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Effects of Gallic Acid and Quercetin on the Production of Fruit Puree

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Abstract

Babies of 0-6 months should be fed with mothers milk, but after that period, their nutrient requirements are getting higher and additional nutrients like purees must be used. In that, it is important to give them such foods to support their immunology. Due to polyphenol oxidase activity, apple and banana puree have browning reactions, and thus in production of such puree, rapid preparation and consumption in homes or addition of some protective agents in industry have been used as alternatives. Additives are synthetic materials and some researchers announced that they are capable of cancerous precursors. Reversibly, most of the polyphenols like gallic acid and quercetin are natural molecules having antioxidant properties in plants. In this study, gallic acid and quercetin usability for the production of apple, jerusalem artichoke and banana puree was investigated. In the preliminary experiments with those fruit juices, the concentrations require for stopping browning reactions were determined as 0.001M, 0.01M and 0.1M; so that fruit purees were prepared by glass shredder in gallic acid or quercetin added media. Browning and spoiling were analyzed in all samples and compared with two different control groups; home-made and commercial purees, namely. Quercetin was found more effective on browning than gallic acid in both juices and also in purees. The microbial growth was reduced by gallic acid in a sequence of apple (90.49%), banana (80.24%), and then jerusalem artichoke (68.00%); while quercetin reduction sequence was banana (96.48%), apple (73.56%) and then jerusalem artichoke (46.22%). Therefore, it has been determined that, it may be advisable to add, instead of cancerous materials, gallic acid and quercetin for prevention of browning and to strengthen the immune system of the baby during the period of lacking prebiotics.

Keywords: Browning reactions, Fruit puree, Gallic acid, Quercetin, Spoiling

INTRODUCTION

The World Health Organization recommends that infants be fed only breast milk for the first six months, starting complementary foods at the end of the sixth month (World Health Organization, 2013). Nutritive value of the complementary food depends solely on its composition; the materials used and the proportions of fruit or vegetable content (Čizkova et. al., 2009).

Commercial infant formula contains chemical products with properties that slow down the formation of microorganisms, color protectors, thickeners and sweeteners. These compounds result in a number of diseases, such as mental decline in infants, Alzheimer's and cancer, as a result of certain consumption. It is clear that stopping the use of artificial products will positively affect the baby's health. The majority of the antioxidant capacity of a fruit or vegetable resulted from compounds such as flavonoids, isoflavones, flavones, anthocyanin's, catechins and isocatechins rather than from vitamins C, E or β-carotene (Wang et al., 1996; Kahkonen et al., 1999).

Quercetin, a flavonoid species, is found in plants, especially in vegetables and fruits. It is found in various quantities in many foods, mainly crucifers, grapes, apples, tomatoes and wild mussels (Manach et al., 2004; Kelly, 2011). The other well-known phenolic compound is gallic acid with a chemical formula of 3, 4, 5-trihydroxybenzoic acid. It is also found in a wide variety of vegetables, fruits, tea, coffee and wine (Naira et al., 2016). The structure of gallic acid has phenolic groups that are a source of readily available hydrogen atoms so that radicals produced can be delocalized over the phenolic structure (Nikolic, 2006). The antioxidant activity of gallic acid and its derivatives has been reported in several studies (Fogliani et al., 2005; Kaur et al., 2005). Gallic acid has been shown to possess antimicrobial activity against human pathogens (*Staphylococcus aureus*, *Corynobacterium accolans*), a plant pathogen (*Erwinia carotovora*) and a human pathogenic yeast (*Candida albicans*) (Fogliani et al., 2005). The cytotoxic effects of Triphala, an Indiana herbal drug, on breast cancer cells were attributed to gallic acid (Kaur et al., 2005).

It is known that substances with antioxidant properties have different effects such as binding of free metals, clearing of free radicals, enzyme inhibition and induction of expression of protective enzymes (Nam et al., 2016). It has been proved to have potential preventive and therapeutic effects in many diseases, where the oxidative stress has been implicated, including cardiovascular diseases, cancer, neurodegenerative disorders and in aging (Nikolic, 2006; Kaur et al., 2005).

