Study on the Biochemical Composition of Defatted Residues Derived from Grape Seeds in the Winemaking Industry

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Abstract. The present research focuses on the efficient utilization and recycling of waste materials generated within the winemaking industry. The main objec-tive of the study was to investigate the biochemical composition of defatted residues obtained after oil extraction from grape seeds and to assess their potential applications in the food industry and animal husbandry.
Comprehensive biochemical analyses were carried out to determine the contents of moisture, ash, oilness, crude protein, indigestible fiber, nitrogen and nitrogenous compounds, dry matter, as well as macroelements such as Ca, K, Mg, P, and S, and microelements including As, Al, B, Ba, Co, Cr, Cu, Fe, Mn, Na, Ni, Pb, Sr, and Zn. According to the analysis results, the moisture content of the defatted residues was 8.7%, determined in accordance with GOST 13586.5-2015. The oilness content varied from 5.19 to 6.0 g/100 g (GOST 27670-88). The dry protein content was 9.0–14.0 g/100 g (GOST 10846-91), crude fiber ranged from 40–42%. Moisture content ranged between 6.02–11.42%, ash be-tween 1.98–3.26%, oilness 0.82–1.12%, crude protein 7.86–9.92%, and total indigestible fiber ranged from 67–81%. Dry matter content was rec-orded between 52.8–68.4%, while the concentrations of macro- and micro-elements also fluctuated depending on variety and growing conditions. The findings demonstrate that the defatted residues are rich in biologically active compounds and possess substantial potential for use as additives in the food industry and as supplements in animal feed. This study contributes to the development of sustainable winemaking practices and the rational utilization of grape processing by-products in Azerbaijan.

Keywords: grape varieties, rainfed condition, irrigated condition, biochemical indicators.

R. Rzayev et al. (eds.), *Proceedings of the International Conference on Current Problems in Engineering and Applied Sciences (ICCPEAS 2025)*, Advances in Engineering Research 299,
https://doi.org/10.2991/978-94-6239-668-5_82

1. Introduction

The defatted residue of grape seeds refers to the remaining grape seed particles obtained after the cold pressing stage of grape seed oil extraction. The residue is released from the oil press in a coiled form, measuring 100–400 mm in length and 8–10 mm in diameter [1]. The defatted residue serves as a raw material for the extraction of residual grape seed oil (up to 6.0%) and the complex of grape polyphenols that do not pass into the oil during cold pressing. It is also recognized as a carrier of valuable grape polyphenols. These polyphenols include both flavonoid and non-flavonoid monomers and their derivatives, such as caffeic acid, malvidin, quercetin, peonidin, cyanidin, petunidin, protocatechuic acid, chlorogenic acid, rutin, (−)-epicatechin, (+)-catechin, (−)-epicatechin gallate, delphinidin, syringic acid, gallic acid, and trans-resveratrol [2-5].
It should be noted that the defatted residue is rich in minerals — one kilogram contains 4.4–4.6 g of calcium, which is approximately 10 times higher than that of corn grain and 6 times higher than that of barley grain. The phosphorus content is approximately at the same level, while microelements such as zinc, cobalt, iron, copper, and manganese are more abundant in the residue. In addition, the defatted residue contains vitamin C, thiamine, riboflavin, choline, and nicotinic acid [6,7].
The defatted grape seed residue can be used as a food additive or as a fortifying ingredient in foods such as bakery products. Defatted grape seed flour can be utilized for both human and animal consumption, as it is a source of functional macro- and microelements that contribute to maintaining optimal health and well-being [8].
The aim of the study is to determine the biochemical indicators composition of oils obtained by cold pressing from the seeds of three different grape varieties grown under irrigated and rainfed conditions, which were thoroughly analyzed and found to be rich in biologically active compounds, as well as to investigate the biochemical properties of the defatted residues remaining after oil extraction.
The grape seeds of the varieties Madrasa, Moldova, and Shamakhi Marandi used as research materials were separated from the residues during grape processing. The seeds were first dried in an open area exposed to sunlight for 7–10 days and subsequently dried under shade conditions for 15–20 days. The dried seeds were then subjected to cold pressing using a screw press device (“Kochmaksan, Type – IRFM 53/90 L 4a”), and the biochemical indicators composition of the extracted oils was determined by İSP deviceThe determination of biochemical compounds in the defatted residues was carried out using an ISP device [9]. The aim of this study is to evaluate the potential nutritional value of the grape varieties.
During the study, several parameters such as taste, aroma, and color of the defatted residues were evaluated through organoleptic analyses. The obtained defatted residues were light brown in color, with taste and aroma characteristic of grape seed residues. The moisture content of defatted residues was 8.7% according to GOST 13586.5-2015, oilness content 5.19–6.0 g/100 g according to GOST 27670-88, crude protein 9.0–14.0 g/100 g according to GOST 10846-91, crude fiber 40–42%.
In order to investigate the biochemical properties of the defatted residue obtained after oil extraction from grape seeds, a series of research studies were conducted [Table I]. The objects of the study were the defatted residues obtained from the seeds of the grape

