UDC УДК 665.3:634.23:664.86:67.03-035.2(477)

QUALITY CHARACTERISTICS OF OILS FROM KERNELS OF VARIOUS SOUR CHERRY CULTIVARS FOR THE DEVELOPMENT OF A CRAFT TECHNOLOGY

https://doi.org/10.15673/fst.v19i1.3121

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Cite as Vancouver style citation

Kotliar Ye., Iegorov B., Shoful I., Chabanova O., Yasko V. Quality characteristics of oils from kernels of various sour cherry cultivars for the development of a craft technology. Food science and technology. 2025;19(1):54-66. https://doi.org/10.15673/fst.v19i1.3121

Цитування згідно ДСТУ 8302:2025

Quality characteristics of oils from kernels of various sour cherry cultivars for the development of a craft technology / Kotliar Ye. et al // Food science and technology. 2025. Vol. 19, Issue 1. P. 54-66. https://10.15673/fst.v19i1.3121

Abstract. A topical line of research is developing new technologies and improving the existing ones to obtain and process nonconventional oil-containing plant raw materials (kernels of cherry stones, or pits). This is supposed to allow obtaining oil and oilcake of high nutritional value and biological quality. The paper describes the cold pressing method and ways to improve it.

The cherry pit kernels considered were those of the following Ukraine-grown sour cherry cultivars harvested in 2021, 2022, and 2023: English Early, Lotivka (Łutówka), Lyubska, and Podbyelska. It has been studied whether cherry pit kernels from these cultivars and their mixture (25 % of each sample) are promising raw materials for fat-and-oil products. The study provides a scientific basis for a technology of manufacturing oils from kernels of various cherry cultivars of Ukrainian horticulture. The mode selected as the most suitable for stones of different sour cherry cultivars involves treating them with 1:1 NaCl solution (one part rock salt to one part water) for 5–10 min. This treatment ensures the cracking of 90–100 % of stones. Thus, this is the optimum solution ratio to make this operation effective, which gives reasons for the proposed improvement of the technology. Process conditions of cold pressing (extra virgin) have been determined for kernels of various cherry cultivars. The most practical temperatures of wet-heat treatment of crushed sour cherry kernels are as follows: for English Early, Lotivka, Lyubska – 50–60 °C, τ 5–10 min; for Podbyelska and the mixture – 40–50 °C, τ 10–15 min. It has been established that the pressing of cherry kernels is effective at t = 60–70 °C, τ 6–15 min for English Early, Lotivka, Lyubska and at t = 50–60 °C, τ 4–10 min for Podbyelska and the mixture.

This operating mode of obtaining oils allows the maximum retention of the initial fatty acid content of the raw materials. It has been proved that oils from the English Early kernels contained 97.4 % (2021), 98.2 (2022), 98.6 (2023) of ω-6 PUFA and 98.7 % (2021), 97.5 (2022), 97.1 (2023) of ω-9 MUFA; oils from the Lotivka kernels – 98.8 % (2021), 98.6 (2022), 97.3 (2023) of ω-6 PUFA and 98.1 % (2021), 98.3 (2022), 96.1 (2023) of ω-9 MUFA; oils from the Lyubska kernels – 94.2 % (2021), 85.1 (2022), 96.0 (2023) of ω-6 PUFA and 98.5 % (2021), 97.6 (2022), 97.4 (2023) of ω-9 MUFA; oils from the Podbyelska kernels – 98.7 % (2021), 98.4 (2022), 98.4 (2023) of ω-6 PUFA and 97.8 % (2021), 97.7 (2022), 97.7 (2023) of ω-9 MUFA. Oils from the mixture of kernels contained 97.1 % (2021), 95.7 (2022), 97.8 (2023) of ω-6 PUFA and 98.5 % (2021), 99.1 (2022), 97.3 (2023) of ω-9 MUFA.

The quality characteristics of oils from kernels of various sour cherry cultivars have been studied for the development of a craft technology.

Keywords: sour cherry stones; craft technology; crushed stones; cherry pit oil; cherry oilcake; fatty acid composition

Introduction. Formulation of the problem

Every year, the food industry yields huge amounts of waste. This opens up a new study area aimed at minimising and effectively controlling this problem based on the zero-waste approach [1].

It is specific of this raw material that fruit stones normally enter oil-producing plants in batches, which are unsorted mixtures of pyrenes from different fruit cultivars. Generally, these batches vary markedly in their quality depending upon the stoning method used when processing the fruit. Thus, stones left after sulphitation or boiled stones contain oil with the high acid value (up to 20 mg KOH/g). This results from intensified hydrolytic processes that take place when stones are removed from the fruit pulp and further, when they are temporarily stored and transported to oil-extracting factories. 'Healthy' kernels of stones contain low-acid oil.

The pressing of sour cherries results in the prime product, anthocyanin-rich juice [2], and leaves quite an amount of pomace that is mainly thrown out as waste or processed to obtain less valuable products. The last decades have witnessed a constantly growing interest in the valorisation of byproducts and waste from agrarian production, as these are a source of various nutrients and bioactive compounds. Byproducts that remain after processing of small fruit (usually berries) are of special interest due to their high content of valuable nutrients and bioactive compounds, in particular, polyphenol antioxidants and polyunsaturated fatty acids [2, 3]. It is worth noting that pomace can be as high in bioactive compounds as the fruit pulp or a whole fruit is or even higher [4].

Generally, pomace from berries is a non-homogeneous byproduct. It is made up of components of different nature, mostly skins, residues of the pulp and seeds. Sour cherries and other drupes, on the contrary, have a large stone inside the fruit. A review of possible ways of valorising and utilising byproducts from cherry fruit processing has shown that reports about sour cherry pomace are quite scarce [4]. The composition of sour cherry pomace, its functional properties, restoration of polyphenol antioxidants, and valorisation in general were considered in 2018 [3] and 2024 [4]. The skin and pulp residues of many berries are a good source of polyphenol antioxidants, whereas the kernel contains quite a number of oils rich in polyunsaturated fatty acids and other valuable lipophilic compounds [5]. In the cherry fruit, the weight of the stone was 14.6 %, while the kernels only were 23 % of the weight of the stone [5]. Depending on the cultivar, the oil content in the kernels ranged 17.5–37.1 % [6].

The paper presents studies of the varietal differences in sour cherry stones and their quality indicators. The sour cherry stones examined were taken from Ukrainian horticultural farms. A model has been proposed of how cherry stones should be processed and how their kernels should be separated from shells before pressing. The process of pressing extraction of extra virgin oil has been studied, which has allowed determining the optimum process conditions and durations. The research has revealed different fatty acid compositions in oils from the kernels of different sour cherry cultivars.

The main method of isolating oil from the kernels of sour cherry stones is cold-press extraction, when the temperature of pressing is below 60 °C. This oil is immediately reclassified from ordinary table oil to a medicinal product.

