UDC 664:635.64]:613.2 **DOI: 10.58407/bht.3.25.18**

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FUNCTIONAL POTENTIAL OF SECONDARY TOMATO RAW MATERIALS: DEVELOPMENT OF AN ANTIOXIDANT DRESSING FOR HEALTHY NUTRITION

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ФУНКЦІОНАЛЬНІ МОЖЛИВОСТІ ВТОРИННОЇ ТОМАТНОЇ СИРОВИНИ: СТВОРЕННЯ АНТИОКСИДАНТНОГО ДРЕСИНГУ ДЛЯ ЗДОРОВОГО ХАРЧУВАННЯ

ABSTRACT

In the current context of rising concern for food security, sustainable development and the minimisation of food waste, the effective utilisation of by-products from the agro-industrial sector is of particular importance. The paper provides a detailed characterisation of the functional ingredients present in tomato-processing waste and proposes the development of a functional salad dressing based on tomato and olive oils with high levels of antioxidants and polyunsaturated fatty acids.

Aim of the study. The aim of this work was to develop a functional salad dressing based on tomato and olive oils with high antioxidant and polyunsaturated fatty-acid content, capable of improving the nutritional value of the product and supporting consumer health.

Methodology. Calculations and data processing in Microsoft Excel were employed to assess the composition of ingredients and the antioxidant activity of the product.

Scientific novelty. For the first time, recipes for dressings with the addition of cold-pressed tomato oil, oregano and turmeric are proposed. These ingredients provide enhanced antioxidant activity and broaden the spectrum of bioactive components (lycopene, tocopherols, quercetin, rutin and other flavonoids). The dressing is characterised by a high proportion of unsaturated fatty acids (> 80 %), optimal stability during storage and an elevated ω-6/ω-3 ratio, which makes it an innovative functional food product.

Conclusions. The paper presents the development of a functional sauce-dressing based on cold-pressed tomato oil, which exhibits marked antioxidant properties and contains no artificial preservatives. The resulting product contains significant amounts of natural antioxidants (lycopene, tocopherols and vitamin C), unsaturated fatty acids (omega-6 and omega-9), as well as vitamins and minerals important for maintaining the cardiovascular, immune and antioxidant systems. It has been established that this sauce-dressing is a promising functional product for inclusion in a rational daily diet.

Keywords: functional food products, health-promoting products, food additives; tomato pomace, secondary raw materials, functional ingredients, tomato oil, waste processing, food industry, eco-friendly food products, dressing, antioxidant capacity

АНОТАЦІЯ

У сучасних умовах зростаючої актуальності проблем продовольчої безпеки, сталого розвитку та мінімізації харчових відходів особливе значення набуває ефективне використання побічних продуктів агропромислового комплексу. У роботі детально охарактеризовано функціональні інгредієнти, що містяться у відходах томатопереробки, та запропоновано розробку функціонального салатного дресингу на основі томатної та оливкової олій із підвищеним вмістом антиоксидантів і поліненасичених жирних кислот.

Мета статті. Метою дослідження було розробити функціональний салатний дресинг на основі томатної та оливкової олій із високим вмістом антиоксидантів та поліненасичених жирних кислот, здатний покращувати харчову цінність продукту та підтримувати здоров'я споживачів.

Методологія. Використано розрахункові методи та обробку даних у Microsoft Excel для оцінки складу компонентів і антиоксидантної активності продукту.

Наукова новизна. Вперше запропоновано рецептури дресингу із додаванням холодно віджатої томатної олії, орегано та куркуми, що забезпечує підвищення антиоксидантної активності та розширення спектру біоактивних компонентів (лікопен, токофероли, кверцетин, рутин, флавоноїди). Дресинг характеризується високим вмістом ненасичених жирних кислот (>80 %), оптимальною стабільністю під час зберігання та підвищеним вмістом ω-6/ω-3, що робить його інноваційним продуктом функціонального харчування.

Висновки. У роботі представлено розробку функціонального соус-дресингу на основі томатної олії холодного віджиму, що має виражені антиоксидантні властивості та не містить штучних консервантів.. Отриманий продукт містить значну кількість природних антиоксидантів (лікопін, токофероли, вітамін С), ненасичених жирних кислот (омега-6 та омега-9), а також вітамінів і мінералів, важливих для підтримки серцево-судинної, імунної та антиоксидантної систем організму. Встановлено, що соус-дресинг є перспективним функціональним продуктом для раціонального щоденного харчування.

Ключові слова: функціональні харчові продукти, оздоровчі продукти, харчові добавки, томатні вичавки, вторинна сировина, функціональні інгредієнти, томатна олія, переробка відходів, харчова промисловість, екологічні харчові продукти, дресинг, антиоксидантні властивості

Introduction

The increasing demand for environmentally clean products, conservation of natural resources, and reduction of agro-industrial waste motivate scientific research on the reuse of plant raw materials. Secondary plant raw materials are residues left after the primary processing of agricultural crops (husks, stalks, pomace, oilcake, press cake, etc.). They contain a wide spectrum of valuable compounds: polyphenols, fiber, pectins, vitamins, minerals, essential oils, proteins, and amino acids. These components can be effectively converted into food products and biologically active supplements.

The volume of raw materials in industries processing agricultural products is significantly higher than the output of final products; as a result, a large quantity of secondary raw materials is generated, most of which is scarcely utilized (Gasimova, 2024; Kartushina et al., 2017; Kołodziejczyk et al., 2007; Levkivska et al., 2021; Meghwar et al., 2024; Pavlović et al., 2020; Yuneri & Syarifuddin, 2024). Secondary raw materials from tomato processing are a unique source of nutrients – vitamins, antioxidants, polyphenols, tannins, and essential trace elements – that contribute to the normal functioning of the human body (Table 1).