varieties Madrasa, Moldova, and Shamakhi Marandisi grown under rainfed and irrigated conditions. During the study, the contents of moisture, ash, oilness, crude protein, indigestible total fiber (cellulose, hemicellulose, lignin), nitrogen (% N), nitrogenous compounds, dry matter, and mineral elements such as Ca, K, Mg, P, S, As, Al, B, Ba, Co, Cr, Cu, Fe, Mn, Na, Ni, Pb, Sr, and Zn in the defatted residues were determined. It was found that the chemical composition of the defatted residues varies to different extents depending on both the grape variety and the growing conditions.

2. Results and Dicussion

2.1. Study of the proximate composition of defatted residues

Thus, in the defatted residue, one of the most important parameters—moisture content varied within the range of 6.02–11.42% across the studied samples. The highest moisture content was recorded in the Madrasa (11.42%) and Moldova (10.8%) varieties grown under irrigated conditions. Relatively lower moisture levels were observed in the Moldova (6.02%), Shamakhi Marandisi (6.08%), and Madrasa (7.04%) varieties grown under rainfed conditions, and even in the irrigated Shamakhi Marandisi variety, where the moisture content reached 9.3%.

During the study of the biochemical composition of the defatted residue, the ash content was also determined. It was found that the ash content in the defatted residues of the varieties grown under both rainfed and irrigated conditions ranged from 1.98% to 3.26%. The highest ash content was observed in Shamakhi Marandisi (3.26%) and Moldova (3.12%) varieties grown under irrigated conditions, while relatively lower values were recorded in Shamakhi Marandisi (1.98%), Madrasa (2.11%), and Moldova (2.66%) grown under rainfed conditions. In addition, the ash content of the irrigated Madrasa variety was 3.04%.

Analysis of the oilness content in the defatted residues showed that this parameter varied within the range of 0.82–1.12%. The highest values were observed in Madrasa (1.12%) and Moldova (1.06%) grown under irrigated conditions, while the lowest oilness content was found in Shamakhi Marandisi (0.82%), Madrasa (0.92%), and Moldova (0.92%) grown under rainfed conditions, as well as in Shamakhi Marandisi (0.98%) grown under irrigated conditions.

Investigation of the crude protein content in the defatted residue revealed that this parameter ranged from 7.86% to 9.92%. The highest crude protein content was observed in the Madrasa (9.92%) and Moldova (9.06%) varieties grown under irrigated conditions, while the lowest values were recorded in Moldova (7.86%) and Shamakhi Marandisi (7.88%) grown under rainfed conditions, as well as in Shamakhi Marandisi (7.92%) grown under irrigated conditions. Additionally, the crude protein content of the Madrasa variety grown under rainfed conditions was 9.03%.

It should be noted that during the study of the biochemical composition of the defatted residue, the content of indigestible total fiber (cellulose, hemicellulose, lignin) was also investigated. It was found that this parameter ranged from 67% to 81%. The highest fiber content was observed in Shamakhi Marandisi (80–81%) and Madrasa (76–82%) varieties grown under rainfed conditions, while relatively lower values were recorded in Moldova (67–71%) and Madrasa (69–74%) grown under irrigated conditions, as well as in Shamakhi Marandisi (76–79%) grown under irrigated conditions, and in Moldova (76–78%) grown under rainfed conditions.