Analysis of recent research and publications

Sour cherry (Prunus cerasus L.) is a widespread and popular drupe from the Rosacea family, subgenus Cerasus. It is widely used in Europe, North America, and Asia. The global output of sour cherry fruit has increased over the last few years from 14.1 million to 38.1 million metric tons in 2006—2016 [7]. Nowadays, cherries can be used both as fresh fruit and in the form of juice, dried products, syrup, food additive, jam. Sour cherry is a rich source of phytochemical and nutraceutical substances, including anthocyanins with such bioactive properties as antioxidative and anti-inflammatory, able to suppress the development of tumours and prevent colon cancer [7]. A large part (about 85 % of a year's produce) of cherries is processed into juice, concentrate, or pitted frozen cherries that results in much waste (stones and pomace). Today, most of this waste is used as animal feed or thrown away. Only a small part of these byproducts can be utilised [7, 8].

Sour cherry pomace is a valuable and rich source of bioactive compounds, including anthocyanins, polyphenols, flavonoids, red and violet pigments. All of them can be used in foodstuffs and pharmaceutical products [8]. Encapsulated bioactive compounds of cherry pomace are also used in biscuit recipes. The findings show that these compounds improve the functional properties of biscuits and the product's stability during storage [9].

To improve the nutritive and functional content of starch-based gluten-free products, the Turkish scientists Ali Cingöz et al. add to them gluten-free cereal and pseudo-cereal products and alternative ingredients. Protein, one of the most important components absent in starch-based products, is increased by adding alternative sources. In this research, protein concentrate powder was obtained from sour cherry stones, which are one of important waste products of the fruit juice industry. When manufacturing gluten-free cake, the concentrates obtained were substituted for flour in 3 different proportions (2, 5, and 10 %). The characteristics established for the resulting baton cakes included their physical, functional, colour, morphogeometric, sensory, and textural properties and the fluidity of the cake batters. The findings allowed establishing that adding the protein concentrate of sour cherry stones increased the general phenol content and the antioxidant capacity of the oilcake samples (by the FRAP and DPPH methods). Such parameter as the hardness of the oilcake samples stored for 60 days was found to increase by more than 2 %, with the sour cherry protein concentrate substituted. Finally, it was established that this concentrate added nutritive properties to gluten-free cakes by increasing their protein and functional content and had no negative effects on the physical properties of the cake samples if added up to a level of 5 per cent. This was the reason to estimate the sour cherry protein concentrate as a functional raw material applicable in the manufacture of gluten-free cakes [10].

Mehtap Çelik et al. researched how pH affected the protein extraction from sour cherry stones (Prunus cerasus L.) and the functional properties of the resulting protein concentrate. The optimum pH values for protein extraction and isoelectric precipitation were determined as 10.0 and 4.5 respectively. The protein concentrate contained 4.03±0.16 % of moisture, 3.31±0.17 % of ash, 2.94±0.36 % of carbohydrates, 1.93±0.16 % of lipids, and 80.48±2.38 % of proteins. The water-retaining capacity, oil-retaining capacity, and the lowest gelling concentration of the protein concentrate were 2.42±0.09 g water/g, 1.73±0.17 g oil/g, and 8 % respectively. The results showed that the emulsifying activity and stability indices, foaming capacity and stability of the protein concentrate were 38.91±2.50 m2/g, 37.49±2.41 min, 35.00±3.54 %, and 71.80±7.25 % (after 30 min) respectively. The concentrate's functional and chemical properties prove that it can be applied as a functional ingredient in various foodstuffs [11].

Most studies of cherry kernels high in protein and fat deal with producing oil from cherry kernels and determining its antibacterial and antioxidant effects [12, 13], producing biodiesel [14, 15], possibilities of everyday consumption [16, 17]. Research on the protein of sour cherries considers the efficiency of protein extraction and establishing their functional properties [11]. The review of literature has shown that there are but few studies like using flour from cherry kernels as a substitute in breadmaking. Lack of diversity of gluten-free products and the public's growing knowledge of coeliac disease lead to the daily-growing demand for diverse gluten-free products. Besides, the low content of nutrients in gluten-free products and a wide range of starch-based products make it necessary to add ingredients of high nutritive value to these products [10].

Anther main byproduct from preserving or freezing is sour cherry kernels (also known as stones). They make up to 7–15 % of the total weight of the fruit [7]. Besides, this byproduct left after sour cherry processing is a good source of phenolic and antioxidant compounds, fat, protein, and dietary fibre.

Kai Kniepkamp et al. in their research proved that despite a considerable lipid content in the waste, using cherry stones as a raw material for lipid extraction is but limited because of high moisture. They researched the main factors influencing the lipid extraction productivity using the Soxhlet and Randall methods and supercritical carbon dioxide (CO2) especially focusing on optimising the productivity of green extraction technologies (CO2) [18].

The research showed that the yield of lipid extraction for CO2 increased from 7.4 g for dry crushed stones to 20.6 g per 100 g dry weight, cherry stones having been separated. The initial high moisture content had an effect on all the three extraction methods, but mostly on CO2 extraction. This resulted in co-extraction of the aqueous phase. The output of lipids and water can be regulated by adjusting such parameters as time, temperature, and pressure. However, it was never observed that there was any observable effect on the composition of the methyl esters of fatty acids [18].

One of the main components of the cherry kernel is oil (17–36 %), a rich source of polyunsaturated and monounsaturated fatty acids. Amino acids like lysine (known as an essential amino acid) and glutamic acid (dominant amino acid), minerals such as calcium and potassium, and group B vitamins (B1, B3, B5, and B6), too, are the valuable compounds found in the sour cherry kernel [7].

It is considered that oil from the kernels of cherry stones is stable, has mollifying properties, and is rich in oleic acid. Its properties make it similar to oils from almonds and peaches. It is the only oil that contains the main vitamins in quantities sufficient for proper metabolism.

Oil from the kernels of cherry stones that is obtained by cold pressing contains natural tocopherols, alpha-, delta-, and gamma-tocopherols plus vitamins. It also contains polyunsaturated fatty acids called eleostearic. They are linked by γ-linolenic acid, which prevents the absorption of ultraviolet radiation and creates a barrier on the surface of the skin and hair.

Cherry kernel oil reduces cholesterol and prevents cardiovascular disease; is used to treat and prevent cancer; stimulates body defences; increases resistance to infection; helps the development of muscles and increases fitness for work; it is wonderful for dry and ageing skin and for massage, and besides, it balances oily skin; produces an anti-inflammatory, burn-relieving, pain-relieving, and mollifying effects; is a natural UV-filter; heals wounds and skin defects leaving no scars.

Sour cherry pit oil (SCPO) has a powerful anti-inflammatory and antioxidant effect. Atieh Darchini Maragheh et al. produced SCPO nanoemulsion (SCPO-NE) to evaluate its antitumour effects on breast cancer, as compared to those of unprocessed oil. Stable SCPO-NE was made by ultrasonication. The samples were measured in terms of their size, stability, and morphology. After that, their cytotoxic effect and apoptotic activity were tested on the breast cancer cell line MCF-7 and compared with normal human foreskin fibroblasts (HFF). Finally, their antitumour action was studied on a murine model of breast cancer (inoculated with TUBO cancer cells). The findings showed that stable 36.5 nm SCPO-NE markedly lowered the viability of MCF-7 as compared with normal HFF and reduced the tumour size in the murine model. The authors suppose that SCPO-NE can effectively suppress breast cancer progression both in the MCF-7 cell line and in a murine model of breast cancer by induction of apoptotic death [19].