Table 1

Summarizes the chemical composition of tomato seeds, tomato skin, and tomato pomace (Maldonado-Torres et al., 2020)

Component	Tomato seeds (% of dry basis)	Tomato skin (% of dry basis)	Tomato pomace (% of dry basis)
Proteins	29,6	10,8	23,9
Lipids	32,5	2,8	21,8
Phospholipids	1,1	trace	0,8
Minerals	2,95	1,9	2,1
Carbohydrates	34,7	80,1	48,3
Fibers	21,2	42,4	27,6
Carotenoids (mg%)	16,4	27,8	25,1
β-Carotene (mg%)	1,2	1,9	1,8
Tocopherols (mg%)	64,4	–	39,3
α-Tocopherol (mg%)	51,5	–	35,4
Naringin (mg%)	–	4,3	1,3
α-Tomatine (mg%)	2,8	3,8	3,1

Tomato processing occupies a leading position in the canning industry both in Ukraine and abroad. Tomatoes are processed at enterprises to produce products such as purée, juices, ketchup, sauce, paste, and tomato powder. The solid residues remaining after pulp extraction are peels, seeds, fibrous mass, and discarded tomatoes unsuitable for human consumption.

In the process of converting tomatoes into juice, paste or ketchup, waste is formed in the amount of 3.5–4.0 % of the total mass of raw

materials. These by-products, with an appropriate technological approach, can serve as sources of valuable food ingredients and food additives that have a positive effect on human health.

Technologies for the production of tomato-oil extract and protein–tomato-oil paste from tomato pulp have been developed, which are used to regulate the technological properties of food systems, such as bakery products, cooked sausages, pâtés, mayonnaise and mayonnaise sauces. A method for processing cake, for example, into protein paste, has been found (Kumar et al., 2022). The components obtained from tomato pulp have pronounced emulsifying and stabilizing properties due to the combination of proteins, lipids and dietary fibers. Tomato oil extract and protein–tomato paste effectively regulate the viscosity, texture, stability and dispersibility of products. This makes it possible to reduce the use of synthetic stabilizers and to enrich the formulations with dietary fibers and natural antioxidants (Nakov et al., 2022).

Tomato seeds are the main by-product in the production of tomato paste and account for approximately 71–72 % of all waste (Kumar et al., 2022). Tomato seeds contain a number of important functional ingredients: essential fatty acids, vitamins (A, D, E and K), phytosterols, and other components that play an important role in human nutrition and health (Kumar et al., 2022). This raw material can be considered a valuable source for obtaining dietary supplements (Table 2). Tomato pulp consists mainly of peel and seeds. It is a lignocellulosic material that is often difficult to utilize (Kaloo et al., 2025).

Tomato seeds are separated from pomace after drying by grinding and sieving into seeds and crushed peel, or by washing pomace with water, using density differences (seeds sink in water, while pulp and peel float). The settled seeds are mechanically pressed to remove moisture and dried in dryers to a moisture content of 11–12 % (Svelander et al., 2010).

Table 2

Nutritional ingredients of tomato seeds (Kaloo et al., 2025)

Component	Functional value
Fats	Source of linoleic (omega-6) and oleic (omega-9) acids; contain phytosterols, tocopherols (vitamin E) with antioxidant properties
Proteins	High content of essential amino acids (lysine, valine, isoleucine); potential alternative to animal protein
Fiber	Represented by insoluble dietary fibers; improves gastrointestinal function
Pectin substances	Natural thickeners and stabilizers in the food industry
Minerals	Calcium, potassium, magnesium, phosphorus, iron
Antioxidants	Carotenoids (lycopene), polyphenols, flavonoids, vitamin E – reduce oxidative processes
Phospholipids	Improve emulsion structure, stabilize dispersed systems

The amount of antioxidants in tomato seeds is significant, although most studies have focused on fruit pulp and peel (Benderska et al., 2021). Main antioxidants in tomato seeds include:

– Lycopene – although most abundant in peel and pulp, small amounts are present in seeds (≈ 0.1–0.5 mg/g dry weight). Lycopene is a tetraterpenoid with conjugated double bonds, which gives it the ability to neutralize reactive oxygen species (ROS) and other free radicals (Bacanli et al., 2017; Shafe et al., 2024). It is superior to β-carotene and α-tocopherol in antioxidant activity. The bioavailability of lycopene increases after heat treatment, especially in the presence of fat, which promotes its absorption in the intestine. Lycopene has a positive effect on the blood lipid profile, reducing total cholesterol and LDL, and improving endothelial function (Kumar et al., 2022). Studies confirm its role in the prevention of atherosclerosis and coronary heart disease. Epidemiological studies indicate an inverse relationship between the level of lycopene

consumption and the risk of developing certain types of cancer, including prostate, lung and stomach cancer (Ni Li et al., 2020). Lycopene is involved in the regulation of mineral metabolism and may contribute to the maintenance of bone density. The nephroprotective properties of lycopene in oxidative damage to kidney tissue have also been described (Silva et al., 2025). The antioxidant activity of lycopene provides photoprotective effects, reduces signs of photoaging of the skin and maintains its elasticity. Some studies indicate a positive effect on hair growth and structure (Shafe et al., 2024).

– Phenolic compounds – seeds contain flavonoids, quercetin, rutin, and other polyphenols (10–40 mg/g dry weight).

– Vitamin E (tocopherols) – fat-soluble antioxidants, present in tomato seed oil (≈ 20–50 mg/100 g). Tocopherols are natural lipophilic antioxidants with high biological activity that protect cell membranes from lipid peroxidation, stabilize the structure of biomembranes and participate in the regulation of signaling pathways. As functional ingredients, tocopherols are widely used in the creation of food products with increased biological value and long shelf life.

