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Effect of different cooking methods on bioactive compounds in vegetarian, broccoli-based bars

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ABSTRACT

Recently, trend toward vegetarianism and veganism has globally increased. Effect of domestic cooking methods including microwaving, frying, frying/microwaving, steaming and baking on bioactive compounds of broccoli-based bars (BBBs) was investigated. Total phenolic content (TPC), antioxidant activity and phytochemicals were investigated. Subsequently, identification and quantification of dominant phenolics and glucosinolates were carried out. A sensory evaluation of cooked BBBs was performed, as well. Results indicate that health-promoting compounds in BBBs were significantly affected by cooking methods. Negligible change was found in TPC, whereas antioxidant activity was significantly affected. Cooking treatments except steaming and baking caused significant losses of chlorophylls, carotenoids, and flavonoids in the range of 20–51, 15–58, and 25–33%. Frying and frying/microwaving caused a loss of single phenolic compounds. Total glucosinolates content decreased significantly during frying, frying/microwaving, steaming, and baking, while microwaving did not. The presented data might be helpful for selecting the optimum processing conditions for innovative BBBs.

1. Introduction

Vegetables of the *Brassica* family such as cabbage, broccoli, cauliflower, and Brussels sprouts have been studied extensively in particular for their health beneficial properties. As one of the most important representatives of *Brassica* vegetables, broccoli (*Brassica oleracea* var. *italica*) contains high levels of phytochemicals, and has been described as a vegetable with high nutritional value (Borowski, Szajdek, Borowska, Ciska, & Zieliński, 2008; Manchali, Chidambara Murthy, & Patil, 2012; Vallejo, Tomás-Barberán, & García-Viguera, 2002; Verkerk et al., 2009) and considerable bactericidal effect against specific infection in type 2 diabetic patients (Bahadoran et al., 2014). However, *Brassica* vegetables are consumed mostly after some types of processing, e.g. blanching, boiling, steaming, microwaving, frying, roasting, or fermentation which are expected to give beneficial effects on the vegetable properties, such as improving palatability and bioavailability of nutrients or shelf-life extension. However, processing can also result in changes of the phytochemicals content (Martínez-Hernández, Artés-Hernández, Gómez, & Artés, 2013; Nugrahedi, Verkerk, Widianarko, & Dekker, 2013). Various reviews have discussed the effect of conventional cooking methods on health-promoting compounds of broccoli (Cieślik, Leszczyńska, Filipiak-Florkiewicz, Sikora, & Pisulewski, 2007; Lin & Chang, 2005; Lippi, Salvagno, Montagnana, & Guidi, 2008; Nugrahedi et al., 2013; Sikora, Cieślik, Leszczyńska, Filipiak-Florkiewicz,

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& Pisulewski, 2008; Zhang & Hamauzu, 2004). With regard to their stability, glucosinolates (GLS) seem to be the most critical class of compounds, as they might be degraded either enzymatically or non-enzymatically under food processing conditions. The endogenous plant enzyme myrosinase hydrolyzes GLS rapidly to glucose and unstable intermediates, which spontaneously rearrange to a variety of biologically active breakdown products including isothiocyanates, thiocyanates, epithionitriles, or nitriles (Tang, Paonessa, Zhang, Ambrosone, & McCann, 2013; Verkerk et al., 2009). However, the same degradation can be observed when the enzyme is thermally inactivated prior to processing (Hanschen et al., 2012a).

Vegetables are commonly prepared at home or presented in the restaurants on a basis of convenience and taste preference rather than retention of nutrient and health-promoting compounds (Masrizal, Giraud, & Driskell, 1997). In this context, in recent years, a growing trend toward vegetarianism and veganism has globally increased not only due to health-promoting benefits but also for reducing the adverse effects resulting from excessive processed meat consumption. This is accompanied by a controversial discussion about a processing effect on the 'healthiness' of vegetarian diets. While some consumers think that unprocessed food is healthier, it has to be kept in mind that processing often is necessary to extend shelf-life or even to activate some compounds before they become health-beneficial as well as to deactivate some undesired enzymes.