In cosmetology, sour cherry oil is used in the period of wrinkle formation and pigmentation as well as for skin overdrying. It slows down the ageing processes.

In cookery, it can substitute conventional oils in salad dressings, cold dishes, and sauces.

Sour cherry kernel oil is one of the mildest and least aggressive bases, has no contraindications, and causes no adverse sensations. It can be applied and used at any age and in any physical condition. Its shelf life is 12 month away from direct sunlight at 8–20 °C.

Laura Jūrienė et al. comprehensively characterised sour cherry pomace fractions extracted with supercritical CO2. In their research, the pomace from destoned cherries were prefractionated mechanically into 6 different particle sizes (>10.4–10, 3–4, 1–3, 0.8–1, <0.8 mm, 9.71–16.41 % of proteins, 5.68–12.16 % of fat, 62.55–78.39 % of carbohydrates) and subjected to supercritical CO2 liquid extraction to recover lipophilic components. The yield of the extract depended on the fat content and was 3.38 % to 8.69 %. Linoleic (38.52–47.11 %) and oleic (21.85–39.03 %) were the major fatty acids, whereas triacylglycerols that are composed of these acids were the major ones in the oils extracted. The concentrations of tocopherols, carotenoids, and phytosterols in the extracts were 116.3–432.0, 1218–2564, and 4294–8449 μg/g respectively [20].

To obtain valuable substances from agrifood materials, different extraction methods were used. Mostly, the focus was on improving the extraction efficiency to increase the yield in general and the concentration of the target compounds. The process largely depends on the solvent, particle size, solvent to solid matter ratio, temperature, and duration. The choice of the proper solvent is crucial to increasing the solubility and selectivity of the components. It is also important as to the technical and economic aspects of recovery and safety. The traditional (conventional) extraction methods, such as maceration, reflux extraction, percolation, and Soxhlet extraction, normally involve using large amounts of organic substances.

Besides, in cherry kernel oil recovered using different solvents, bioactive compounds were detected and quantified [21].

It was reported that to extract oil from oilseed crops, various methods could be used: solvent extraction, microwave, ultrasound, supercritical fluid extraction, fermentative methods, and cold pressing [22]. Oil from Prunus stones, including the sweet cherry (P. avium L.), sour cherry (P. cerasus L.), apricot (Prunus armeniaca L.), nectarine (P. persica var. nectarina (Aiton) Maxim.), peach (P. persica (L.) Batsch var. persica), and plum (P. domestica L.), is high in unsaturated fatty acids and bioactive compounds [23].

Maryam Kazempour-Samak et al. researched the recovery of oil from fresh sour cherry kernels (Cerasus vulgaris Miller) by cold pressing. The data obtained on the oil content and moisture were 31.89 % and 4 % respectively. The sensory evaluation of the oil was acceptable, the free fatty acid value was 1.36 mg KOH/g oil. Besides, the peroxide value and anisidine index of the oil from sour cherry kernels were 0.99 mmol ½ O/kg oil and 0.15 respectively. The predominant fatty acids were linoleic (42.34 %), oleic (35.45 %), α-Eleostearic (9.34 %), and palmitic (6.54). The kernel oil contains nine major triacylglycerols composed of OLL (20.44 %), OOL (16.99 %), LLL (8.20 %), LLEl (7.28 %), PLO (7.24 %), OE1O (5.03 %), OOO (4.70 %), ElLO (4.54 %), PLL (4.35 %), and POO (3 %). The most common sterol compounds were β-Sitosterol (83.55 %), Δ-5-Avenasterol (6.8 %), sitostanol (4.8 %), campesterol (3.5 %), and stigmasterol (0.53 %). The amygdalin amount in the oil sample was not established [17].

Nathan M. Korlesky, Lucas J. Stolp et al. extracted oil from the Montmorency sour cherry kernels and characterised it using various methods, including GC, LC–MS, NMR, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), and X-ray powder diffraction (XRD). The oil had an acid value of 1.45 mg KOH/g, saponification value of 193 mg KOH/g, and unsaponifiable matter content of 0.72 %. It contained oleic (O) and linoleic (l) acids as the major components with small concentrations of α-Eleostearic acid (El, 9Z, 11E, 13E octadecatrienoic acid) and saturated fatty palmitic (P) acid. The CPO contained six major triacylglycerols (TAG), OOO (16.83 %), OLO (16.64 %), LLO (13.20 %), OLP (7.25 %), OOP (6.49 %), and LElL (6.16 %) plus a number of other minor TAG. The TAG containing at least one saturated fatty acid constituted 33 % of the total. The polymorphic behaviour of CPO studied by DSC and XRD confirmed the presence of α, β′ and β crystal forms. The oxidative induction time of CPO was 30.3 min at 130 °C, and the thermal decomposition temperature was 352 °C [24].

The physicochemical parameters, fatty acid composition, and yield of cherry kernel oil depend on the sour cherry cultivar and the year of harvest [25].

In the paper by Bülent Başyiğit et al., sour cherry seed oil (SCSO) and pomegranate seed oil (PSO) extracted using cold-press technology were characterised in terms of their physicochemical properties, content of bioactive compounds, biological activity, and spectroscopic features. They were rich in unsaturated fatty acids (UFA). The predominant carotenoid was zeaxanthin (13.15 mg/kg) for SCSO and β-carotene (33.45 mg/kg) for PSO. In the samples, naringenin, ellagic acid, resveratrol, kaempferol, catechin, and gallic acid were found by LC/MS-MS to be the major secondary metabolites. The phenolic compounds and fatty acids were further analysed using 13C and 1H NMR. The α-glucosidase inhibition activity of SCSO and PSO was 4.38 and 5.16 mg/ml respectively. SCSO exhibited antimicrobial activity against Staphylococcus aureus although the growth of Staphylococcus aureus and Escherichia coli was inhibited by the PSO [26].

In another research by Bülent Başyiğit et al., SCSO microcapsules loaded with gum arabic (GA) and maltodextrin (MD) were developed using the spray drying technique. The optimum processing conditions determined using the response surface methodology (RSM) were as follows: weight ratio of GA to MD (GA:MD composition) 1:11, weight ratio of oil to total solid (core-wall ratio) 20 %, and inlet temperature 195 °C. SCSO powder (SCSOP) was characterised in terms of morphology and size using scanning electron microscopy (SEM), and a laser particle diameter analyser. The antimicrobial potential of the microcapsules was assessed against pathogenic bacteria, yeast, and mould [27].

Pomace obtained after processing berries with soft pits can be dried and further processed without mechanical separation of the pits. However, in sour cherry pomace, the stones must be separated from other pomace parts. Dried pomace or its parts mechanically prefractionated can be crushed and used directly in food formulations. For example, pomace from destoned cherries was added to muffins as a source of phenolic antioxidants [28]. Gumul et al. added to gluten-free breads extruded preparations of cherry pomace containing 13.57 % of protein, 3.02 % of fat, 10.97 % of carbohydrates, and 48.7 % of dietary fibre (4.5 % soluble, 44.2 % insoluble) [29]. Pavlović et al. microencapsulated stoned cherry pomace extracts rich in phenolic substances and assessed their bioavailability during in vitro digestion [30]. Toprakçı et al. extracted sour cherry peel using aqueous 80 % ethanol and encapsulated the extract obtained by ionic gelation in alginate beads [31]. To obtain pectins, Zhang et al. used sweet cherry pomace [32]. Hosseini et al. optimised simultaneous extraction of pectin and phenols from sour cherry pomace [33]. Sezer et al. in their research focused on improving the yield of soluble dietary fibre in sour cherry pomace and on the characteristics of the total phenolic content and antioxidant capacity [34].