– Phytosterols – have antioxidant and anti-inflammatory effects.

– Oleic and linoleic acids – unsaturated fatty acids that protect cells from oxidative stress.

The oil content in tomato seeds is 24-26 %, in pomace – up to 19–21 % (depending on variety and fruit ripeness) (Kaloo et al., 2025). Tomato seeds contain 0.8–1.0 % phospholipids, 112–150 mg/100 g tocopherols, up to 1 % carotenoids, and 0.8–1.88 % of other unsaponifiable substances. To obtain tomato seed oil, several technological operations are applied, such as drying, grinding, pressing and filtration. Tomato oil can be obtained by different methods (Table 3). Mechanical pressing (cold or hot) or expeller pressing – seeds are compressed by a screw press under high pressure. Cold pressing is often considered the best option for preserving taste and bioactive compounds. Solvent extraction (e.g., hexane) ensures high oil yield (residual oil in cake ≈ 0.5–0.7 %) or other solvents (acetone, chloroform, ethers) for special purposes. Modern technologies: CO_2 extraction, ultrasound, microwaves. Water extraction – using water as the medium instead of toxic solvents; safe but less efficient (Giuffrè et al., 2017).

Table 3

Main methods of tomato oil extraction

Method	Yield, %	Advantages	Disadvantages
Cold pressing	up to 17	Preservation of bio-components	Lower yield
Soxhlet (solvents)	20-21	Maximum extraction	Time-consuming, possible degradation
Microwave extraction	11-25	Speed, preservation of antioxidants	Technically complex
Ultrasound extraction	19-23	Combined effect	Expensive equipment
Accelerated, under pressure	17-20	High lycopene activity	High cost
Supercritical CO_2 extraction	17	Solvent-free, product purity	Lower yield, costly equipment
Water extraction	smaller	Eco-friendly approach	Low efficiency without pretreatment

The oil has an intense red-brown color due to natural carotenoids (lycopene, β-carotene), and also contains vitamins E, K, phytosterols, and antioxidants, with a sharp peppery aroma. Tomato seed oil is rich in bioactive compounds, particularly unsaturated fatty acids, antioxidants, and vitamins. Table 4 below shows the typical chemical composition of tomato oil.

Table 4

Chemical composition of tomato oil (Giuffrè et al., 2017)

Component	Content (% of total oil mass)
Linoleic acid (omega-6)	50-60
Oleic acid (omega-9)	20-30
Palmitic acid	10-15
Stearic acid	1-3
Lycopene	0.005-0.02
Phytosterols	0.5-1.5
Tocopherols (vitamin E)	0.05-0.2
Calcium, magnesium, iron	Trace amounts

The high content of linoleic acid makes the oil a valuable source of omega-6 – essential fats for skin, immunity, and metabolism. Tomato oil is characterized by low saturated fat content (less than 20 % overall) and contains antioxidants (lycopene, tocopherols, phytosterols), giving it stability and functional properties. The cake remaining after pressing or extracting tomato seed oil is the main by-product in tomato oil production. It has been reported (Egorov & Malaki, 2014) that after oil extraction, the cake retains high protein content (40–45 %). On this basis, protein paste can be obtained with a composition: protein ≈ 80–85 %, fat ≈ 9–10 %, ash ≈ 2.3–2.5 %. This paste has a spreadable consistency, light gray color, neutral odor and taste, and is used as an ingredient in the production of various food products and canned goods. The development of food products using tomato oil is a promising direction in functional nutrition, since this oil is rich in linoleic acid, antioxidants (lycopene, tocopherols), as well as vitamins A and E. It has a characteristic bright red color and a mild tomato aroma, providing both functionality and an attractive appearance to food products.

The aim of the work was to create a salad dressing with antioxidant properties, without artificial preservatives, based on tomato oil. Such sauces can become an effective component of dietary and preventive diets aimed at supporting the cardiovascular system, reducing oxidative stress and normalizing metabolic processes.

Materials and methods

Methodology. During the study, computational methods were applied. The results were processed using the MC Excel database.

The following recipe components were used for technology development:

– Certified Organic Cold Pressed Tomato Seed Oil. Biopurus – Certified Organic by Soil Association Certification Limited GB-ORG-05, certificate reference DC25977)

– Olive oil extra virgin – DSTU 5065:2008;

– Lemon juice – DSTU 7159:2010 “Canned foods. Reconstituted juices. General technical specifications”;

– Dijon mustard – DSTU 1052:2005 “Edible mustard. General technical specifications”;

– Acacia honey – DSTU 4497:2005 “Natural honey. Technical specifications”;

– Salt – DSTU 3583:2015 “Edible salt. General technical specifications”;

– Fresh garlic – DSTU 3233-95 “Fresh garlic. Technical specifications”;

– Ground black pepper – DSTU ISO 959-1:2008 “Pepper (Piper nigrum L.) whole or ground. Technical specifications”;

– Dried oregano – CXS 342-2021;

– Turmeric (powder) – ISO 5562:1983 “Turmeric whole and ground (powdered). Technical specifications”;

– Drinking water – SanPiN 2.2.4–171–10 and DSTU 7525–2014.

Results and Discussion

During the study, two samples of tomato-based sauce with a high content of antioxidants and linoleic acid were developed. The preparation technology of the dressing involves the following operations, in order:

Preparation of raw materials: Tomato and olive oils are inspected for quality, clarity, and odor. Fresh lemon juice is extracted. Garlic is peeled and crushed. The recipe ingredients are measured according to the formulation (Table 5).