In this research, the usage of gallic acid and quercetin in inhibition of browning reactions in a fruits was investigated. By this way, they may be used instead of chemicals in the production of especially baby foods. As a result, the baby purees produced with these phenolics will have anticancerous, antimicrobial and antioxidant properties, and thus they will have beneficial effect for baby growth instead of decline observed with chemicals. In addition, since gallic acid and quercetin have antimicrobial properties in themselves, the self-life of the purees will also be increased due to the presence of these compounds in purees.

MATERIAL and METHOD

Quercetin and gallic acid used in the study were purchased from Sigma_Aldrich, and red apples, jerusalem artichoke and banana were supplied from a regional greengrocery. In the preliminary experiments, in order to determine the concentrations that can capable of stopping the browning reaction of the fruits, red apple and jerusalem artichoke juices prepared by Arcelik Fruit Juice were mixed with 5 ml of quercetin or gallic acid solutions, of three different concentrations (0.001M, 0.01M, 0.1M). Control groups were established for each fruit type, which does not contain any solution. Color differences were compared by taking photographs at the end of same time durations.

In the second part of the study, the effect on the duration of microbial deterioration of addition of quercetin and gallic acid into the fruit purees was investigated. In the sterilized ESCO Laminate Flow Cabinet, fruit purees were prepared using glass grater and then added to sterile containers containing 5 ml of gallic acid or quercetin solutions. In this part of the study, both pure fruit puree and commercial fruit puree (banana and carrot-red apple mixture) were used as a control group. The porridge was closed with parafilm and kept at room temperature in the MIPRO water bath until visible microbial deterioration occurred. Color formation and microbial deterioration in the purees were compared with taking their photographs. In order to quantify the microbial growth, at every 24 hours, 500 µl of the sample was inoculated into the test tubes containing 20 ml of sterilized MRS medium in Laminar flow cabinet. The number of microorganisms formed after growth period of 6 hours at 37°C in the ILDAM incubator was expressed as the absorbance values read at 420 nm on an Agilent Technologies Cary 60 UV-Vis spectrophotometer. Analyzes of microorganisms

were also carried out periodically until visible deterioration was observed and compared with control groups.

RESULTS and DISCUSSION

In the first part of the study, control purees, commercial purees (banana and carrot-apple mixture) and experimental purees that had been obtained by mixing with quercetin or gallic acid solutions at different concentrations were stored for 5 days at room temperature in a water bath. In that period they were being photographed to observe the browning reaction results and microorganism formation processes were also followed (Figures 1-4). As seen in Figures 1 and 2, addition of 0.1M quercetin and 0.001M gallic acid solutions into red apple purees were found more effective on delaying browning reaction than commercial and control groups.

In banana puree (Figure 3), the same concentrations of both quercetin and gallic acid solutions were found effective on delay of coloring reaction. When commercial banana puree was compared with the experimental purees containing 0.001M gallic acid or 0.1M quercetin solutions (Figure 4), gallic acid or quercetin were found better. By comparing between two experimental purees, it was concluded that 0.1M quercetin addition was preferable to 0.001M gallic acid.

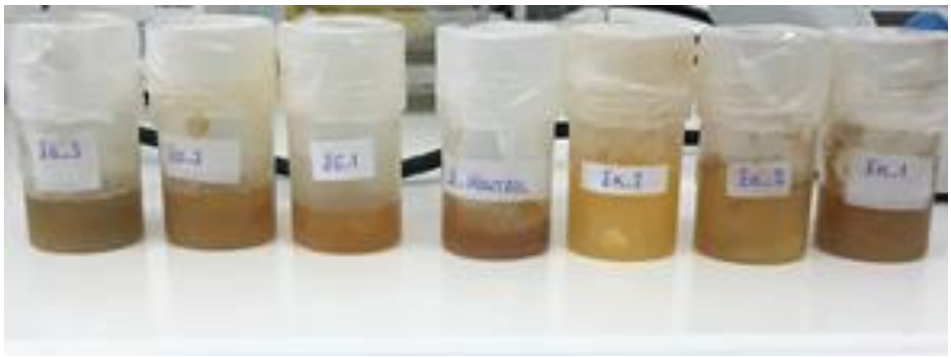

Figure 1. The appearance of the experimental red apple mashes and control group at the end of 5 days.

