical investigations and toxicological data in humans, farm animals, pets, or experimental animals. Of the 23 flowers reviewed, nine contained compounds with toxic or potentially toxic effects if eaten, two contained unidentified toxic compound (s), and four were flowers from plants with potentially toxic compounds present in other plant parts or related species. Many of the flowers may be considered novel, since a use to a significant degree in Europe prior to 15 May 1997 before Regulation (EC) 258/97 on novel food and novel food ingredients came into force could not be established. In conclusion, this review illuminates a striking lack of chemical and toxicological data of many of the proposed wild or cultivated flowers for food use.

1. Introduction

With the introduction of a new cuisine known as New Nordic Food in Denmark and other Nordic countries more than ten years ago there has been an increasing interest in using locally grown food plants and plants collected from the countryside (for detailed information on definition and principles on New Nordic Food, see <http://www.newnordicfood.org/>). This interest has been driven by highly profiled gourmet restaurants serving New Nordic Cuisine. The movement has been supported by the Nordic Council of Ministers that has assigned leading chefs as New Nordic Food ambassadors aiming at establishing the New Nordic Cuisine as part of the gourmet world map (Mithril et al., 2012; Nordic Council of Ministers, 2017). Additionally, one large Danish research project OPUS (Optimal well-being, development and health for Danish children through a healthy New Nordic Diet; <http://foodoflife.ku.dk/opus/english/about/>) has studied the impact on a newly developed New Nordic Diet on health. The guidelines developed for this diet did not only focus on local traditionally cultivated plant foods but also recommended inclusion of local wild foods, underlining the possible health potential of e.g. wild plants, mushrooms, berries and fruits, their gastronomic potential and an increased focus on sustainability (Mithril et al., 2012). The idea that wild plants can be collected

for food has spread by e.g. cookbook recipes with wild plants, developed smartphone apps and tours arranged by nature guides having the specific purpose of leading interested individuals to areas where wild plants can be collected for culinary purposes.

Other gastronomic arguments for this diet are that foods collected from the wild differ from country to country and are an important part of the identity of a regional cuisine that could give rise to great gastronomic experiences (Mithril et al., 2012). It is, however, also mentioned that the composition of some wild plants is still unknown, some plants may have a high content of bioactive substances, and some plants may be toxic in large quantities (Mithril and Dragsted, 2012; Mithril et al., 2012). Various flowers have been described as edible decoration on e.g. desserts and cakes, or as ingredients in salads, sometimes constituting a substantial part of the salads. Lately, Danish media and cookbooks have also shown interest in the use of cultivated plants, often known for their traditional ornamental value more than for having been edible. This is not only a Nordic trend. Description of flowers of ornamental plants for human nutrition have e.g. been published by a Czech research group (Mlcek and Rop, 2011; Rop et al., 2012) and reviewed by other groups for their nutritional value, flavour and benefits to human health, mostly describing use outside Europe (Fernandes et al., 2017; Ghosh, 2013; Kelley et al., 2001; Lara-Cortes et al., 2013; Lim,

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Abbreviations

ADI	Acceptable Daily Intake	HCN	hydrogen cyanide
ARfD	Acute Reference Dose	IARC	International Agency for Research on Cancer
BAPN	3-aminopropanenitrile	JECFA	Joint FAO/WHO Expert Committee on Food Additives
BfR	The German Federal Institute for Risk Assessment	L-BOAA	3-[(carboxycarbonyl)amino]alanine
BMDL ₁₀	benchmark dose lower confidence limit 10%	MOAIs	monoamine oxidase inhibitors
BVL	German Federal Office of Consumer and Food Safety	NOAEL	No Observed Adverse Effect Level
bw	body weight	NOEL	No Observed Effect Level
DIBOA	2,4-dihydroxy-1,4-benzoxazin-3-one	NTP	National Toxicology Program
DVFA	Danish Veterinary and Food Administration	OPUS	Research project on optimal well-being development and health for Danish children through a healthy New Nordic Diet
EFSA	European Food Safety Authority	TDI	Tolerable Daily Intake
EMA	European Medicines Agency	TMDI	Theoretical Maximum Daily Intake
GABA _A	γ-aminobutyric acid subtype A receptor		

2014).

However, the potential toxic effects of the flowers caused by inherent constituents were not assessed in any of these publications. In addition, potential health concerns arise when eating harvested or purchased ornamental flowers not intended for food use as suggested by Fernandes et al. (2017) including pathogens like *Salmonella* and addition of unauthorised chemicals as sulphite or pesticides like dimethoate (CAS 60-51-5).

