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A Functional Beverage: Lemonade

F. Z. Yekeler, H. Ozyurek, and C. E. Tamer

***Abstract*—**Fruits and vegetables are the essentials of a healthy diet, mainly because of their antioxidant properties contributing to disease blockage especially for some certain types of cancer. Being a favourite fruit, citrus are produced for economic and commercial purposes worldwide. Particularly, lemon fruit (*Citrus limon* L.), has an important place in export products of Turkey. Lemon has a great importance on human nutrition with regard to being a source of nutrients, flavonoids, vitamin C and minerals. It is used for food flavouring and pickling and also processed for lemonade. By processing citrus into fruit juices, consumption may increase and also become easier. Like many fruits and vegetables lemons are cheap and abundant during harvesting period, while they are quite expensive in other seasons. Lemon juice and concentrate production allows consumers to get benefits from lemon fruit in any time of the year. Lemonade is getting in to the focus of consumers' attention preferring non-carbonated drinks. The demand of healthy, convenient functional foods affects consumer trends through innovative products. For this reason, lemonade could be enriched with different natural herb extracts such as ginger (*Zingiber officinale*), linden (*Tilia cordata*), and mint (*Mentha piperita*).

***Keywords*—**Lemonade, herb extracts, antioxidant activity.

I. Introduction

CITRUS genus is the most important fruit crop in the world [1]. Citrus species of various origins have been assessed for their phenolic constituents, essential oils, vitamins, minerals, dietary fibre, and carotenoids [2], [3]. Citrus fruits are among the most important dietary sources of bioactive compounds [4]. The healthy properties of citrus fruits have been attributed to ascorbic acid and phenolic compounds, mainly to flavonoids [5].

Lemon (*Citrus limon*) is the third most important citrus crop [1]. Particularly lemon native to Asia is a leading citrus species with the production quantity nearly 13.861.411 around the world in 2011. Today, Mexico is the first lemon producing country, following by India and China [6].

Lemon is generally used for culinary purposes such as, flavoring of salads and other types of foods and also for fruit juice production. Lemon juice is widely used as an antioxidant natural substitute for the synthetic ascorbic or citric acids in beverages as acidifier and preservative in fruit juices, jellies and organic and environmentally friendly foods. These features open new ventures for producers and processing companies of lemon fruit in food industry [7], [8]. Moreover, lemon juice could prevent browning reactions and color deterioration of pomegranate juice [9].

There is a significant overproduction of lemon fruits in some countries and, hence, new uses for lemon fruits should be developed with the aim of minimizing production losses and generating more profits with along a sustainable use of wastes. In this sense, new alternatives for beverages elaboration may result in a promising use of surplus production [10].

C. E. Tamer, F. Z. Yekeler, and H. Ozyurek are with Uludag University Faculty of Agriculture Department of Food Engineering, 16059 Bursa/Turkey (phone: +90 2242941501; fax: +90224 2941402; e-mail: etamer@uludag.edu.tr).

II. Functional Properties of Lemon

Lemon fruit is a rich source of nutrients, including flavonoids, citric acid, vitamin C and minerals (e.g. potassium, calcium, phosphorus, sodium, iron and zinc), which provide numerous health promoting properties (Table I) [11]. Vitamin C is probably the most important water-soluble antioxidant as well as an efficient scavenger of reactive oxygen species, and lemon is a rich source of this nutrient [1]. Citrus juices, particularly lemon juice, contain high levels of flavonoids (800-1500mg L^{-1}), especially flavanone and flavone glycosides [12]. Among flavonoids, hesperidin and eriocitrin (flavanones) (e.g. 90% in lemon), together with small amounts of diosmetin 6,8-di-Cglucoside, diosmin and vicenin-2 (flavones) are the main compounds present. Moreover, additional minor flavonoids identified in lemon juice are iso/limocitrol 3-b-glucoside and limocitrin 3-b-glucoside. Quercetin and myricetin as well as other phenolic compounds such as hydroxycinnamic acids are also known to be present in very low concentrations [13], [14].

Flavonoids in citrus fruits exhibit a wide range of promising biological properties including anti-atherogenic, anti-inflammatory, antiallergic, antiviral, antiproliferative, cardioprotective and antitumor activity, inhibition of blood clots, and strong antioxidant activity [15]. For example, hesperidin, its main flavanone, has venotonic and vasoprotective properties (they reduce capilar permeability and enhance its resistance). It also has analgesic, antioxidant and anti-inflammatory properties [14], [16].

