The use of orange peel in the technology of drinks fermentation

Olga Ivanchenko [1*], *Anna* Gargalyk[2], *Petr* Balanov[2], *Irina* Smotraeva[2], and *Nadezhda* Zhilinskaya[1,3]

[1]Peter the Great St. Petersburg Polytechnic University (SPbPU), 29 Politekhnicheskaya str., St. Petersburg, 195251, Russia
[2]Faculty of Biotechnologies (BioTech), ITMO University, 49 Kronverksky Ave., Saint Petersburg, 197101, Russia
[3]Laboratory of Cancer Chemoprevention and Oncopharmacology, N.N. Petrov National Medical Research Center of Oncology, St. Petersburg, Russia

Abstract. Nutrition is one of the most important factors determining human health. Enrichment of food products with minerals, antioxidant compounds, and vitamins are relevant today. In this work, dry orange peel was used to enrich a fermented drink based on kvass wort with phenolic compounds and vitamin C. The following indicators were determined: the content of vitamin C, the amount of phenolic compounds and anthocyanins, the antioxidant activity of orange peel dried to a moisture content of 18%. The drink fermentation lasted 12 hours at 30 °C. Secondary fermentation was carried out for 48 hours. At this stage, orange peel was added in the amount of 10 g/l. During the experiment, the concentration of dry matter content, the acidity of the medium, and the content of ethyl alcohol were measured. Organoleptic indicators were determined during the tasting of the finished product. In the finished drink, the content of ethyl alcohol was 0.98%. It was found that the finished drink with peel contains 4 times more phenolic compounds and 1.5 times more vitamin C.

1 Introduction

Achievements of modern medicine indicate that nutrition is one of the most important factors determining human health, endurance, immune status, and the rate of organism adaptation. The problem of nutrition is important in the sports industry, since deviation from the principles of optimal nutrition, deficiency or excess of any nutrients or biologically active substances in the athlete's diet can lead to a decrease in physical performance, slow recovery processes, metabolic disorders, and the appearance of alimentary-dependent diseases.

Human nutritional ingredients are used in the formulations of common food products such as yoghurts, candies, crispbreads, and other baked goods, not only in special and healthy products. The Russian manufacturers have a considerable experience in introducing

* Corresponding author: obivanchenko@yandex.ru

plant-based additives into recipes and food production technologies [1,2]. In addition, many people began to pay more attention to improving their own health. Therefore, food products and drinks that have a beneficial effect on the human body came to the fore, and the Russian food industry was reoriented. For example, now there are many beverage formulations with various natural plant extracts [3-5].

Orange peel is a secondary raw material obtained during the industrial processing of orange fruits in juice production technology. Although the peel has many useful substances in its composition, it is mainly used for livestock feed [6,7]. The chemical composition of the orange peel is very diverse. It includes a complex of essential substances, such as B vitamins, various essential oils, phytoncides. The peel is also the richest source of vitamin C, phenolic compounds, and carotenoids. The human body cannot store vitamin C, so one should constantly get it from food.

The aim of this work was to develop a fermentation drink based on kvass wort enriched with orange peel. The objectives of the study included:

1. Determination of the antioxidant activity of orange peel.
2. Determination of the content of vitamin C, polyphenolic compounds, and anthocyanins in orange peel.
3. Development of a fermentation technology for a drink enriched with orange peel.
4. Assessment of physical and chemical parameters and organoleptic characteristics of the finished product.

2 Materials and methods

2.1 Materials

The following materials were used in the work:

1. Kvass wort concentrate (Rospak, Russia);
2. Dry yeast "Safmoment" ("SAF-NEVA" Ltd., Russian enterprise of the Lessafre Group France, St. Petersburg);
3. Oranges (Turkey).

2.2 Methods

2.2.1 Assessment of antioxidant potential

The amperometric method is used to determine the mass concentration of antioxidants. It is based on measuring the amperage. When antioxidant molecules are oxidized, current appears on the surface of the working electrode, which is converted into a digital signal. Under the conditions of amperometric measurement, compounds containing hydroxyl groups are well oxidized [8,9].

The total content of antioxidants was measured using a calibration plot for the relationship between the intensity of the output signal on the concentration of quercetin.