The nitrogen (N) content in the defatted residue was determined to range from 1.08% to 1.54%. The highest nitrogen content was found in Shamakhi Marandisi (1.54%) and Moldova (1.46%) grown under irrigated conditions, while relatively lower values were observed in Shamakhi Marandisi (1.08%), Madrasa (1.12%), and Moldova (1.42%) grown under rainfed conditions, as well as in Madrasa (1.22%) grown under irrigated conditions. Furthermore, the content of nitrogenous compounds varied between 5.4% and 7.8%, with the highest levels recorded in Shamakhi Marandisi (7.8%) and Moldova (6.8%) grown under irrigated conditions. The lowest values were found in Shamakhi Marandisi (5.4%), Madrasa (6.2%), and Moldova (6.2%) grown under rainfed conditions, as well as in Madrasa (5.8%) grown under irrigated conditions.

It was found that the dry matter content of the defatted residue ranged from 52.8% to 68.4%, with the highest values observed in Shamakhi Marandisi (68.4%) and Moldova (65.4%) grown under irrigated conditions. Relatively lower dry matter contents were recorded in Shamakhi Marandisi (52.8%), Madrasa (57.4%), and Moldova (58.8%) grown under rainfed conditions, as well as in Madrasa (62.6%) grown under irrigated conditions.

Relatively lower moisture levels were observed in the Moldova (6.02%), Shamakhi Marandisi (6.08%), and Madrasa (7.04%) varieties grown under rainfed conditions, and even in the irrigated Shamakhi Marandisi variety, where the moisture content reached 9.3%.

During the study of the biochemical composition of the defatted residue, the ash content was also determined. It was found that the ash content in the defatted residues of the varieties grown under both rainfed and irrigated conditions ranged from 1.98% to 3.26%. The highest ash content was observed in Shamakhi Marandisi (3.26%) and Moldova (3.12%) varieties grown under irrigated conditions, while relatively lower values were recorded in Shamakhi Marandisi (1.98%), Madrasa (2.11%), and Moldova (2.66%) grown under rainfed conditions. In addition, the ash content of the irrigated Madrasa variety was 3.04%.

Analysis of the oilness content in the defatted residues showed that this parameter varied within the range of 0.82–1.12%. The highest values were observed in Madrasa (1.12%) and Moldova (1.06%) grown under irrigated conditions, while the lowest oilness content was found in Shamakhi Marandisi (0.82%), Madrasa (0.92%), and Moldova (0.92%) grown under rainfed conditions, as well as in Shamakhi Marandisi (0.98%) grown under irrigated conditions.

Investigation of the crude protein content in the defatted residue revealed that this parameter ranged from 7.86% to 9.92%. The highest crude protein content was observed in the Madrasa (9.92%) and Moldova (9.06%) varieties grown under irrigated conditions, while the lowest values were recorded in Moldova (7.86%) and Shamakhi Marandisi (7.88%) grown under rainfed conditions, as well as in Shamakhi Marandisi (7.92%) grown under irrigated conditions. Additionally, the crude protein content of the Madrasa variety grown under rainfed conditions was 9.03%.

It should be noted that during the study of the biochemical composition of the defatted residue, the content of indigestible total fiber (cellulose, hemicellulose, lignin) was also investigated. It was found that this parameter ranged from 67% to 81%. The highest fiber content was observed in Shamakhi Marandisi (80–81%) and Madrasa (76–82%) varieties grown under rainfed conditions, while relatively lower values were recorded in Moldova (67–71%) and Madrasa (69–74%) grown under irrigated conditions, as well as in Shamakhi Marandisi (76–79%) grown under irrigated conditions, and in Moldova (76–78%) grown under rainfed conditions.