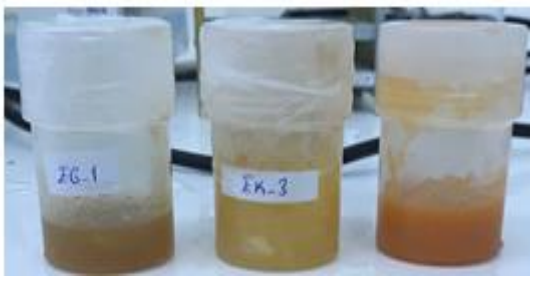

Figure 2. Appearances of Commercial apple juice (apple and carrot mixture) - Experimental apple juice containing (EG-1) 0.001M gallic acid solution - experimental apple juice containing (EK-3) 0.1M quercetin solution.

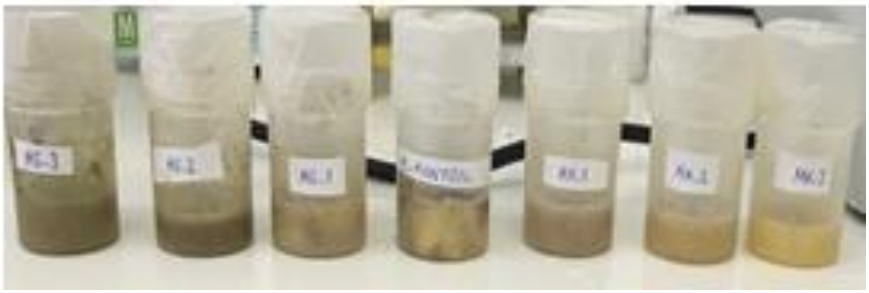

Figure 3. The appearance of the experimental banana purees and control group at the end of 5 days.

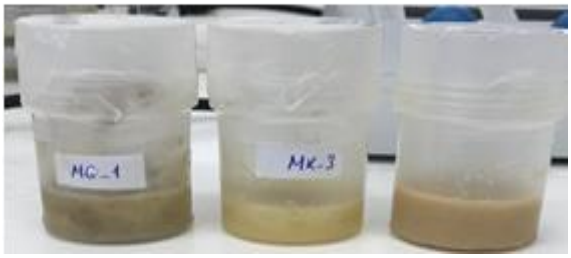

Figure 4. Appearances of Commercial banana puree – experimental puree containing (MG-1)0.001M gallic acid solution – Experimental puree containing (MK-3)0.1M quercetin solution.

The results of microbial growth analysis of all the purees supplied and produced were summarized in Table 1. At the end of 24 hours, 0.001M gallic acid containing experimental red apple puree was found as much durable than commercial red apple puree. In terms of quercetin usage in red apple purees, 0.1M was determined as effective for delaying the microorganism formation. This may resulted from the fact that quercetin is capable of sweeping of reactive oxygen species in the medium (Sakanashi, et al., 2008). The same concentrations for gallic acid and quercetin resulted microbial growth delaying in banana puree, too (Table 1). Although, commercial banana puree has some chemicals to increase the shelf-life, experimental banana purees containing 0.001M gallic acid or 0.1M quercetin solutions had less microbial concentration than commercial one. At the end of the first day, gallic acid resulted microbial growth decrease nearly 90% in red apple, 97% in banana, and 68% in jerusalem artichoke purees, while the usage of quercetin resulted 73%, 96%, and 46% decrease, respectively.

At the end of the second day, it was determined 0.001M gallic acid containing experimental red apple puree was as durable as the commercial puree. The decrease in microbial growth was found less (nearly 46% for gallic acid and 41% for quercetin), but none of the experimental red apple purees were intact. In the banana purees, microbial growth rate was increased in the second day, thus absorbance values were getting close to the commercial banana puree, although they were again so less than the control group. This showed that, in order to prepare much durable banana puree, the more concentrated solutions should be preferred. For jerusalem artichoke purees, the gallic acid and quercetin addition was not found effective, especially after 24 hours.

At the end 3-day period, all of the commercial purees were intact and the visible microbial colonies were observed, except red apple-carrot mixture. In this study, the experimental jerusalem artichoke puree containing 0.001M gallic acid solution was found the most durable against microbial growth (Table 1). Experimental banana purees containing either gallic acid or quercetion solutions were much resistant than to red apple purees.

Microbial growth analyses were continued up to 5-days, but since none of the control group and commercial puree was durable up to that time, making comparison was impossible.