Vladimír Frišták et al. physicochemically characterised cherry pit biochar (CPB) pyrolysed from cherry pit biomass (CP) at 500 °C, and assessed their As and Hg sorption efficiencies in aqueous solutions in comparison with activated carbon (AC) [35].

Kernel-derived oils can be used in foodstuffs, nutraceuticals, cosmetics, and a number of other products. It is reported that sour cherry kernels are a good source of monounsaturated and polyunsaturated fatty acids, mainly oleic and linoleic [36, 37], as well as of bioactive lipophilic components like carotenoids and tocopherols [5]. Phytosterols, too, are important trace elements contained in sour cherry oil [6, 37]. Thus, the lipophilic fraction of cherry pomace is rich in bioactive components, so developing effective methods of their recovery is an issue of much interest to the nutraceutical and cosmeceutical industries.

From the above, it is clear that a valuable and promising source is the kernels of different sour cherry cultivars containing beneficial nutrients and biological substances. Processing cherries into juices and jams is a source of a secondary raw material, sour cherry stones, or pits, that contain valuable oil and bioactive substances [38–40].

Cold pressing requires less energy than other oil isolation methods do, and besides, it is environmentally-friendly. It allows obtaining high quality oils at low temperatures [41, 42]. The use of no solvents makes applications of this technology green. In other words, cold pressing involves no thermal or chemical extraction of soya beans, sunflower, rapeseed, maize, grapes, hemp, flax, rice. Cold pressing was used to obtain olive and pumpkin oils [43–45].

This oil production technology is used in craft manufacture too.

The term craft has such synonyms as artisan, handmade, author-developed, etc. Until quite recently, the epithet craft was mainly used in the word combination craft beer (i. e. beer manufactured by small breweries and in limited amounts, often by the manufacturers' original recipes). No wonder: the process that had become a real craft beer revolution in Ukraine had given an impact on the development of Ukrainian craft production in general. Today, the term craft is used in quite a number of contexts: one can speak of craft cheeses, craft dried meat, craft oils, etc.

So, a craft product is any product manufactured with one's own hand and normally in small quantities. The main thing about craft production is the high quality in its every aspect, from the selection of the raw materials up to the production technology.

In the food industry and industrial agriculture, byproducts and waste are still not fully utilised. So, craft technologies of manufacturing kernel oil from different sour cherry cultivars needs further development.

The purpose of this study was to develop a technology for obtaining oils from kernels of stones of different sour cherry cultivars, with their quality characteristics and fatty acid composition retained. This was to be achieved by developing new process conditions, regulating the pressing duration, and studying the indicators of quality.

The objectives of the study:

1. To study the quality indicators of the kernels of stones of different sour cherry cultivars.

2. To develop a craft technology for isolating oil from kernels of stones of different sour cherry cultivars.

3. To analyse the fatty acid composition of the oils obtained.

Materials and methods.

The following cherry cultivars (harvested in 2021, 2022, and 2023) were selected as the source of the cherry pit kernels that became the raw materials for oil: English Early, Lotivka, Lyubska, Podbyelska, and their mixture (25 % of each sample).

The weight of 1000 cherry stones, volumetric mass of the cherry stones, and length of a cherry stone were measured according to DSTU (State Standard of Ukraine) ISO 658:2006 *Seeds of oil crops. Method of determining the content of impurities*.

The mass fraction of impurities and oil admixtures was determined according to DSTU ISO 658:2006 *Seeds of oil crops. Method of determining the content of impurities* (ISO 658:2002, IDT).

The mass fraction of moisture was measured individually for the kernels and the hard shells of cherry stones by the rapid method. It involved their single-time keeping in a drying chamber at a certain temperature and preset duration, according to DSTU 4811:2007 *Seeds of oil crops. Methods of determining the moisture content*.

In a laboratory environment, a method of recovering extra virgin oil from sour cherry pit kernels was developed. Firstly, cherry kernels were cleaned from impurities. Next, the stones were treated in a sodium chloride solution (1:1 % NaCl:H_2O) for 5–10 minutes to soften the shell. The treated stones were then split, and fragmented mass composed of kernels and their outer shells was obtained.

The main thing needed to obtain oil is the destruction of the cellular structure of cherry pit kernels. The ultimate result of the crushing is the transition of oil contained in the cells of seeds into the form suitable for further technological treatment. That is why we first ground 100 g of sour cherry kernels on the laboratory mill LZMK-1. Crushed mass of kernels was obtained from the cherry stones by comminuting them as finely as to achieve the undersize of 90–95 % for a screen with 1 mm meshes. In the course of processing the stones, it is practical to apply wet-heat treatment to the crushed kernels before they enter the press: by this, we overcome or weaken noticeably the forces that bind oil with the upper parts of the crushed kernels, and facilitate its separation from the oil-free components. 100 g of the crushed kernels prepared for the pressing had been preliminarily subjected to wet-heat treatment in a water bath. The sample was put on a 5 mm sieve with spunbond material and placed on the bath under a lid with a hole for a thermometer, thus determining the temperature and duration of saturation of the crushed kernels with steam. For a certain variety of crushed cherry kernels, the temperature conditions and duration of filling the pores with oil were determined. The degree of filling the pores in the crushed kernels was determined as a percentage by pressing the mass on a press under three operating modes, with the temperature ranging 40 to 60 °C and the process duration 10 to 20 min. The processed mass of crushed kernels was put on a manual press PROM-1U on the bottom of the operating cylinder in a layer as thick as 10–20 mm and slightly rammed down with a press punch. The oil yield was determined as a percentage of the maximum oil content in cherry kernels. By raising the rod of the jack to the upper position, we create the pressure P = 0.063 mPa in the cylinder with the product placed below the punch, which is enough for the oil pressing. The sufficiency of the effort applied is controlled by appearing oil. Throughout the time of applying this pressure, one should give the press handle 3–5 pushes more. If necessary, the sample is precompacted, then some more material to be pressed is added, followed by further pressing. On completion of oil pressing, the rod of the jack is returned to the lower position. The product (press cake) is taken out of the cylinder, and the oil that has run down into a preweighed flask is weighed. Thus we obtain the data on how much the pores in the crushed material are filled with oil.

The pulp obtained as a result of the wet-heat treatment of crushed kernels was pressed using a laboratory hydraulic press of the U1 EPM type. 100 g of the pulp was poured into the press container, closed with a plunger. Using a hand pump, the pressure was increased to the maximum indicated on the manometer P=0.072 mPa. During the three operating modes of pressing, the parameters considered were the temperature (50–70 °C), the rate of load application (5–15 kN/cm), the compressive strength (10–20 kN), and the load resistance time (3–15 min). As the pressure decreased, it continued to be raised to the maximum with the hand pump. During the pressure augmentation, particles of the pulp stick together into a block, the density of the press cake increases, and the oil pressing stops. The thickness of the resulting oilcake piece was measured in millimetres. The oil after it has flowed down into a pre-weighed flask is weighed, and thus we obtain the data on its yield as a percentage.