The nitrogen (N) content in the defatted residue was determined to range from 1.08% to 1.54%. The highest nitrogen content was found in Shamakhi Marandisi (1.54%) and Moldova (1.46%) grown under irrigated conditions, while relatively lower values were observed in Shamakhi Marandisi (1.08%), Madrasa (1.12%), and Moldova (1.42%) grown under rainfed conditions, as well as in Madrasa (1.22%) grown under irrigated conditions. Furthermore, the content of nitrogenous compounds varied between 5.4% and 7.8%, with the highest levels recorded in Shamakhi Marandisi (7.8%) and Moldova (6.8%) grown under irrigated conditions. The lowest values were found in Shamakhi Marandisi (5.4%), Madrasa (6.2%), and Moldova (6.2%) grown under rainfed conditions, as well as in Madrasa (5.8%) grown under irrigated conditions.

It was found that the dry matter content of the defatted residue ranged from 52.8% to 68.4%, with the highest values observed in Shamakhi Marandisi (68.4%) and Moldova (65.4%) grown under irrigated conditions. Relatively lower dry matter contents were recorded in Shamakhi Marandisi (52.8%), Madrasa (57.4%), and Moldova (58.8%) grown under rainfed conditions, as well as in Madrasa (62.6%) grown under irrigated conditions.

2.2. Study of the mineral composition of defatted residues

During the biochemical analyses, the calcium (Ca) content was determined to vary between 21.4% and 25.6%. The highest calcium levels were recorded in Madrasa grown under both irrigated (25.6%) and rainfed (28.5%) conditions, while the lowest values were observed in Shamakhi Marandisi (21.4%) and Moldova (22.8%) grown under rainfed conditions, as well as in Shamakhi Marandisi (23.8%) and Moldova (24.4%) grown under irrigated conditions.

The potassium (K) content in the defatted residue was determined to range from 28.6% to 38.8%. The highest potassium levels were observed in the varieties grown under irrigated conditions, specifically Moldova and Shamakhi Marandisi, with values of 34.4–38.8%. Relatively lower potassium contents were recorded in Madrasa grown under both rainfed and irrigated conditions (28.6–29.32%), as well as in Shamakhi Marandisi (32.0%) and Moldova (32.4%) grown under rainfed conditions.

In addition, the magnesium (Mg) content of the defatted residue was analyzed and found to vary between 9.4% and 16.35%. The highest magnesium content was observed in Madrasa grown under both irrigated and rainfed conditions (16.32–16.35%), while relatively lower values were recorded in Shamakhi Marandisi (9.4–9.8%) grown under both conditions, and in Moldova (14.8–16.4%).

During the biochemical analysis of the defatted residue, the phosphorus (P) content was found to be highest in Shamakhi Marandisi grown under both irrigated and rainfed conditions (26.8–27.8%), and lowest in Moldova (5.46–9.90%) and Madrasa (5.86–6.45%) grown under both conditions.

The sulfur (S) content varied from 3.38% to 9.65%, with the highest levels observed in Madrasa (9.65%) and Moldova (8.54%) grown under irrigated conditions.

The arsenic (As) content ranged from 0.12% to 0.56%, while barium (Ba) ranged from 0.98% to 7.92%.

Aluminum (Al) content varied between 1.08% and 11.2%, with the lowest levels recorded in Moldova (1.08–3.66%) and Shamakhi Marandisi (2.06–2.23%) grown under rainfed and irrigated conditions.

Boron (B), an essential biochemical element of the defatted residue, was highest in Moldova (12.4%) and Shamakhi Marandisi (11.4%) grown under irrigated conditions.

Furthermore, during the analysis of the defatted residue, the cobalt (Co) content was found to be lowest in Madrasa grown under both rainfed and irrigated conditions (0.08–0.11%) and in Shamakhi Marandisi grown under both rainfed and irrigated conditions (0.16–0.20%).

The highest chromium (Cr) content was observed in Madrasa grown under both irrigated and rainfed conditions (2.48–2.96%).

In the comprehensive biochemical analysis of the defatted residue, the copper (Cu) content was also examined and found to range from 11.8% to 21.4%, with the lowest values recorded in Madrasa grown under rainfed conditions (11.8%), Shamakhi Marandisi (12.6%), and Moldova (14.6%).

The iron (Fe) content of the defatted residue varied between 28.8% and 42.4%, while the manganese (Mn) content ranged from 19.8% to 36.6%, with the highest levels observed in Moldova grown under both irrigated and rainfed conditions (34.6–36.6%).