Table 5

Presents the formulation of raw materials per 100 g of finished sauce-dressing product

Ingredient	Control vinaigrette dressing	Sample 1 (g)	Sample 2 (g)	Note
Cold-pressed tomato oil	-	50	30	Source of lycopene (natural antioxidant)
Olive oil (extra virgin)	70	20	40	Omega-9 fatty acids, polyphenols
Fresh lemon juice	15	10	10	Natural preservative, source of vitamin C
Dijon mustard	5	5	5	Natural emulsifier
Acacia honey	3	3	3	Natural sweetener and preservative
Salt	1	1	1	Flavor additive
Fresh garlic	1	1	1	Antimicrobial properties
Ground black pepper	0,5	0,5	0,5	Antioxidant, flavoring
Dried oregano	-	0,5	0,5	Antibacterial, antioxidant
Turmeric powder	-	0,5	0,5	Antioxidant
Purified drinking water	4,5	8,5	8,5	For adjusting consistency
Total (yield)	100	100	100	

Mixing: In a tall container, mix the tomato and olive oils. Add lemon juice, Dijon mustard, and honey – thoroughly whisk or blend with a mixer to form an emulsion. Add spices, crushed garlic, salt, and water. Whip again until a homogeneous consistency is achieved.

Holding: Allow the mixture to infuse in a refrigerator at +4 to +6 °C for at least 12 hours to stabilize the flavor and aroma. Store the dressing in a tightly closed glass or food-grade PET container at a storage temperature of +2 to +6 °C for up to 7 days. Developing new types of sauces using natural ingredients is a promising area in the food industry, focused on creating safe, functional and healthy products. The modifications introduced into the developed dressing formulations (samples 1 and 2) involve the addition of cold-pressed tomato oil, dried oregano and turmeric, which significantly enhance the functional properties of the product. Cold-pressed tomato oil is rich in lycopene (a powerful carotenoid antioxidant) and contains significant quantities of phytosterols and tocopherols. The addition of oregano, which, according to research (Moghrovyan et al., 2019), has a high content of flavonoids and exhibits strong radical-scavenging and metal-chelating activity, enhances the antioxidant component of the formulation. Turmeric, owing to the presence of the active component curcumin, contributes to an overall increase in the antioxidant activity of the product and gives it additional functional value (Jakubczyk et al., 2020). As a result, samples 1 and 2, compared with the control, acquire the characteristics of a functional product with enhanced value, as they contain an expanded spectrum of bioactive components (lycopene, flavonoids, phytosterols, mono- and polyunsaturated fats) that strengthen the antioxidant action.

Samples 1 and 2 demonstrate high stability during storage at +2 – +6 °C for 7 days: thanks to the optimal ratio of oils, water, citric acid and natural emulsifiers (mustard, honey) the product does not stratify and retains a homogeneous consistency. The control has a less balanced structure, which may lead to slight separation of the liquid and fat phases during storage at +2 – +6 °C for 5 days. Thus, samples 1 and 2 ensure prolonged homogeneity and ease of use.

To evaluate the consumer characteristics of the sauce-dressing product samples, organoleptic studies were conducted using a closed

tasting method on a five-point scale. Sample 1 demonstrates clear advantages over the control and sample 2, combining a bright taste and rich aroma with an attractive orange color, which increases its sensory appeal. The light texture ensures convenience in use.

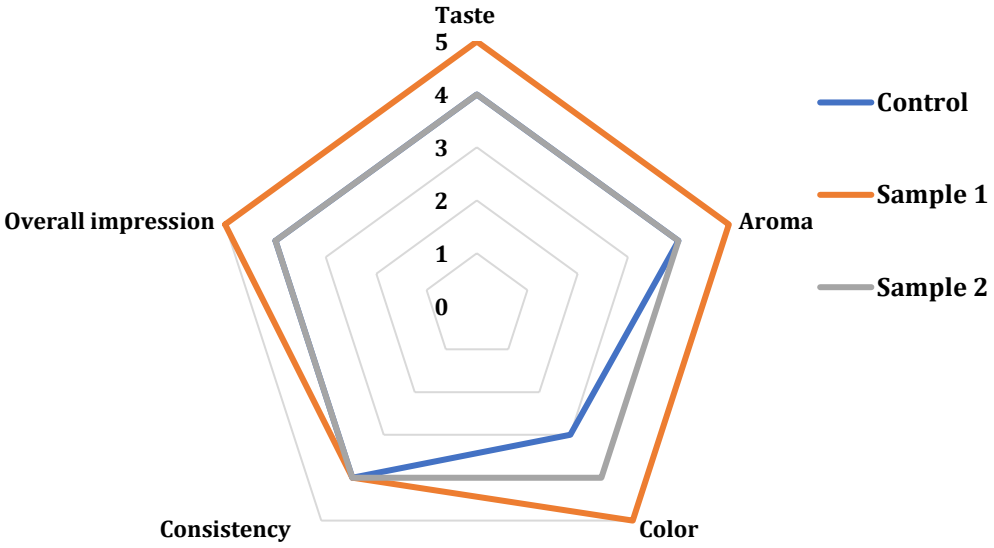

Fig. 1. Organoleptic indicators of experimental samples

In the developed dressing (sample 1) the enhancement of the antioxidant profile due to the introduction of specially selected components is particularly evident. In addition to tocopherols, sample 1 has increased amounts of lycopene, quercetin, rutin and flavonoids, providing a broader spectrum of action on the organism (Table 6). Lycopene from tomato oil is a powerful carotenoid antioxidant capable of effectively neutralizing free radicals, protecting lipids from oxidation and contributing to the maintenance of cardiovascular health (Imran et al., 2020). In addition to lemon juice and garlic, which are sources of vitamin C and allicin, the addition of spices in the developed dressings – oregano and turmeric – ensures substantial enrichment of the product with flavonoids and polyunsaturated antioxidant compounds. Although the amount of tocopherols in sample 1 is lower than in the control, the advantage of sample 1 in the variety of antioxidants makes it more innovative and functional.

