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Screening of changes in content of health benefit compounds, antioxidant activity and microbiological status of medicinal plants during the production of herbal filter tea

Senka Vidović[a,*], Dragoljub Cvetkovic[a], Milica Ramić[b], Mirjana Dunjić[c], Radomir Malbaša[a], Aleksandra Tepić[a], Zdravko Šumić[a], Aleksandra Velićanski[a], Stela Jokić[d]

[a] University of Novi Sad, Faculty of Technology, Bulevar cara Lazara 1, 21000 Novi Sad, Serbia
[b] Fructus d.o.o., Novosadski put 15/2, 21400 Bačka Palanka, Serbia
[c] Galenika, Batajnicki drum bb, 11080 Belgrade, Serbia
[d] Faculty of Food Technology, Osijek, F. Kuhaca 20, 31000 Osijek, Croatia

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ABSTRACT

During the production of fine cuts in tea factory difference in the content of essential oil in investigated raw and investigated processed plant material was detected. The content of essential oil in *Melissa officinalis* fine cut, in comparison to the content measured in raw material, has been decreased for 13.0%. Content of total phenols in investigated plant materials (raw and fine cuts) varied from 3.2096 mg GAE/g to 177.6038 mg GAE/g. Industrial processing affected on the content of total phenols, lower was measured in produced fine cuts in comparison to raw materials. All vitamin C was lost during the production of *Cassia angustifolia* and *Mentha piperita* fine cuts. Investigated samples were of satisfactory microbiological quality due to the presence of *Salmonella* spp. (not detected in 25 g of analyzed plant material) and *E. coli* (<103 cfu/g). Processing of raw materials was not significantly increased total aerobic microbial count and total yeasts/moulds count.

1. Introduction

From the ancient times up to the present day medicinal plants have been used as an essential resource of health benefit compounds. According to World Health Organization, traditional medicines, including herbal medicines, have been, and continue to be, used in every country around the world. In some developing countries in fact 70–95% of the populations rely on these traditional medicines for primary care (Robinson and Zhang, 2011). Most of herbal products of traditional medicine are produced and are used in the form of tea.

Today tea is used as a beverage and as a source of health benefit compounds. Due to the awareness of health benefit compounds, consumption of tea is becoming more and more popular in all world countries, including Serbia. Many therapeutic properties such as neuroprotective, cardioprotective, chemoprotective, anti-carcinogenic, hepatoprotective and anti-inflammatory have been attributed to herbal preparations (Campanella et al., 2003; Visioli et al., 2000), including teas. In Serbia the production of teas and other herbal products have been increased at a rate of 10% annually. The export of locally produced bulk herbs, filter and instant tea, to the markets of EU and North America was increased over the last decade. Serbia and all Balkan regions have significant quantities of medicinal plant resources. These resources encompass 89 families including *Laminaceae*, *Asteraceae*, *Apiaceae*, *Malvaceae*, *Rosaceae*, etc (Dajić, 2012). Many of these medicinal herbs, available on Serbian market, are collected from the wild, but there is an increasing number of species obtained by commercial cultivation. Numbers of medicinal plants, processed in Serbian tea factories, are purchased from the local markets, but there are still some, like *Cassia angustifolia*, *Hibiscus*, and *Camellia sinensis*, that are imported from markets like India and China.

Herbal teas are sources of entire network of health benefit compounds. Almost all herbal teas are rich in phenolic compounds, which are proved to posses important antioxidant activity and are recommended to be included in human diet as health promoters (Seeram et al., 2001; Kim et al., 2005; Piccolella et al., 2008; Khoo et al., 2011). According to the Lee phenolic compounds showing considerable diversity in their structure, and except to antioxidant activity they contribute to flavour, colour and sensory properties such as bitterness and astringency of food products (Lee, 2000). Essential oils, present in number of herbal teas, represent another

* Corresponding author. Tel.: +381 21 485 3731; fax: +381 21 450 413.
E-mail address: senka.curcin@yahoo.com (S. Vidović).

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Table 1
Investigated unprocessed/raw and processed plant material/fine cut.

Sample number	Plant material	Origin/year of harvesting and collecting	Purchased and stored/ processed date
1	*Rosa canina* fructus	Southeast Serbia, 2011	08.03.2012
2	*Rosa canina* fructus-fine cut	Southeast Serbia	15.06.2012
3	*Melissa officinalis* herb	Central Serbia, 2012	07.06.2012
4	*Melissa officinalis* herb-fine cut	Central Serbia	15.06.2012
5	*Mentha piperita* folium	Northwest Vojvodina, Serbia, 2012	13.06.2012
6	*Mentha piperita* folium-fine cut	Northwest Vojvodina Serbia	15.06.2012
7	*Foeniculum vulgare* fructus	Northwest Vojvodina, Serbia, 2010	30.07.2010
8	*Foeniculum vulgare* fructus-fine cut	Northwest Vojvodina, Serbia	15.06.2012
9	*Cassia angustifolia* folium	India, 2011	06.03.2012
10	*Cassia angustifolia* folium-fine cut	India	15.06.2012
11	*Uva ursi* folium	Macedonia, 2011	08.11.2011
12	*Uva ursi*-fine cut	Macedonia	15.06.2012

very important almost key compound of these products. Essential oils are known to posses very strong antibacterial, antiviral and antioxidant properties, and are used for their analgesic, sedative, anti-inflammatory and spasmolytic properties (Serrano et al., 2011; Bakkali et al., 2008). The consumption of food containing bioactive volatile plant extracts (essential oils), commonly found in leaves, flowers or buds, bulbs, seeds, rhizomes and fruits, is therefore expected to prevent the risk of many diseases (Gardeli et al., 2008). Beside phenolic compounds and essential oils herbal teas are also reported to contain some other essential compounds among important are vitamins A, B6, C and E (Atoui et al., 2005).