The total content of antioxidants in terms of quercetin was determined by expression (1):

$$CA = \frac{CA_k \cdot V_n \cdot n}{m_n}, \qquad (1)$$

where CA is the total content of antioxidants in terms of quercetin (mg/l);
CA_k is the quercetin concentration, mg/dm^3;
V_n is the sample volume, dm^3;
n is the dilution factor;

m_n is the weight of the product sample, g.

2.2.2 Determination of the content of ascorbic acid

This analysis was carried out by the volumetric method, based on the state standard. First, vitamin C was extracted with a hydrochloric acid solution. Then the solution was titrated with sodium 2,6-dichlorophenolindophenolate until the color changed to light pink [10].

2.2.3 Determination of the content of polyphenolic compounds

For this analysis, the Folin-Denis method was used. It is based on the formation of colored products during the oxidation of phenolic compounds with a phosphorus-molybdenum-tungsten reagent in an alkaline medium. The alkaline medium was created with a saturated sodium carbonate solution [11].

The total content of phenolic compounds was calculated by expression (2):

$$X = \frac{a \cdot V_0 \cdot P}{M}, \quad (2)$$

where X is the amount of phenolic compounds, mg/g;
a is the content of chlorogenic acid, determined by the calibration curve, mg/ml;
V_0 is the total extract volume, ml;
P is the degree of dilution;
M is the sample weight, g.

2.2.4 Determination of the content of anthocyanins

This analysis was carried out by the spectrophotometric method. Firstly, 1 g of crushed raw material was placed into a 100 ml flask with a thin section. Then, 30 ml of 70% ethanol acidified with hydrochloric acid (1% by volume) was added. Next, the flask with the test solution was attached to a reflux condenser and heated on a boiling water bath for 40 min. After cooling to a temperature of 25±2 °C, the flask was weighed, its content was brought to the initial mass with 70% alcohol, stirred, and filtered through a paper filter. 2 ml of the studied filtrate was transferred into a 25 ml volumetric flask and adjusted with 70% alcohol to the mark on the flask. Next, the optical density was measured using the UNICO-2802S spectrophotometer (USA) [12].

The quantitative content of anthocyanins in terms of cyandin-3-o-glucaside and absolutely dry raw material was calculated by expression (3):

$$X = \frac{A \cdot 25 \cdot 30 \cdot 100}{100 \cdot m \cdot 1 \cdot (1-W)}, \quad (3)$$

where X is the amount of anthocyanins, mg/100 g;
A is the optical density of the test solution;
m is the mass of raw materials, g;
W is the weight loss during drying of raw materials, %;
100 is the specific absorption rate of cyanidin-3-O-glucoside

2.2.5 Acidity of the drink

The method for determining acidity is based on the titration of all acids in the analyzed drink [3]. The total acidity of the drink (K_{vol}) was expressed in cm^3 of 0.1 normal NaOH solution per 100 cm^3 and was calculated using expression (4):

$$K_{vol} = V \cdot k, \quad (4)$$

where V is the volume of 0.1 normal NaOH solution that was used for titration;
k is dilution.

2.2.6 Determination of the mass fraction of ethyl alcohol

The analysis was carried out using the analyzer of alcoholic beverages "Kolos-2" (NPP "Biomer", Russia). This analyzer is designed to measure the mass fraction of ethyl alcohol in alcoholic beverages, low-alcohol products, and water-alcohol solutions.

2.2.7 Determination of the mass fraction of dry substances

The analysis was carried out by the refractometric method. This method is based on the determination of the mass fraction of dry matter content on the scale of the IRF-454 B2M refractometer at a temperature of 25±2 °C (KOMZ JSC, Russia).

2.2.8 Development of technology for a fermented drink with orange peel Citrus sinensis

The fermentation drink recipe was developed based on kvass wort concentrate. Kvass wort was prepared with dry matter content concentration of 3 and 4% (Table 1). All components were added to water and mixed well.