Table 6

Antioxidant content (per 100 g of sauce dressing)

Antioxidant Compound	Control	Sample 1
Tocopherols	≈ 17,6 мг	≈ 5,0 мг
Lycopene	≈ 0 мг	≈ 20,0 мг
Quercetin	≈ 0,1 мг	≈ 7,0 мг
Rutin	≈ 0,1 мг	≈ 2,0 мг
Total flavonoids	≈ 5-11 мг	≈ 15-25 мг

Table 7

The fatty acid composition of the dressing per 100 g

Fatty Acid Type	Control	Sample 1
Oleic (omega-9)	47 g	25g
Linoleic (omega-6)	4,9 g	29 g
Linolenic (omega-3)	0,6 g	1,2 g

Table 8

The analysis of the dressing's fatty acid profile

Fatty Acid	Control	Sample 1	Comment
Linoleic (C18:2, ω-6)	7,13 %	42,3%	Main polyunsaturated fat; important for growth and regulation of inflammation. At high levels, omega-6/omega-3 balance should be controlled.
Oleic (C18:1, ω-9)	72 %	36,5%	Monounsaturated fat; lowers «bad» cholesterol and supports heart health.
Palmitic (C16:0)	12 %	16,0%	Saturated fat; normal in moderate amounts, but excess may influence cardiovascular risk.
Stearic (C18:0)	3,18 %	3,5%	Saturated fat; less harmful than other saturated fats; can serve as an energy source.
Linolenic (C18:3, ω-3)	0,6 %	1,7%	Omega-3 fat; beneficial for brain and heart; reduces inflammation. Content is low, so it is recommended to balance with other omega-3 sources.
Total MUFA	72 %	36,5%	
Total PUFA	7,73 %	44%	

The dressing Sample 1 and control has a healthy fatty acid profile, with over 80 % of its fatty acids being unsaturated. This is one of the key nutritional indicators of the quality of the product's fat component. An additional advantage of sample 1 compared with the control is the key components of the fatty acid profile:

– A higher proportion of polyunsaturated fatty acids (PUFA) – in sample 1 PUFA are 44 % versus 7.73 % in the control.

– A higher content of linolenic acid (ω-3) – in sample 1 ≈ 1.7 % versus ≈ 0.6 % in the control.

Linoleic acid (omega-6 42,4%): The dominant fatty acid, constituting the main portion of the composition. Its high concentration is characteristic of tomato oil, which is the base ingredient of the dressing. This acid is essential for immune function, cell growth, and regulation of inflammation (Johnson & Fritsche, 2012).

– Oleic acid (omega-9): Provided primarily by olive oil, it has a well-balanced content. It supports the health of the cardiovascular system, promotes reduction of "bad" cholesterol levels, and reduces the risk of heart disease (Lopez-Huertas, 2010; Sales-Campos et al., 2012).

– Saturated fatty acids (palmitic and stearic): Together they make up about 12.8% of the total fat profile, which is an acceptable level for products based on vegetable oils.

The high content of unsaturated fatty acids (> 80,5%), including omega-6 and omega-9, makes the dressing suitable for daily consumption (Johnson & Fritsche, 2012). Oleic acid (omega-9) has an anti-atherosclerotic effect and positively affects the blood lipid profile. The high content of linoleic acid has a positive effect on the skin, immune system, and metabolic processes (Sales-Campos et al., 2012).

The ratio of omega-6 to omega-3 in the dressing is high (24:1), while 4:1 is considered optimal. The MUFA/SFA ratio is 1,87, which shows the dominance of monounsaturated fats (MUFA – mainly oleic acid from olive oil) over saturated fats. The higher the MUFA/SFA ratio, the healthier the fat profile (>1,5 is considered optimal). The PUFA/SFA ratio of 2,25 indicates a high proportion of polyunsaturated fats (ω 6 + ω 3) compared to saturated fats. PUFAs (especially ω3) have a cardioprotective effect, reduce the risk of atherosclerosis, and help lower triglycerides. Normative significance: PUFA/SFA > 1 is a sign of a healthy lipid profile (Siqi Luo et al., 2024).

The total proportion of unsaturated fats is 80,5%. This is an excellent indicator, since most of the fats in the recipe are unsaturated.

Below are calculations of functional ingredients per 100 g of sauce dressing according to the recipe in the process chart, using average data from scientific sources (Szabo et al., 2021; Skoczylas et al., 2023; Mazzocchi et al., 2019; Lorente et al., 2014; Czipa et al., 2019).

Table 9

The nutritional composition per 100 g of the sauce-dressing

Parameter	Value
Caloric content	645 kcal
Fats	70,6 g
Carbohydrates	5,5 g
Proteins	0,7 g

The dressing stands out for its high content of key micronutrients, specifically vitamin E, potassium, and magnesium, which play an important role in supporting the cardiovascular system, normalizing blood pressure, and overall strengthening of the body. Vitamin C, a powerful antioxidant, is preserved in the dressing thanks to the use of natural lemon juice and fresh garlic, which ensure the stability of this sensitive vitamin.