Table 1. Microbial growth in all purees incubated at 37°C during 5-day period

Fruit purees	Microbial growth (absorbance values)					
	First analysis	%	Second analysis	%	Third analysis	%
R.A. control	0.2841		0.5455		-	-
C.R.A-C	0.1879		1.4096		1.8417	-
R.A-G.A-1	0.0270	90.49%	0.2939	46.12%	-	-
R.A-G.A-2	0.2654	41.24%	0.3306	39.40%	-	-
R.A-G.A-3	0.2638	40.39%	0.4298	21.20%	-	-
R.A-Q-1	0.0868	69.44%	0.3202	41.33%	-	-
R.A-Q-2	0.0751	73.56%	0.4089	25.04%	-	-
R.A-Q-3	0.1583	44.28%	0.5518	1.15%	-	-
Control banana puree	0.2247		2.1067		-	-
Commercial banana puree	0.1790		1.24		-	-
Banana-Gallic acid-1 puree	0.0444	80.24%	1.46	30.69%	-	-
Banana-Gallic acid-2 puree	0.1709	23.8.%	1.41	33.07%	1.8618	-
Banana-Gallic acid-3 puree	0.1804	19.71%	1.79	15.03%	1.9630	-
Banana-Quercetin-1 puree	0.3615	60.88%	1.25	40.57%	1.7322	-
Banana-Quercetin-2 puree	0.2702	50.94%	1.26	40.19%	1.7803	-
Banana-Quercetin-3 puree	0.0079	96.48%	1.29	38.76%	1.7952	-
Jerusalem artichoke control puree	0.5519		1.0062		1.9730	
Jerusalem artichoke-Gallic acid-1 puree	0.5003	9.34%	0.93	7.57%	1.4880	24.58%
Jerusalem artichoke-Gallic acid-2 puree	0.6875	24.56%	1.59	58.02%	-	-
Jerusalem artichoke-Gallic acid-3 puree	0.1766	68.00%	1.91	89.82%	2.1029	-
Jerusalem artichoke-Quercetin-1 puree	0.2968	46.22%	1.56	55.03%	-	-
Jerusalem artichoke-Quercetin-2 puree	0.8211	48.77%	1.94	92.8%	-	-
Jerusalem artichoke-Quercetin-3 puree	0.7796	41.25%	1.47	46.09%	1.9787	-

Note: ***** 1; 0.001M, 2; 0.01M, 3; 0.1M.

CONCLUSIONS

It is known that, when some fruits and vegetables such as apples, quince and potatoes are cut or damaged, their colors change. As a result of polyphenol oxidase enzymes oxidation reaction with phenolic compounds, enzymatic browning occurs. This effect is considered as

loss of quality in food, and they are tried to be prevented by various methods during food processing (Anonymous, 2006). Nowadays, commercial thickeners (thickening gels) and/or E-coded additives for cutting of the fruit surface interaction to oxygen and for inhibition of the formation of microorganisms are used, and these substances are known to be detrimental to human health (Boga and Binokay, 2010). Antioxidants can also inhibit the enzymatic reactions required by keeping oxygen, and they can also reduce the activity of enzymes such as polyphenol oxidase in these reactions (Gur and Altug, 2001). In this study, the effects of gallic acid and quercetin, which are well-known antioxidants, on the browning and microbial disruption of fruit purees were investigated.

In the study, in general, experimental fruit purees containing gallic acid and quercetin were found to be more effective in retarding darkness of the color than commercial fruit purees containing additives that could harm to human health. In the experiments, the experimental fruit purees containing quercetin with a concentration of 0.1M produced the most effective result in retarding color decay. During the second phase of the study, the microorganism formation processes of all of the purees whose mouths were covered with parafilm for 5 days at room temperature were followed. At the end of this period, it was concluded that experimental fruit purees containing gallic acid and quercetin in different concentrations were very resistant to other commercial fruits containing preservatives.

Experimental fruit purees containing gallic acid at a concentration of 0.001M, which slows down the growth rate of microorganisms, had been the most effective. It was also concluded that, delaying browning reaction and decreasing microbial growth formation, the concentrations must be taken into account carefully and dependent of the fruit used. This study showed that, instead of consuming commercially available fruit purees containing preservatives that are harmful to human health, natural molecules crush as gallic acid or quercetin having anticancer, antimicrobial and antioxidant properties can be used. Since they can easily be obtained from plants and fruits, the production cost will also be lowered.

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