Table 1. Drink components

Ingredient	Quantity, g/ dm^3
Kvass wort concentrate, 4% of dry matter content:	
Total	45.0
Added before fermentation	31.5
Sugar	40.0
Water	26.7
Sugar syrup, 60% of dry matter content:	
Total	66.7
Before fermentation	16.7
For blending	50
Water	Based on the dry matter content of the initial wort
Orange peel	10

The yeast was removed by filtration after 12 hours of fermentation. The blending of the drink was carried out at the stage of secondary fermentation. The rest of the sugar was added to the kvass wort in the form of sugar syrup after the main fermentation stage. At the same time, the orange peel in an amount of 10 g/l and the remaining kvass wort concentrate were also added. The drink was left at a temperature of 4±2 °C for 48 hours. During this time, the extraction of substances from the peel took place, the taste and aroma of the drink were finally formed.

3 Results and discussion

The peel is the outer pigmented layer of the citrus fruits, which contains many essential compounds. The useful area of orange peel is relatively small, although it is known that orange peel contains a lot of substances beneficial to the human body [13-16].

Firtsly, fresh oranges were washed with a brush under running warm water. Then, strips of peel about 1–2 cm wide were cut with a knife. As it is known, humidity is one of the indicators which determines the long-term storage of the product. Therefore, orange peel was crushed and dried at 25 °C and 70 °C until the moisture content reached 18-20%. Antioxidant activity was determined in the obtained dried samples (Table 2).

Table 2. Antioxidant activity of orange peel, mg/dm^3

Drying temperature, °C	Antioxidant activity, mg/dm^3
25	18.3± 0.7
70	9.7±0.4

The study showed that a higher antioxidant activity was recorded in the sample dried at 25 °C, so this peel was used in further studies.

Natural antioxidants are vitamins C, E, P, A, carotenoids, flavonoids, aromatic hydroxy acids, anthocyanins and other compounds [17,18].

A series of experiments was carried out to determine substances from the group of natural antioxidants in the considered samples. This was a necessary step to study the components that determine the antioxidant activity of the peel.

Vitamin C is a powerful antioxidant. It is hydrophilic, so it functions well in an aquatic environment. It plays an important role in redox processes, has a protective effect in case of colds, normalizes vascular permeability, and increases the body's resistance to various infections. Theoretical and experimental studies prove the importance of vitamin C intake in preventing the development of cancer [19].

Anthocyanins are a group of water-soluble pigments found in most plant species. They are part of plant cells and cause pink, red, purple color of flowers and fruits of plants. Anthocyanins have pronounced antioxidant, capillary-strengthening, and bactericidal properties [20]. Therefore, the next step in this work was to determine the amount of anthocyanins in the studied peel.

The results of peel examination are presented in table 3.

Table 3. The content of vitamin C, anthocyanins, phenolic compounds in the orange peel

Indicator	Quantity
Vitamin C, mg/100 g	94.3 ±0.3
Anthocyanins, %.	0.23±0.03
Phenolic compounds, mg/g.	4.73±0.04
Antioxidant activity mg/l	18.3± 0.7

Considering the therapeutic and prophylactic properties of individual antioxidants, it should be noted that their principal functions are performed in close synergy and complex interaction. For example, fat-soluble antioxidants (vitamins A and E) perform the biological function in membrane lipids and lipoproteins; water-soluble antioxidants (vitamin C and bioflavonoids) perform the function in biological fluids of the body; trace elements are indispensable cofactors of enzymes. Thus, it is impossible to discuss the isolated properties of individual antioxidants. It is necessary to consider them as part of the entire antioxidant system and in interaction with other compounds.

3.1 Development of technology for a fermented drink with orange peel *Citrus sinensis*

Two types of kvass wort were prepared during the development of the new drink. The first sample contained 3% of dry matter, and the second one contained 4%. The fermentation of the drink took place within 12 hours. Then a secondary fermentation was carried out. At this time, orange peel was added in an amount of 10 g/l.

Further the drink acidity was determined. Acidity is one of the most important indicators of the finished drink, as it affects its taste characteristics. The drink acidity increases due to the organic acids (citric, succinic, fumaric, malic, etc) synthesized by yeast. The dynamics of changes of the drink acidity with orange peel is presented in table 4.