The mass fraction of moisture in the crushed material was measured by the rapid drying method or using an electrical moisture meter according to DSTU ISO 771:2006. *Oilcake and oilseed meal. Determining the content of moisture and volatile substances* (ISO 771:1977, IDT).

The thickness of a cherry oilcake piece was measured in order to monitor daily the operation of the press, and also, when testing new makes of presses.

The fat content in the cherry pit kernels, oilcake, and pores of the crushed material was determined by exhaustive extraction in a Soxhlet extractor according to DSTU ISO 7577:2014. *Oilseeds. Determining the oil content by extraction in a Soxhlet extractor*.

The acid value was determined according to utility model patent No. 107906 Ukraine MPK G01N 33/03 (2006.01) [46]. The oil obtained before pressing (in the Soxhlet extractor) and after pressing the kernels of pits of different cherry cultivars by the above methods was placed in a 250 cm^3 conical flask. Three to five grams of the oil analysed was weighed with accuracies down to 0.01 g and heated in a bain-marie, then 50 cm^3 of neutralised alcohol/hexane mixture was poured into the vessel to fill it up, and the sample was stirred. The resulting solution, continuously stirred, was quickly titrated with a potassium or sodium hydroxide solution (C (KOH) = 0.1 mol/dm^3) until it became distinctly pink and could keep the colour for 30 s.

During titration with a potassium or sodium hydroxide solution, the quantity of alcohol in the composition of the alcohol/hexane mixture should be 5 times as big as the volume of the potassium or sodium hydroxide solution, so as to avoid hydrolysis of the soap formed. The acid value (AV) expressed in mg KOH/g was calculated according to the formula:

$$AV = \frac{V \cdot k \cdot c(KOH) \cdot M(KOH)_{eq}}{m} \qquad (1)$$

where V is the volume of the KOH or NaOH solution spent on titration, cm^3;

k is the correction coefficient for the alkali solution to be expressed in terms of exact 0.1 mol/dm^3;

m is the weight of the oil under study, g;

c (KOH) is the molar concentration of the alkali, 0.1 mol/dm^3;

M $(KOH)_{eq}$ is the molar equivalent mass equal to 56.11 g/mol.

The smell, taste, colour, and transparency of the oil from the kernels of stones of different cherry varieties were determined according to DSTU 8842:2019. Oils. Methods of determining the smell, taste, colour, and transparency.

The fatty acid composition of the cherry kernels and cold-pressed oils was determined by gas–liquid chromatography on a Hewlett Packard HP-6890 gas chromatograph, according to DSTU ISO 5508:2001. Fats and oils of animal and plant origin. Analysing by the method of gas chromatography of fatty acid methyl esters (ISO 5508:1990, IDT) [47].

All numerical data obtained were processed using Excel from the Microsoft Office 2007 service software package. The numerical data were presented in the form of the arithmetic mean and the standard deviation (M±m).

Results of the research and their discussion

After the oil-containing raw material enters fat-and-oil enterprises, its quality indicators are studied in the first place in order to determine the quality characteristics of the raw material, predict the economic effect, and organise the technological process. Sour cherry stone kernels of the following cultivars (harvested in 2021–2023) were considered: English Early, Lotivka (Łutówka), Lyubska, Podbyelska, and their mixtures, with 25 % of each sample. Table 1 lists the quality parameters of the stone kernels for each sour cherry variety.

According to the research results, Lyubska is the variety with the highest average content of impurities (2.31 %), and the mixture is the lowest in impurities (1.74 %). One can regard all the samples as complying with the general quality standards. No sample was infected or treated with pesticides. The average moisture content in the samples of cherry stones under study (harvested in 2021–2023) is as follows: English Early – 6.9 %, Lotivka – 6.0 %, Lyubska – 6.6 %, Podbyelska – 6.6 %, and the mixture – 7.0 %. One can conclude that all the samples meet the requirements. The average size of a cherry stone depends on the variety: English Early – 0.9 mm, Lotivka – 0.85 mm, Lyubska – 0.75 mm, Podbyelska – 0.9 mm, and the mixture – 0.85 mm. The weight of 1,000 cherry stones averages, depending on the cultivar: English Early – 210 g, Lotivka – 245 g, Lyubska – 170 g, Podbyelska – 240 g, and the mixture – 190 g. The acid value in the oils produced from the cherry kernel samples under study (harvested in 2021–2023) never exceeds 3.0 mg KOH/g, which meets the general requirements.

The mass fraction of oil in sour cherry kernels of different cultivars is presented in Fig. 1

Table 1 – Quality indicators of the kernels of different sour cherry cultivars

Indicators	English Early			Lotivka			Lyubska			Podbyelska			Mixture of the samples (25 % of each sample)		
	Years														
	2021	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**	**2021**	**2022**	**2023**
Impurities, %	2.10	1.14	0.57	1.13	1.50	1.02	1.35	2.00	1.32	1.87	1.31	0.44	1.50	1.55	1.08
Oil admixture, %	0.10	0.20	0.10	0.50	0.30	0.10	0.90	0.70	0.65	0.31	0.10	0.20	0.45	0.35	0.28
Total contamination, %	2.20	1.34	0.67	1.63	1.80	1.12	2.25	2.70	1.97	2.18	1.41	0.64	1.95	1.90	1.36
Moisture, %	7.00	8.00	8.70	8.50	7.00	8.00	7.00	6.00	8.0	7.10	4.50	4.10	7.20	6.50	6.50
Volumetric mass, kg	2.00	2.05	2.05	1.40	1.50	1.50	1.70	1.60	1.60	1.60	1.60	1.65	1.80	1.70	1.75
Weight of 1000 kernels, kg	2.10	2.15	2.15	1.45	1.60	1.55	1.70	1.60	1.65	1.68	1.60	1.65	1.80	1.75	1.78
Kernel size, mm	0.90	0.85	0.80	0.85	0.80	0.75	0.75	0.70	0.60	0.90	0.85	0.80	0.80	0.85	0.80
Acid value, mg KOH/g	1.20	1.30	1.20	0.80	0.90	0.70	1.40	1.10	1.20	0.50	0.40	0.20	1.30	1.40	1.50

The mass fraction of oil varies with the variety of cherry pit kernels. The average oil percentage is the highest in Lyubska (28.7 %), and the lowest is that of the Lotivka kernels (20 %).

Fig. 2 shows a vector diagram of processing the stones of different cherry varieties (harvested in 2021–2023), where the process conditions are experimentally confirmed.

With the one-time pressing of cherry pit kernels, the extent of oil removal in presses is largely determined by how finely they are crushed.

Acceptance of cherry stones starts with their sampling to determine the quality parameters according to regulatory documents. Depending on their original condition (level of moisture, impurities, etc.), the stones are either put into storage or immediately directed for processing.

The samples studied were of different cultivars harvested in 2021–2023: English Early, Lotivka, Lyubska, Podbyelska, and their mixture (25 % of each sample). First, they were purified from contamination. The foreign matter and oil admixtures were removed from the stones on laboratory screens with meshes 5, 4, 3, 2, and 1 mm in diameter. The screenings were sorted on a selection board, where the foreign matter and oil admixtures were separated. All undersize is regarded as foreign matter.