A lack of botanical knowledge and the assumption that everything natural possesses no risk is a dangerous cocktail when harvesting wild plants, which in Italy already from the mid-1990s resulted in an increasing number of intoxications mainly due to misidentifications of species (Colombo et al., 2010). In the European Union (EU), novel food is defined as ‘food that has not been consumed to a significant degree by humans in the EU before 15 May 1997’ (Regulation (EC) No 258/97). The newest regulation (Regulation (EU) 2015/2283) came into force 1 January 2018. According to the regulation, the determination of whether a food was used for human consumption to a significant degree within the Union before 15 May 1997 should be based on information submitted by food business operators and, where appropriate, supported by other information available in Member States. One of the underlying principles is that novel foods must be safe for the consumers. Whereas it is common to use plant parts like roots/tubers, stems, leaves, fruits and seeds for foods or as spices, blooming flowers have historically rarely been used. Among over 300 major reviewed food plants (Pilegaard et al., 2007), mainly cultivated, used in Europe up to 1997 for which plant parts have been specified, flowers were only mentioned for two species i.e. garden nasturtium (*Tropaeolum majus* L.) and borage (*Borago officinalis* L.). Further, it was noted that use of the latter plant might give rise to health concern. Flowers from a few other species were also listed e.g. two species of *Tilia* L. (lime) but for preparations of infusions and not for eating as such.

From May to October 2016 as part of a control campaign the Danish food authorities (the Danish Veterinary and Food Administration, DVFA) visited 150 restaurants and local producers of e.g. jams, and investigated their use of plants and mushrooms picked from the wild, grown in private gardens or market gardens with special emphasis on the species used aiming at developing a list of plants for which safety and novel food status has been clarified as guidance for business operators. It was a general finding that there was a huge interest in using plants and mushrooms from the wild as foodstuffs (DVFA, 2017).

Here, we present a toxicological review of flowers identified in the campaign for food use. The review is based on published information on food use of the flowers before 1997 in addition to published phytochemical analyses and toxicological data of the flowers after intake in humans, farm animals, pets, or experimental animals.

2. Methods

The DVFA listed the common Danish and scientific names of the plants, and plant parts used according to information obtained from the campaign when visiting 150 restaurants and local food producers distributed all over Denmark. The plant material was photographed. If there was later doubt about the identity of a reported species, these photos were consulted and the identity of the species was established. Information on the exact food use, including potential preparation of the plants, was not provided to DVFA and therefore not reported in this review. This review is restricted to plants from the campaign for which flowers or inflorescences are used as foodstuffs.

The preferred scientific plant names and commonly used synonyms were substantiated in the botanical databases first in The Plant List (The Plant List, 2013. Version 1.1. Published on the Internet <http://www.theplantlist.org/>) and additionally in the US National Plant Germplasm System (<https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx>). A plethora of English plant names exist for all the reviewed plant species. The English common names used stem from either the US National Plant Germplasm System or Mansfeld's World Database of Agricultural and Horticultural Crops (<https://mansfeld.ipk-gatersleben.de>). Danish common names were identified after consulting a botanical textbook with recommended common names (Jensen et al., 2003). It should, however, be kept in mind that compared to a scientific name the vernacular or common name does not uniquely identify the species (Pilegaard et al., 2010).

In the period from February to October 2017, searches were performed in the bibliographic databases: Web of Science, Scopus, and SciFinder using the preferred scientific name, and if relevant also synonyms. The full scientific papers were obtained if abstracts described ethnobotanical studies on food use in European countries (prior to 1997), constituents, especially if toxicological relevant, experimental laboratory animal studies on the toxicological effects of the plants and cases of intoxications in humans or animals exposed to the individual plants. This study focus only on the food use of flowers prior to 15 May 1997, as this is the cut-off date from which a food substance is considered novel, and thus requiring regulation and testing as stipulated by EU regulation 2015/2283. Since the novel food regulation for ordinary food use does not apply for use as flavourings or sole use as ingredients in food supplements, such use of the flowers are not reported in this review. Use only in aqueous extracts as herbal teas/infusions are also considered as out of the scope of this paper as is use as traditional herbal medicine when considering a history of food use. It was checked whether the use of the flowers or inflorescences were mentioned in the Novel Food Catalogue (https://ec.europa.eu/food/safety/novel_food/catalogue_en), a non-exhaustive list, serving as an orientation on

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