Table 4. The dynamics of changes in the acidity of the drink

Initial concentration of dry matter content in the wort	Experimental option	Stage	Acidity, a.u.
3%	Control	Starting	0.4±0.02
		12h.	2.2±0.02
		After fermentation	2.7±0.02
	Sample with peel	Starting	0.5±0.02
		12h.	2.0±0.02
		After fermentation	2.5±0.02
4%	Control	Starting	0.6±0.02
		12h.	1.7±0.02
		After fermentation	2.5±0.02
	Sample with peel	Starting	0.7±0.02
		12h.	1.5±0.02
		After fermentation	2.3±0.02

The concentration of ethyl alcohol was determined at the end of fermentation and gave the following results.

1. Sample with an initial wort concentration of 3%.

The alcohol content was 0.95% in the control sample and 0.94% in the sample with peel.

2. Sample with an initial wort concentration of 4%.

The alcohol content was 1.05% in the control sample, and 0.98% in the sample with peel.

The intensity of fermentation is determined by the change in dry matter content. A decrease in dry matter content from 3% to 1.7-2.2% was observed in the experimental and control option at the fermentation stage. An increase in the dry matter content up to 3.3% was registered after the addition of peel at the secondary fermentation stage. This can be explained by the extraction of peel substances into kvass wort. A further decrease in the dry matter content to 1.95% was observed in the control sample after 36 hours of the entire technological process.

The content of vitamin C and the concentration of phenolic compounds were assessed in the test samples. The results are presented in Table 5.

Table 5. The amount of phenolic compounds and vitamin C in finished drinks

Experimental option	Initial wort concentration, %	Content of phenolic compounds, mg/ml	Vitamin C content, mg/100 ml
Control	3	1.10±0.07	5.0±0.1
	4	1.15±0.08	5.1±0.1
Sample with peel	3	4.55±0.10	6.1±0.09
	4	4.76±0.09	7.3±0.1

At the end of the study it was found that the concentration of kvass wort has a slight effect on the change in the content of phenolic compounds, while orange peel showed a significant influence on their amount.

A tasting assessment allows one to identify all the disadvantages and advantages of a new product. Sometimes this is the only way to judge the quality of a sample. An important contribution to the aroma and taste is made by its components. The stages and conditions of the technological process also matter. 10 respondents participated in the tasting assessment of kvass drinks. The scoring of the quality of finished drinks is given in Table 6.

Table 6. Organoleptic assessment of the drink in points

Indicator	Initial wort concentration			
	3%		4%	
	Control	Sample with peel	Control	Sample with peel
Sweetness	4.3	4.5	4.3	4.7
Acidity	4.1	4.1	4.1	4.1
CO_2 saturation degree	2.9	3.5	3.1	4.5
Fullness of taste	2.8	3.6	3.4	4.8
Bread tone	3.4	3.1	4.1	3.3
Lack of yeast tone	3.2	5.0	3.9	5.0
Orange flavor	0	3.1	0	3.2

Table 6 shows that the introduction of orange peel affects not only the physicochemical parameters of the product but also its organoleptic characteristics. The strongest influence was registered in such indicators as fullness of taste, orange flavor, and degree of CO_2 saturation, that strongly contrasts the finished drink with the control sample.

So, the sample with the initial dry matter content of 4% and orange peel concentration of 10 g/dm^3 was chosen as the best. This sample is enriched with the beneficial substances of orange peel and has the most attractive characteristics for the consumers.

4 Conclusion

Currently, the most relevant development direction in the food industry is the creation of products for systematic use that preserve and strengthen human health due to the presence

of functional food ingredients in their composition. Such products are suitable for most diets of all age groups of the healthy population, as they reduce the risk of developing many diseases.

Based on literature data, the prospects of using Citrus sinensis orange peel in food production technology were shown. It was determined that the content of vitamin C in the studied orange peel was 94.3±0.3 mg/100g; the amount of phenolic compounds was 4.73±0.4 mg/g; the content of anthocyanins was 0.23±0.03% in terms of cyanidin-2-O-glucoside and absolutely dry matter. It was studied how different modes of orange peel drying affect the preservation of its antioxidant activity. The antioxidant activity of peel dried at 25 °C and 70 °C was 18.3 ± 0.7 mg/dm^3 and 9.7 ± 0.4 mg/dm^3, respectively. The tasting assessment of drink enriched with orange peel in an amount of 10 g/l showed that the sample with an initial wort concentration of 4% was the most harmonious drink.

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