Table 10

The content of vitamins and minerals per 100 g of dressing

Nutrient (Vitamins)	Amount	Nutrient (Minerals)	Amount
Vitamin E	39,6 mg	Potassium (K)	619,9 mg
Vitamin K	8,8 µg	Magnesium (Mg)	119,1 mg
Vitamin C	7,0, mg	Sodium (Na)	387,3 mg
Vitamin B_1	0,006 mg	Iron (Fe)	6,7 mg
Vitamin B_2	0,0003 mg	–	–
Vitamin B_3	0,045 mg	–	–
Vitamin B_6	0127 mg	–	–

Thanks to the content of vitamins E and C, as well as lycopene – a natural pigment with powerful antioxidant activity – the dressing can be considered a complete source of antioxidants. These compounds help neutralize free radicals, slowing the aging process, reducing the risk of inflammation, and supporting cell health.

Particularly noteworthy is that all micronutrients in the dressing are naturally derived – there are no synthetic additives or artificial enhancers.

Conclusions

The rational use of secondary plant raw materials is an important strategy for ensuring the sustainable development of the agro-industrial sector. Processing by-products – in particular, tomato pomace – not only helps reduce the environmental burden but also yields valuable functional ingredients for the food and pharmaceutical industries.

Tomato pomace is a source of proteins, fats, dietary fibers, vitamins, minerals, antioxidants (lycopene, β-carotene, tocopherols), phytonutrients, and biologically active compounds (glycosides, flavonoids) that have a broad spectrum of biological activities: antioxidant, anti-inflammatory, antitumor, cardioprotective, hepatoprotective, photoprotective, and more.

Technological processing of tomato raw materials makes it possible to produce food ingredients with emulsifying, stabilizing, and antioxidant properties. In particular, protein–tomato paste and tomato-oil extract are successfully used in bakery, meat, and sauce products as substitutes for synthetic additives. The most valuable by-product is tomato seeds, which are a source of oil rich in linoleic and oleic acids, phospholipids, tocopherols, carotenoids, and phytosterols. Various extraction methods allow the technological process to be adapted to the desired chemical composition and functional purpose of the product.

The functional components of tomato by-products have potential for creating dietary supplements, nutraceuticals, natural preservatives, antioxidants, and even pharmaceuticals. They can improve the quality of food products, increase their nutritional value, and

contribute to the prevention of a wide range of diseases.

Utilizing secondary tomato raw materials in production not only makes economically efficient use of agro-industrial waste but also enables the development of innovative, high-value-added products with pronounced health benefits. This approach aligns with current trends in functional nutrition.

As a result of this research, a salad dressing based on tomato and olive oils was successfully developed. It is characterized by a high content of natural antioxidants (lycopene, tocopherols, vitamin C), unsaturated fatty acids (linoleic and oleic), and a comprehensive vitamin-mineral complex. The proposed product contains no artificial preservatives, and all its functional components are of natural origin.

The developed dressing has an attractive appearance, a bright color, a characteristic aroma, and balanced organoleptic properties. Due to its high content of monounsaturated and polyunsaturated fatty acids (>80%), the dressing positively affects cardiovascular health, the regulation of inflammatory processes, and metabolic activity.

The nutritional composition of the dressing confirms its functionality: it is a source of vitamins E, K, C, B_6, potassium, magnesium, iron, and bioflavonoids (quercetin, rutin), which contribute to the body's antioxidant defense.

Thus, the created salad dressing can be recommended as part of functional nutrition for daily consumption, especially for individuals seeking to maintain their health, support antioxidant balance, and avoid artificial additives in their diet.

Фінансування / Funding

Це дослідження не отримало зовнішнього фінансування / This research received no external funding.

Заява про доступність даних / Data Availability Statement

Набір даних доступний за запитом до авторів/ Dataset available on request from the authors.

Заява інституційної ревізійної ради / Institutional Review Board Statement

Усі процедури, пов'язані з сенсорним тестуванням, проводилися відповідно до етичних норм та були схвалені на засіданні кафедри харчових технологій хімічного факультету Дніпровського національного університету імені Олеся Гончара (протокол №1 від 27.08.25) / All procedures related to sensory testing were carried out in accordance with ethical standards and were approved at the meeting of the Department of Food Technologies, Faculty of Chemistry, Oles Honchar Dnipro National University (Protocol No. 1 dated August 27, 2025).

Заява про інформовану згоду / Informed Consent Statement

Усі учасники сенсорного тестування надали усну інформовану згоду на участь у дослідженні. Дані знеособлені та представлені в узагальненому вигляді без можливості ідентифікації особистості / All participants in the sensory evaluation provided verbal informed consent prior to participation. The data were anonymized and are presented in an aggregated form without the possibility of individual identification.

Конфлікт інтересів / Conflict of interest

Автори заявляють про відсутність конфлікту інтересів / The authors declare no conflict of interest.

Декларація про генеративний штучний інтелект і технології на основі штучного інтелекту в процесі написання / Declaration on Generative Artificial Intelligence and AI-enabled Technologies in the Writing Process

Автори використовували інструменти генеративного штучного інтелекту (ChatGPT, OpenAI) лише для покращення мови та граматики статті. Науковий зміст, дизайн дослідження, інтерпретація даних та висновки були повністю розроблені авторами без

генерації змісту за допомогою ШІ. Після використання цього інструменту автори ретельно переглянули та відредагували вміст і несуть повну відповідальність за остаточну опубліковану версію/ The authors used generative AI-based tools (ChatGPT, OpenAI) to improve the language and grammar of the article. The scientific content, study design, data interpretation, and conclusions were entirely developed by the authors without the generation of content by AI. After using this tool, the authors carefully reviewed and edited the content and takes full responsibility for the final published version.