Dietary fiber is defined as plant polysaccharides resistant to human digestive system. The main components of dietary fiber are pectin, cellulose and hemicellulose. Citrus fruits are the most important source of pectin. Intake of high carbohydrates with diet causes an increase in the level of serum glucose and insulin. For diabetics, it is critical to control level of serum glucose and insulin. Consumption of pectin prevents sudden increases in blood sugar levels. This effect is due to the fact that, pectin slows down the excretory system and lowering the absorption rate. Accordingly, consuming pectin with diet may help in the treatment of diabetes [17].

Patil et al. investigated antioxidant activity of freeze-dried lime juice. Furthermore, they have observed the inhibition of pancreatic cancer cell proliferation. It was reported that

proliferation of pancreatic cancer cells inhibition was proportional to flavonoids and limonoids. Limonoids cause citrus taste bitter [4]. Rats were fed with a diet that includes 10 mg limonoid and carcinogenic benzopyrane during 18 weeks. At the end of the study, there were seen 40 % less oncogenesis on the rats who were fed with limonoids than control group. Besides, the tumors were found less. Likewise, it was found that limonoids are protective against to skin cancer caused by dimetilbenzilantrasen. d-Limonene is found in high concentration in citrus peel oil with anticancer effects in preclinical studies of mammary carcinogenesis [18].

From a nutritional point of view, lemon juice intake results in cleavage of the rhamnoglycoside bonds of flavanones for absorption in the colon. C-Glycosyl flavones are also metabolized by the colonic microflora. Some of these flavonoids are deglycosylated and then glucuronidated in the liver or the intestinal lumen. In the gut, they undergo ring fission by colonic bacteria and are catabolised to a wide variety of phenolic acids [19], [20]. Pharmacokinetic, metabolic and absorption studies have shown the occurrence of lemon polyphenols at physiological level for at least 24h after a single intake of juice and for a longer time through intake of a daily dose of lemon juice or other types of citrus juice [19], [21]. These compounds have been demonstrated by in vivo and in vitro assays to have beneficial properties for health. For example, flavanones can prevent bone loss in rats, and this effect is associated with a daily dose of flavanones through intake of citrus juice [22], [23]. Moreover, the administration of citrus juice has been shown to limit tumour burden in animal models of carcinoma, and it has also been reported that carginogenic processes may affect the bioavailability of citrus flavonoids [24], [25]. All these results suggest that the high concentration of flavonoids in citrus juices, particularly in lemon juice, may favor a higher occurrence of bioavailable flavonoids at human physiological level, thus leading to beneficial effects on health [12].

III. Lemonade and Its Enrichment

Nowadays, the interest in dietary antioxidants, mainly present in fruits and vegetables, has prompted research in the field of commercial polyphenol-rich beverages. Fruits are good sources of these bioactives, and there are a number of commercial polyphenol-rich beverages, which base their marketing strategies on antioxidant potency [14].

Lemonade is a delicious and nutritive non-alcoholic beverage; which is combination of lemon juice, sucrose, acidity regulators and preservatives [18], [26]. Besides traditional homemade production of lemonade, it has been industrially produced since 2007 in Turkey. Especially lemonade takes the attention of consumers that prefer non-carbonated beverages. Furthermore, this refreshing drink is preferred especially during summer time, reaching the approximate consumption amount of 1L per person and also promising an increase during the years ahead [27], [28].

TABLE I
Nutritional Value of Lemon (*Citrus limon* L.)

NUTRIENT	UNIT	VALUE PER (100 g)
Water	g	92.46
Energy	Kcal	21
Protein	g	0.40
Total lipid (Fat)	g	0.29
Carbohydrate	g	6.48
Fiber, total dietary	g	0.4
Sugars, total	g	2.40
Calcium, Ca	mg	11
Iron, Fe	mg	0.13
Magnesium, Mg	mg	8
Phosphorus, P	mg	9
Potassium, K	mg	102
Sodium, Na	mg	21
Zinc	mg	0.06
Vitamin C	mg	24.8
Thiamin	mg	0.041
Riboflavin	mg	0.009
Niacin	mg	0.197
Vitamin B-6	mg	0.043
Folate, DFE	µg	10
Vitamin A, RAE	µg	1
Vitamin A, IU	µg	15
Vitamin E	mg	0.15
Fatty acids, total saturated	g	0.038
Fatty acids, total monounsaturated	g	0.011
Fatty acids, total polyunsaturated	g	0.085