Due to important properties of health benefit compounds and demands of modern consumer, the tendency of modern food producers is to produce the final food product with preserved content of vitamin C, phenolic compounds and other valuable phytochemicals (Šumić et al., 2013). That is why the control of quality, but also insurance of safety and efficiency, should be considered as a very important issue in the process of herbal tea production. To insure the production of quality and safe final herbal product, beside the tendency to preserve health benefit compounds, it is essential to set the limits for microbial contamination (Barnes et al., 2007). Microbial contamination of botanical raw materials occurs in all stages of plant production: growth, harvesting and post-harvest handling. The contamination at some stages of production can be controlled to some extent in cultivated plants, while some sources, especially wild ones, are quite beyond man's control. The final contamination level is the result of many factors acting in microbial ecology. Dried herbs may therefore contain high levels of microbial contamination, depending on whether they have received a form of pathogen reduction treatment or not (McKee, 1995). According to Kunle et al. (2012) aerobic bacteria and fungi are normally present in plant material and may increase due to harvesting, storage and processing of plant material. Pathogenic organisms including *Salmonella*, *Enterobacter*, *Enterococcus*, *Clostridium*, *Pseudomonas*, *Shigella* and *Streptococcus* species have been shown to contaminate herbal ingredients.

The present study was taken up as means to find out the changes in the content of health benefit compounds (total phenols, vitamin C and essential oils), changes in antioxidant activity and changes in microbiological status of medicinal plants (selected herbs, seeds and fructus) during their processing (production of fine cuts) in the local herbal tea factory. The processing of medicinal plants includes few mechanical operations: cutting, grinding, sieving and fractionating. Fine cut represent herbal plant material of particle sizes from 0.315 to 2.0 mm. Particle sizes of this material are higher than that of pores of filter tea bag. The fine cuts thereby represent the herbal material that will be further processed in the term of packaging in the herbal tea factory. This research is based on evaluation of quality, safety and efficiency what is needed to improve approaches to the herbal tea production.

2. Materials and methods

2.1. Chemicals

Vitamin C (ascorbic acid), produced by J.T. Baker (Holland) was used as a standard. Standard substance and samples were dissolved/extracted in the solution of 3% m-phosphoric acid (Riedel-de Haën, Germany) in 8% acetic acid (J.T. Baker, Holland). Ammonia-acetate solution was used as a mobile phase (0.1 M; pH 5.1). Solutions were prepared in redistilled water with appropriate quality for HPLC analysis. 1,1-Diphenyl-2-picryl-hydrazyl-hydrate (DPPH) and Folin–Ciocalteu reagent, were purchased from Sigma (Sigma–Aldrich GmbH, Sternheim, Germany). Chlorogenic acid was purchased from Sigma (Sigma, St. Luis, MO, USA). All other chemicals and reagents were of analytical reagent grade.

2.2. Plant material

For analysis 12 different plant samples were obtained from the local tea factory (Fructus d.o.o., Bačka Palanka, Serbia). Six plant samples (samples number 1, 3, 5, 7, 9, and 11) represented unprocessed raw plant material purchased from the local traders, with different origin for every different species (Table 1).

Six other samples (sample 2, 4, 6, 8, 10 and 12) represent processed plant materials (fine cuts). These samples were obtained after cutting, grinding, sifting and fraction collecting (Fig. 1) of *Rosa canina* and *Foeniculum vulgare* fructus, *Melissa officinalis* herb, *Mentha piperita*, *C. angustifolia* and *Uva ursi* folium in the tea factory. All samples were processed at the same day, under same conditions (temperature from 23 °C to 25 °C, relative humidity from 55% to 60%). All samples were the same particle size, from 0.315 to 2.0 mm.

Production of fine cuts included: cutting and grinding, sifting and fractioning of plant material. Mechanical operations like cutting and grinding are leading to the opening of plant cells and crushing of their structure. Also, during the industrial processing, the occurred friction my increase the temperature inside the plant material. All this could induce the increase of moister content, the loss of active components and the growth of microorganisms. This trend could be continued during the storage stage. To determine the overall impact of these operations on the characteristics of the herbal plant material, samples for testing were taken before cutting and after storage of processed material (produced fine cuts).

2.3. Analysis of moisture content

Moister content in investigated plant samples was determined by drying the samples at 105 °C until the constant weight. All analysis were performed in three replicates.