After purification, the raw material goes through the cracking stage, when the kernel is separated from the shell, followed by comminuting in a laboratory mill. At least 90–95 % of the ground material should be as fine as the undersize from a screen with 1 mm meshes.

During the processing, the crushed material, before entering the press, was moisturised with steam. To overcome and weaken the forces that bind oil with the surfaces of the kernels crushed, and to facilitate its separation from the oil-free components, the processed material undergoes wet-heat treatment. It consists in treating the crushed kernels with hot vapour, which is accompanied by intensive stirring, to obtain the mash sufficiently moisturised. The temperature and duration of treating the kernels were as follows: for the cultivars English Early, Lotivka, Lyubska – 50–60 °C, τ 5–10 min; for Podbyelska and the mixture – 40–50 °C, τ 10–15 min.

After this treatment, the mash enters the press for the final removal of oil. This is an element of the manufacturing line where oil is isolated by the cold pressing of different varieties of cherry pit kernels. The effectiveness of pressing established for cherry kernels of different cultivars is as follows: English Early, Lotivka, Lyubska – t = 60–70 °C, τ 6–15 min; Podbyelska and the mixture – t = 50–60 °C, τ 4–10 min. The oil obtained passes the primary stage of refining and is directed for bottling, labelling, packaging, and storage. The press cake is portioned, labelled, and put into storage.

This made it necessary to determine the fatty acid composition (FAC) in the oil samples from different varieties of sour cherry kernels and their mixture. The fatty acid compositions of the studied oils before pressing (in the raw materials prior to heat treatment) and after pressing are presented in Fig. 3, 4.

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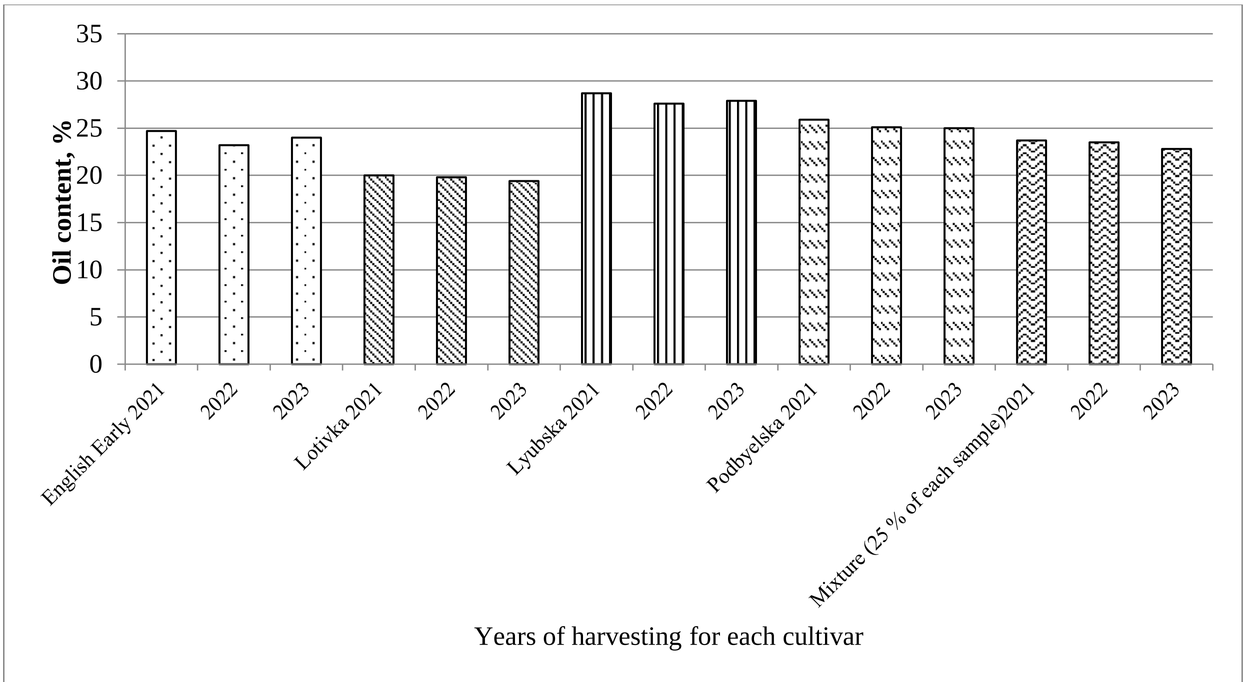

Fig. 1. Mass fraction of oil in the kernels of different sour cherry cultivars harvested in 2021–2023

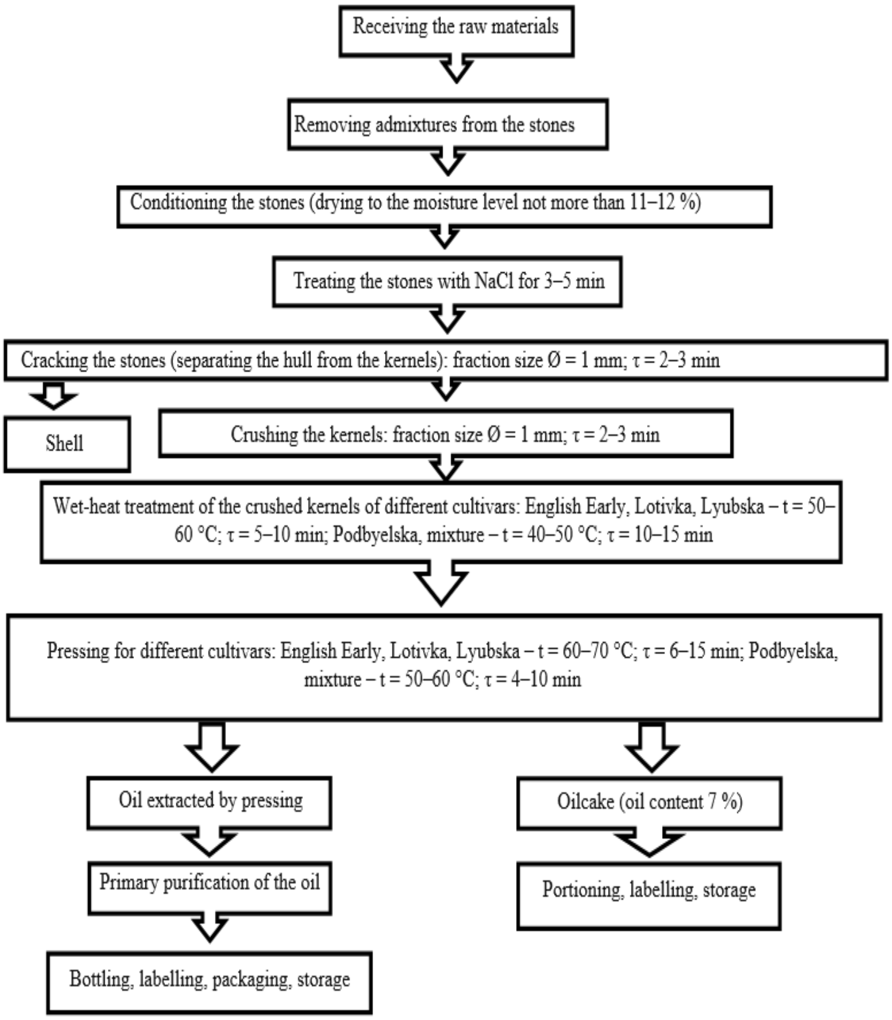

Fig 2 . Vector diagram of processing the stones of different cherry varieties harvested in 2021–2023