To meet the purposes described, innovative vegetarian, broccoli-based bars (BBBs) containing appropriate amounts of healthy nutritional ingredients have been developed. The main objective of this study was to investigate the fate of potential bioactive compounds by applying different conventional cooking methods. The contents of GLS, carotenoids, chlorophylls, and phenolic compounds were analyzed in differently prepared BBBs and sensory attractiveness of the products was evaluated as well. In addition, the antioxidant activities of the BBBs were estimated as an indicator for their stability and the potential health beneficial effects.

2. Materials and methods

2.1. Plant materials

Broccoli florets (*B. oleracea* var. *italica*), chickpea (*Cicer arietinum* L.), sweet potato (*Ipomoea batatas* L.), naked barley (*Hordeum vulgare* L. var. *nudum*), carrot (*Daucus carota* L.), onion (*Allium cepa* L.), sweet red pepper (*Capsicum annuum* L.), fresh garlic (*Allium sativum* L.), fresh coriander leaves (Cilantro; *Coriandrum sativum* L.), fresh dill (*Anethum graveolens* L.), fresh parsley (*Petroselinum crispum* Mill.), and table salt of prime fresh quality were purchased from a local supermarket in Hamburg, Germany. Traditional seasoning species were brought from Ragab El-Attar's local spices supermarket, Egypt.

2.2. Preparation of the different broccoli-based bars (BBBs) ingredients

The green leaves of fresh broccoli plants were removed; the florets were cut into 1.5–2 cm parts prior to blanching under live steam for 3 min then they were immediately cooled down. Unpeeled chickpeas were washed and soaked in water for 12 h. Then excessive water was drained and chickpeas were peeled and ground for 3 min using a conventional kitchen machine. Sweet potato and carrots were peeled, washed, chopped in 1 cm slices, and blanched using live steam blancher for 7 and 5 min, respectively. Subsequently, the blanched materials were immediately cooled down and homogenized to a puree. The whole naked barley kernels were milled twice to obtain homogeneous and fine barley flour. Sweet red pepper was washed and chopped in small cubes after removing the seeds. Further ingredients such as fresh onion and garlic were peeled, washed and then chopped immediately before preparing the vegetarian bars. To prepare the green leafy mix of herbs, fresh coriander, dill, and parsley leaves were washed, ripped and then mixed as (2:1:1), respectively. The spices were ground and mixed as [25 g ground black pepper (*Piper nigrum* L.), 20 g ground cumin (*Cuminum cyminum* L.), 20 g relish ('Baharat'; ready-mix of specific spices), 10 g ground dried coriander seeds (*C. sativum* L.), 10 g ground ginger (*Zingiber officinale* R.), 10 g ground paprika (*Capsicum annuum* L.) and 5 g ground hot chili (*Capsicum chinense* L.)] to prepare 100 g of traditional spices mix for using it immediately.

2.3. Preparation of ready-to-use BBBs

Broccoli-based vegetarian bars were prepared from the previously described ingredients according to the recipe in Table 1. This has been established after wide trails to find suitable recipe. About 2.5 kg from this formula was prepared using a kitchen machine mixer on low speed level for 2 min. For the phytochemicals analyses, about 100 g uncooked/untreated BBB samples were frozen overnight, freeze-dried for at least 96 h, and then subjected immediately to analysis.

2.4. Preparation of ready-to-eat BBBs

The whole prepared diet mixture was divided into equal portions immediately before applying the different domestic cooking methods. Appropriate amounts of each BBB mixture

Table 1 – Composition of the untreated vegetarian broccoli-based bars[a] (BBBs).

Ingredients	(%)
Blanched broccoli	25
Peeled soaked chickpea	25
Blanched sweet potato	12
Whole barley flour	10
Blanched carrot puree	7
Green leafy herbs mix[b]	8
Red pepper paste	5
Fresh onion	5
Salt	1.25
Fresh garlic	0.75
Traditional spices mix	1

[a] Proximate content of nutrients (27.8 g protein, 3.8 g fat, 7.9 g ash, 11.6 g crude fiber and 48.9 g carbohydrates per 100 g calculated on dw basis).
[b] Green leafy herbs mix (2:1:1, fresh coriander, dill, and parsley leaves).