Since its nutritional properties and high trade value, increasing the consumption of lemonade may be taken into account. In this manner, production of innovative and functional lemonade like beverages would be facilitated. For instance; sweetened lemonade, mixture of lemonade with citrus or other fruits such as apple juice or enrichment with functional herb extract can be formulated. González-Molina et al. prepared an *Aronia* enriched lemon juice in order to increase its antioxidant capacity and improve its organoleptic characteristics. Although anthocyanin degradation reached up to 90%, colour was retained during 60 days of storage period [18]. González-Molina et al. designed a new beverage rich in polyphenols. For this aim, lemon and pomegranate juices were mixed in different proportions (25%, 50%, %75). They suggest that the combination of 75% pomegranate and 25% lemon juices had high antioxidant capacity and desirable colour promising a new functional beverage [8]. Likewise, Gironés-Vilaplana developed a beverage including lemon and maqui berry (*Aristotelia chilensis*) and observed its antioxidant capacity, colour and stability at the end of 70 days of storage. Phenolic compounds were noted to increase owing to maqui polyphenols and new product was stable and had attracting color [29].

Rising awareness on healthy eating, tendency is focusing on to functional foods [30]. As being the keys of a healthy life; vitamin, mineral and antioxidant promoters is building up a growing industry. Hence synthetic promoters have their

negative reputation of their side effects on health; natural antioxidants have taken the interest on [31]. Seasonings and aromatic plants known as their association with organoleptic properties of foods have yet been used as antioxidant agents. Phenolic compounds in these plants show antioxidant activity via scavenging free radicals, binding metal ions and quenching singlet oxygen [32], [33]. Most of the plant and seasoning species that have antioxidant activity are the members of *Labiatae (Lamiaceae)* family. Terpenic compounds in these species are responsible for their antioxidant and antimicrobial effect. Giving their hydroxyl groups to free radicals, these compounds block lipid, carbohydrate and protein oxidation [34]. Sufficient antioxidant content in nutrition is reported to decrease hypertension, arteriosclerosis and associated heart disease cases. Vitamin A, C, E, phenolic compounds and antioxidant enzymes are known to preclude or reduce the damages generated by free radicals arise from metabolic activity of human body [35]. Microbial deterioration in foods during shelf-life could be delayed by the antimicrobial action of herbs and seasonings [36], [37]. Besides the characteristic flavor, antibacterial, antifungal, antiviral and antioxidant activity, their bioactive profile put these plants and seasonings forward as natural additives [38].

With the purpose of improve flavor and functional properties, lemonade can be enriched with natural herb extracts such as ginger (*Zingiber officinale*), linden (*Tilia cordata*) and mint (*Mentha piperita*). Ginger is an aromatic plant traditionally used for medical applications [39]. Mint, which is commonly added in to homemade lemonade could be a suitable ingredient for industrial scale. Its antioxidant activity generating from vitamin A, vitamin C and β-carotene helps reducing the hazards caused by free radicals [40].

Ginger extract, containing of polyphenol compounds such as; 6-gingerol, 8-gingerol, 10-gingerol and derivates, is known for having high antioxidant activity, antibacterial, antifungal and anti-inflammatory effect. It is also rich in terpenoids [41]. Ginger consumption has also been reported to prevent uterine cancer [42]. Linden, is often considered as a good medical support for common cold. It helps body to recover through supporting the immune system. Its phenolics such as 'quercetin' and 'kaempherol' help sweltering and show antispasmodic effect. It has antibacterial effect on H. pylori which is a pathogen bacteria habitat in gastrointestinal system [43].

IV. Conclusions

Lemon is processed into fruit juice or fruit juice concentrate in order to fulfill demands of the consumers in any season with affordable costs, and to meet recommended daily intake values.

Lemon juice is an interesting food matrix for designing new beverages, as well as being a suitable source of value-added products.

The demand of healthy and convenient functional foods urges industry to design innovative products. Recent researches on improving the functional properties of lemon juice have shown importance the need of novel lemonade beverages.

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Canan Ece Tamer is Assoc. Prof. Dr. at Food Engineering Department, Uludag University (Turkey). She got her B Sc (1996) in Food Engineering in Engineering Faculty, Ege University; M Sc (1999) and Ph D (2004) in Food Engineering Department of Agriculture Faculty, Uludag University. Her researches focus on fruit & vegetable processing technology, food fermentations and traditional foods.