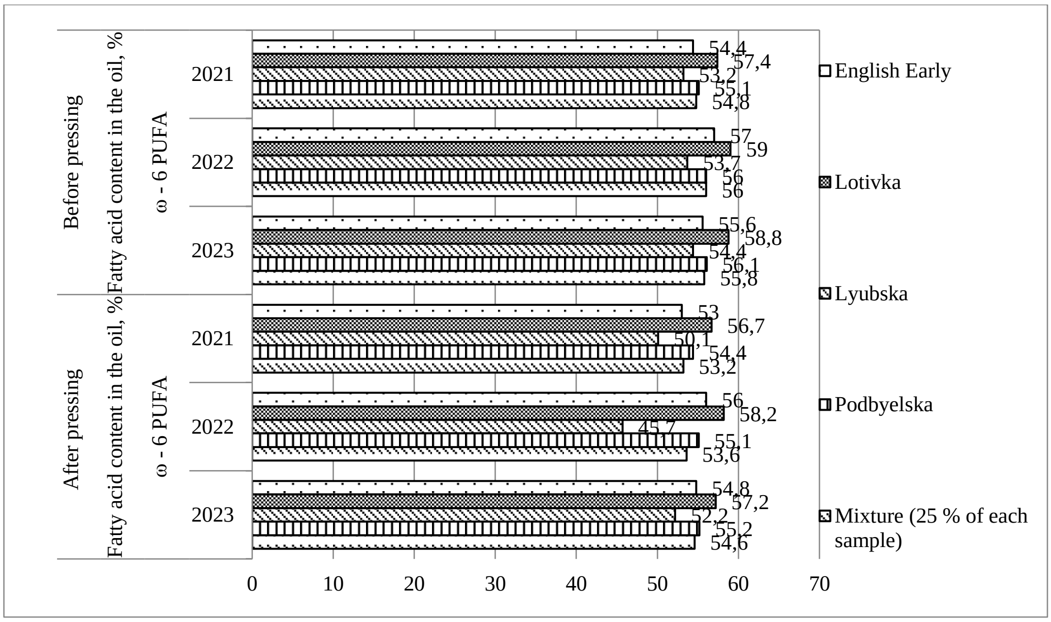

Fig. 3. Fatty acid composition of the studied oils from different varieties of sour cherry kernels: ω-6 PUFA in the raw material prior to heat treatment and after pressing

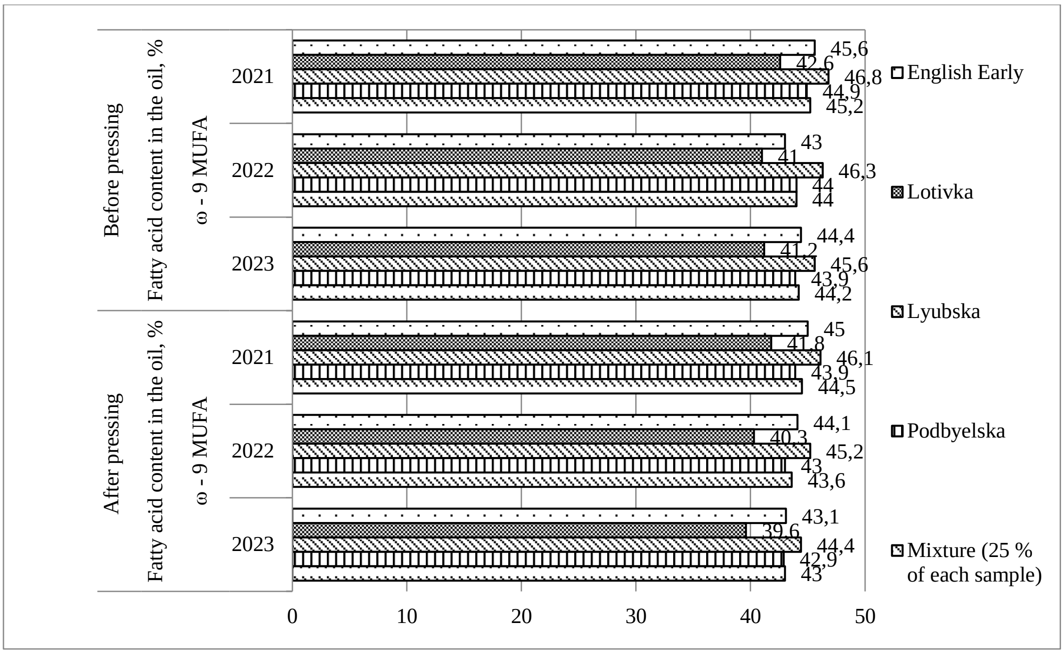

Fig. 4. Fatty acid composition of the studied oils from different varieties of sour cherry kernels: ω-9 MUFA in the raw material prior to heat treatment and after pressing

As can be seen in Fig. 3, 4, it is proved that in the oils from cherry kernels, depending on the cultivar and crop year, the fatty acid contents are as follows.

English Early – 97.4 % (2021), 98.2 % (2022), 98.6 % (2023) of ω-6 PUFA and 98.7 % (2021), 97.5 % (2022), 97.1 % (2023) of ω-9 MUFA.

Lotivka – 98.8 % (2021), 98.6 % (2022), 97.3 % (2023) of ω-6 PUFA and 98.1 % (2021), 98.3 % (2022), 96.1 % (2023) of ω-9 MUFA.

Lyubska – 94.2 % (2021), 85.1 % (2022), 96.0 % (2023) of ω-6 PUFA and 98.5 % (2021), 97.6 % (2022), 97.4 % (2023) of ω-9 MUFA.

Podbyelska – 98.7 % (2021), 98.4 % (2022), 98.4 % (2023) of ω-6 PUFA and 97.8 % (2021), 97.7 % (2022), 97.7 % (2023) of ω-9 MUFA.

Mixture – 97.1 % (2021), 95.7 % (2022), 97.8 % (2023) of ω-6 PUFA and 98.5 % (2021), 99.1 % (2022), 97.3 % (2023) of ω-9 MUFA.

Field testing of the results.

Based on the findings of this research, the newly-developed technology of extra virgin oil from the kernels of different sour cherry cultivars has been introduced into the production process at Odesa Factory of Kernel and Vegetable Oils *TOV AVA* and recommended for manufacturing craft vegetable oils.

Conclusion

Based on the data from the literature, the manufacture of valuable oil from kernels of various sour cherry cultivars looks so promising, because they differ in their fatty acid compositions and yields of oil. A task of current importance is studying the varietal features of cherries in order to prove that their kernels differ in the oil content and physicochemical characteristics, and to develop a technology of producing oil from pit kernels of different sour cherry varieties.

A number of cherry cultivars have been analysed as sources of raw materials for the manufacture of oil from sour cherry pit kernels. As a result, the following cultivars have been found the most promising for studying the kernels of their pits: English Early, Lotivka, Lyubska, Podbyelska, and their mixture (25 % of each sample). These cultivars are the ones most often used in the fruit-processing and canning industries.