The lead (Pb) content, which is considered hazardous at high levels in food and feed products, ranged from 0.86% to 1.44% in the defatted residue. Zinc (Zn) content varied from 16.8% to 25.6%, sodium (Na) from 32.8% to 46.4%, and nickel (Ni) from 1.06% to 1.08%.

The strontium (Sr) content in the defatted residue was lowest in Moldova (12.6–14.6%) and Shamakhi Marandisi (12.9–14.4%) grown under both rainfed and irrigated conditions.

The zinc (Zn) content of the defatted residue ranged from 16.8% to 25.6%, with the highest values observed in Madrasa grown under irrigated conditions (25.6%) and Madrasa grown under rainfed conditions (24.4%).

Table I. Biochemical composition of defatted residue (seed residue from which oil has been removed), (%)

Indicators	Madrasa (rainfed)	Madrasa (irrigated)	Moldova (rainfed)	Moldova (irrigated)	Shamakhi Marandi (rainfed)	Shamakhi Marandi (irrigated)
Moisture	7.04	11,42	6,02	10,8	6,08	9,3
Ash	2,11	3,04	2,66	3,12	1,98	3,26
Oilness	0,92	1,12	0,92	1,06	0,82	0,98
Crude protein	9,03	9,92	7,86	9,06	7,88	7,92
Total indigestible fiber (cellulose, hemicellulose, lignin)	76–82	69-74	76-78	67-71	80-81	76-79

Nitrogen, % (N)	1,12	1,22	1,42	1,46	1,08	1,54
Nitrogenous compounds, %	6,2	5,8	6,2	6,8	5,4	7,8
Dry matter, %	57,4	62,6	58,8	65,4	52,8	68,4
mg/100 g db						
Ca	25,6	28,5	22,8	24,4	21,4	23,8
K	28,6	29,32	32,4	38,8	32,0	34,4
Mg	16,32	16,35	14,8	16,4	9,4	9,8
P	5,86	6,45	5,46	9,90	26,8	27,8
S	7,76	9,65	3,38	8,54	4,42	4,88
μg/100 g db						
As	0,12	0,18	0,33	0,54	0,42	0,56
Al	8,4	11,2	1,08	3,66	2,06	2,23
B	6,64	9,42	6,68	12,4	10,8	11,4
Ba	0,98	1,38	1,08	7,92	1,28	1,48
Co	0,08	0,11	0,28	0,32	0,16	0,20
Cr	2,48	2,96	0,78	1,24	1,49	1,23
Cu	11,8	18,8	14,6	21,4	12,6	18,6
Fe	32,8	36,6	28,8	36,8	38,8	42,4
Mn	19,8	24,6	34,6	36,6	25,4	20,8
Na	34,4	42,4	46,4	40,5	32,8	34,2
Ni	1,12	1,08	0,76	0,75	0,88	1,06
Pb	1,14	0,86	1,44	1,36	1,28	1,22
Sr	21,4	23,3	12,6	14,6	12,9	14,4
Zn	24.4	25,6	16,8	22,4	20,3	21,2

3. Conclusion

This study shows that agricultural plant wastes, although different in composition, can be effectively used as raw materials for bioconversion because of their rich lignocellulosic content. The use of fungi such as Pleurotus ostreatus and Cerrena unicolor proved particularly effective, as they are able to break down complex plant polymers like cellulose and lignin, leading to an increase in protein content and overall nutritional value. Among the methods tested, solid-phase fermentation was more efficient than liquid fermentation, resulting in greater substrate degradation and higher biomass production. Overall, the results highlight a practical and sustainable way to convert plant waste into valuable food and feed products, while also helping to reduce environmental pollution and make better use of available biological resources.

Acknowledgments
The authors express their sincere gratitude to the accredited “Complex Research” laboratory of the Azerbaijan Food Safety Institute for their valuable technical support

and assistance in conducting the biochemical analyses of grape seed oils. Their contribution was essential to the successful completion of this research.

Disclosure of Interests
The authors declare no conflict of interest.

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