References

Bacanli, M., Başaran, N., & Başaran, A. A. (2017). Lycopene: is it beneficial to human health as an antioxidant? *Turk J. Pharm Sci*, *14*(3), 311-318. https://doi.org/10.4274/tjps.43043

Benderska, O., Bessarab, A., Iegorov, B., Kashkano, M., & Shutyuk, V. (2021). Biological value of by-products of tomato processing. *Food Science and Technology, 15*(1). https://doi.org/10.15673/fst.v15i1.1972

Czipa, N., Phillips, C. J. C., & Kovács, B. (2019). Composition of acacia honeys following processing, storage and adulteration. *Journal of Food Science and Technology*, *56*, 1245-1255. https://doi.org/10.1007/s13197-019-03587-y

Egorov, B. V., & Malaki, I. S. (2014). Effect of heat treatment on quality of feed additive using tomato pomace. *East European. Journal of Corporate Technologies,. 4*(10(70), 48-53. https://doi.org/10.15587/1729-4061.2014.26229

Gasimova, A. A. (2024). Obtaining biologikally active additives from secondary raw material of the wine industry. *Chemistry of plant raw material*, *2*, 385-393. https://doi.org/10.14258/jcprm.20240213470

Giuffrè, A. M., Zappia, C., & Capocasale M. (2017). Tomato seed oil: a comparison of extraction systems and solvents on its biodiesel and edible properties. *La Rivista Italiana delle Sostanze Grasse*, *94*(3), 149-160. https://www.researchgate.net/publication/319623801_Tomato_seed_oil_a_comparison_of_extraction_systems_and_solvents_on_its_biodiesel_and_edible_properties

Imran, M., Ghorat, F., Ul-Haq, I., Ur-Rehman, H., Aslam, F., Heydari, M., Shariati, M. A., Okuskhanova, E., Yessimbekov, Z., Thiruvengadam, M., Hashempur, M. H., & Rebezov, M. (2020). Lycopene as a Natural Antioxidant Used to Prevent Human Health Disorders. *Antioxidants*, *9*(8). https://doi.org/10.3390/antiox9080706

Jakubczyk, K., Drużga, A., Katarzyna, J., & Skonieczna-Żydecka, K. (2020). Antioxidant Potential of Curcumin–A Meta-Analysis of Randomized Clinical Trials. Antioxidants, 9(11). https://doi.org/10.3390/antiox9111092

Johnson, G.H., & Fritsche, K. (2012). Effect of dietary linoleic acid on markers of inflammation in healthy persons: a systematic review of randomized controlled trials. *Journal of the Academy of Nutrition and Dietetics*, *112*(7), 1029-1041. https://doi.org/10.1016/j.jand.2012.03.029

Kaloo, I., Habeeb, F., Akhter, N., Fayaz, I., Dar, B. N., & Makroo H. A. (2025). Tomato waste: chemistry, processing and utilization. In K. Muzaffar, S. A. Sofi, & S. A. Mir (Eds.), *Handbook of vegetable processing waste* (pp. 249-276). https://doi.org/10.1201/9781003269328

Kartushina, Yu. N., Nefedieva, E. E., Sevriukova, G. A., Gracheva, N. V., & Zheltobryukhov, V. F. (2017). Technological desition of extraction of melanin from the waste of production of sunflower-seed oil. *IOP Conf. Series: Earth and Environmental Science*, *66*. https://doi.org/10.1088/1755-1315/66/1/012014

Kołodziejczyk, K., Markowski, J., Kosmala, M., Król, B., & Płocharski, W. (2007). Apple pomace as a potential source of nutraceutical products. *Polish journal of food and nutrition sciences, 57*(4(B)), 291-295. https://journal.pan.olsztyn.pl/pdf-98826-30829?filename=30829.pdf

Kumar, M., Chandran, D., Tomar, M., Bhuyan, D. J., Grasso, S., Sá, A. G. A., Carciofi, B. A. M., Radha, Dhumal, S., Singh, S., Senapathy, M., Changan, S., Dey, A., Pandiselvam, R., Mahato, D. K., Amarowicz, R., Rajalingam, S., Vishvanathan, M., Saleena, L. A. K., & Mekhemar, M. (2022). Valorization potential of tomato (Solanum lycopersicum L.) seed: nutraceutical quality, food properties, safety aspects, and application as a health-promoting ingredient in foods. *Horticulturae*, *8*(3). https://doi.org/10.3390/horticulturae8030265

Levkivska, T. M., Benderska, O. V., & Matko S. V. (2021). The pumpkin dry filler production technology for confectionery industry. *Herald of LUTE. Technical sciences*, *26*, 39-45. https://doi.org/10.36477/2522-1221-2021-26-05 (in Ukrainian).

Левківська Т.М., Бендерська О.В., Матко С.В. Технологія виробництва сухого наповнювача з гарбуза для кондитерської промисловості. *Вісник ЛТЕУ. Технічні науки*. 2021. №26. С. 39-45. DOI: 10.36477/2522-1221-2021-26-05

Lorente, J., Vegara, S., Martí, N., Ibarz, A., Coll, L., Hernández, J., Valero, M., & Saura, D. (2014). Chemical guide parameters for Spanish lemon (Citrus limon (L.) Burm.) juices. *Food Chemistry, 162*, 186-191. https://doi.org/10.1016/j.foodchem.2014.04.042

Lopez-Huertas, E. (2010). Health effects of oleic acid and long chain omega-3 fatty acids (EPA and DHA) enriched milks: A review of intervention studies. *Pharmacological Research*, *61*(3), 200-207. https://doi.org/10.1016/j.phrs.2009.10.007

Maldonado-Torres, R., Morales-Camacho, J. I., López-Valdez, F., Huerta-González, L., & Luna-Suárez, S. (2020). Assessment of techno-functional and nutraceutical potential of tomato (Solanum lycopersicum) seed meal. *Molecules*, *25*(18). https://doi.org/10.3390/molecules25184235

Mazzocchi, A., Leone, L., Agostoni, C., & Pali-Schöll, I. (2019). The secrets of the mediterranean diet. Does [only] olive oil matter? *Nutrients*, *11*(12). https://doi.org/10.3390/nu11122941