The study has allowed selecting the research methods. The techniques tried and tested include those of sampling and of analysing the raw materials. According to the regulations, all the quality parameters of the raw materials have been determined.

As for the contamination level, the research results show that the cultivar with the highest average content of impurities is Lyubska (2.31 %), and the mixture is the lowest in impurities (1.74 %). One can regard all the samples as complying with the general quality standards. No sample was infected or treated with pesticides. The average moisture content in the samples of cherry stones under study (harvested in 2021–2023) is as follows: English Early – 6.9 %, Lotivka – 6.0 %, Lyubska – 6.6 %, Podbyelska – 6.6 %, and the mixture – 7.0 %. One can conclude that all the samples meet the requirements. The average size of a cherry stone depends on the variety: English Early – 0.9 mm, Lotivka – 0.85 mm, Lyubska – 0.75 mm, Podbyelska – 0.9 mm, and the mixture – 0.85 mm. The weight of 1,000 cherry stones averages, depending on the cultivar: English Early – 210 g, Lotivka – 245 g, Lyubska – 170 g, Podbyelska – 240 g, and the mixture – 190 g. The acid value in the oils produced from the cherry kernel samples under study (harvested in 2021–2023) never exceeds 3.0 mg KOH/g, which meets the general requirements. The mass fraction of oil varies with the variety of cherry pit kernels. The average oil percentage is the highest in Lyubska (28.7 %), and the lowest is that of the Lotivka kernels (20.0 %).

A craft technology has been developed to obtain oil from the kernels of a number of sour cherry varieties cultivated in Ukrainian horticultural enterprises. Namely, appropriate process conditions have been selected to obtain extra virgin oil by cold pressing.

It has been found that the most practical temperatures of wet-heat treatment of crushed cherry kernels are as follows: for English Early, Lotivka, and Lyubska – 50–60 °C, τ 5–10 min; for Podbyelska and the mixture – 40–50 °C, τ 10–15 min.

The effectiveness of pressing established for cherry kernels of different cultivars is as follows: English Early, Lotivka, and Lyubska – t = 60–70 °C, τ 6–15 min; Podbyelska and the mixture – t = 50–60 °C, τ 4–10 min.

It has been proved that the fatty acid composition of the kernels is retained in the oil isolated from them. The oil from the English Early cultivar contained 97.4 % (2021), 98.2 % (2022), 98.6 % (2023) of ω-6 PUFA and 98.7 % (2021), 97.5 % (2022), 97.1 % (2023) of ω-9 MUFA. That from Lotivka contained 98.8 % (2021), 98.6 % (2022), 97.3 % (2023) of ω-6 PUFA and 98.1 % (2021), 98.3 % (2022), 96.1 % (2023) of ω-9 MUFA. That from Lyubska – 94.2 % (2021), 85.1 % (2022), 96.0 % (2023) of ω-6 PUFA and 98.5 % (2021), 97.6 % (2022), 97.4 % (2023) of ω-9 MUFA. That from Podbyelska – 98.7 % (2021), 98.4 % (2022), 98.4 % (2023) of ω-6 PUFA and 97.8 % (2021), 97.7 % (2022), 97.7 % (2023) of ω-9 MUFA. That from the mixture – 97.1 % (2021), 95.7 % (2022), 97.8 % (2023) of ω-6 PUFA and 98.5 % (2021), 99.1 % (2022), 97.3 % (2023) of ω-9 MUFA.

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ЯКІСНІ ХАРАКТЕРИСТИКИ ОЛІЙ З ЯДЕР КІСТОЧОК РІЗНИХ СОРТІВ ВИШЕНЬ ДЛЯ РОЗРОБЛЕННЯ КРАФТОВОЇ ТЕХНОЛОГІЇ

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Анотація. Актуальним напрямком дослідження є розроблення нових і вдосконалення існуючих технологій отримання та переробки нетрадиційної олієвмістної сировини рослинного походження (ядер вишневих кісточок), що дозволяє отримати олію та макуху високої харчової і біологічної якості. У роботі використано метод холодного пресування і вдосконалено його. Досліджено можливість використання ядер вишневих кісточок, які отримані з вирощених вишень у садах України, врожаїв 2021, 2022 та 2023 років: Англійська рання, Лотівка, Любська, Подбельська та їх суміші у співвідношенні по 25% як перспективної сировини для отримання олійно-жирової продукції. Обґрунтовано технологію виробництва олій з ядер кісточок різних сортів вишень українського садівництва. Підібрано модель обробки різних сортів вишневих кісточок сольовим розчином NaCL у співвідношені 2:2 (дві частини каменевої солі та дві часини води) та тривалість від 5 до 10 хвилин. При цій обробці було забезпечено розколювання кісточок 90–100%, що свідчить про оптимальне співвідношення розчину для забезпечення данної технологічної операції і доведення удосконалення технології. Підібрано технологічні режими холодного пресування Extra Virgin для ядер кісточок різних сортів вишень. Волого-теплове оброблення м'ятки із ядер вишневих кісточок доцільно проводити за температури: для сортів: Англійська рання, Лотівка, Любська – t=50–60 ºC, τ 5–10 хв.; Подбельська, Суміш – t=40–50 ºC, τ 10–15 хв. Встановлена ефективність пресування ядер вишневих кісточок сортів: Англійська рання,Лотівка, Любська – t=60–70 ºC, τ 6–15 хв.; Подбельська, Суміш – t=50–60 ºC, τ 4–10 хв. Отримання олій за запропонованим технологічним режимом дозволяє максимально зберегти вихідний жирнокислотний склад сировини. Доведено, що у складі олії, отриманої із ядрер вишневих кісточок сорту Англійська рання 2021року – 97.4%, 2022 – 98.2%, 2023 – 98.6% по ω-6 ПНЖК та 2021року –98.7%, 2022 – 97.5%, 2023 – 97.1% по ω-9 МНЖК. У сорту Лотівка 2021року –98.8%, 2022 – 98.6%, 2023 – 97.3% по ω-6 ПНЖК та 2021року – 98.1%, 2022 – 98.3%, 2023 – 96.1% по ω-9 МНЖК. У сорту Любська 2021року – 94.2%, 2022 – 85.1%, 2023 – 96.0% по ω-6 ПНЖК та 2021року – 98.5%, 2022 – 97.6%, 2023 – 97.4% по ω-9 МНЖК. У сорту Подбельська 2021року – 98.7%, 2022 – 98.4%, 2023 – 98.4% по ω-6 ПНЖК та 2021року – 97.8%, 2022 – 97.7%, 2023 – 97.7% по ω-9 МНЖК. У суміші 2021року – 97.1%, 2022 – 95.7%, 2023 – 97.8% по ω-6 ПНЖК та 2021року – 98.5%, 2022 – 99.1%, 2023 – 97.3% по ω-9 МНЖК. Досліджено якісні характеристики олій з ядер кісточок різних сортів вишень для розроблення крафтової технології.

Ключові слова: вишневі кісточки; крафтова технологія; м'ятка; олія вишнева; макуха з ядер вишневих кісточок; склад жирних кислот.