Meghwar, P., Ghufran Saeed, S. M., Ullah, A., Nikolakakis, E., Panagopoulou, E., Tsoupras, A., Smaoui, S., & Khaneghah, A. (2024). Nutritional benefits of bioactive compounds from watermelon: A comprehensive review. *Food Bioscience*, *61*. https://doi.org/10.1016/j.fbio.2024.104609

Moghrovyan, A., Sahakyan, N., Babayan, A., Chichoyan, N., Petrosyan, M., & Trchounian, A. (2019). Essential Oil and Ethanol Extract of Oregano (Origanum vulgare L.) from Armenian Flora as a Natural Source of Terpenes, Flavonoids and other Phytochemicals with Antiradical, Antioxidant, Metal Chelating, Tyrosinase Inhibitory and Antibacterial Activity. *Current Pharmaceutical Design*, 25 (16), 1809-1816. https://doi.org/10.2174/1381612825666190702095612

Nakov, G., Brandolini, A., Estivi, L., Bertuglia, K., Ivanova, N., Jukić, M., Komlenić, D. K., Lukinac, J., & Hidalgo, A. (2022). Effect of tomato pomace addition on chemical, technological, nutritional, and sensorial properties of cream crackers. *Antioxidants*, *11*(11). https://doi.org/10.3390/antiox11112087

Ni Li, Xiaoting Wu, Wen Zhuang, Lin Xia , Yi Chen, Chuncheng Wu, Zhiyong Rao, Liang Du, Rui Zhao, Mengshi Yi, Qianyi Wan, & Yong Zhou. (2020). Tomato and lycopene and multiple health outcomes: Umbrella review. *Food Chemistry*, *343*. https://doi.org/10.1016/j.foodchem.2020.128396

Pavlović, N. V., Zdravković, M., Mladenović, J., Štrbanović, R., & Zdravković, J. (2020). Analysis of fresh and processed carrots and beets from organic and conventional production for the content of nutrients and antioxidant activity. *Acta Agriculturae Serbica*, *25*(50), 171-177. https://doi.org/10.5937/AASer2050171P

Sales-Campos, H., Souza, P.R, Peghini, B.C, da Silva, J.S., & Cardoso, C.R. (2012). An overview of the modulatory effects of oleic acid in health and disease. *Mini-Reviews in Medicinal Chemistry*, *13*(2). https://doi.org/10.2174/1389557511313020003

Shafe, M.O., Gumede, N. M., Nyakudya, T. T., & Chivandi, E. (2024). Lycopene: a potent antioxidant with multiple health benefits*. Journal of Nutrition and Metabolism, 1.* https://doi.org/10.1155/2024/6252426

Silva, A. N. A., Nunes, G. P., Aparecido de Paula Domingues, D. V., Alves De Toledo, P. T., Akinsomisoye, O. S., Florencio-Silva, R., & Cerri, P. S. (2025). Effects of lycopene supplementation on bone tissue: a systematic review of clinical and preclinical evidence. *Pharmaceuticals (Basel), 18*(8). https://doi.org/10.3390/ph18081172

Siqi Luo, Hongmei Hou, Yongjin Wang, Yun Li, Le Zhang, Zhang Hui, Qingzhe Jin, Gangcheng Wu, & Xingguo Wang (2024). Effects of omega-3, omega-6, and total dietary polyunsaturated fatty acid supplementation in patients with atherosclerotic cardiovascular disease: A systematic review and meta-analysis. *Food & Function, 15*(3), 1208-1222. https://doi.org/10.1039/D3FO02522E

Skoczylas, J., Jędrszczyk, E., Dziadek, K., Dacewicz, E., & Kopeć, A. (2023). Basic chemical composition, antioxidant activity and selected polyphenolic compounds profile in garlic leaves and bulbs collected at various stages of development. *Molecules*, *28*(18). https://doi.org/10.3390/molecules28186653

Svelander, C. A., Tibäck, E.A., Ahrné, L. M., Langton, M., Svanberg, U., & Alminger, M. (2010). Processing of tomato: impact on in vitro bioaccessibility of lycopene and textural properties. *Journal of the Science of Food and Agriculture, 90*(10), 1665-1672. https://doi.org/10.1002/jsfa.4000

Szabo, K., Dulf, F. V., Teleky, B.-E., Eleni, P., Boukouvalas, C., Krokida, M., Kapsalis, N., Rusu, A. V., Socol, C. T., & Vodnar, D. C. (2021). Evaluation of the bioactive compounds found in tomato seed oil and tomato peels influenced by industrial heat treatments. *Foods*, *10*(1). https://doi.org/10.3390/foods10010110

Yuneri, D. R., & Syarifuddin, A. (2024). Cocoa bean shell by-products as potential ingredients for functional food and beverage – a review. *BIO Web of Conferences, 96*. https://doi.org/10.1051/bioconf/20249601006

Received: 09.10.2025. **Accepted:** 10.11.2025. **Published:** 16.12.2025.

Ви можете цитувати цю статтю так:

Chernushenko E., Novik A., Khrychov S., Savchenko A. Functional potential of secondary tomato raw materials: development of an antioxidant dressing for healthy nutrition. *Biota. Human. Technology*. 2025. № 3. С. 193–206. DOI: https://doi.org/10.58407/bht.3.25.18

Cite this article in APA style as:

Chernushenko, E., Novik, A., Khrychov, S., & Savchenko, A. (2025). Functional potential of secondary tomato raw materials: development of an antioxidant dressing for healthy nutrition. *Biota. Human. Technology*, (3), 193–206. https://doi.org/10.58407/bht.3.25.18

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