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The utilization of off-the-range vegetables in the diet of diabetics – the development of a new product with high prohealthy quality

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INTRODUCTION & AIM

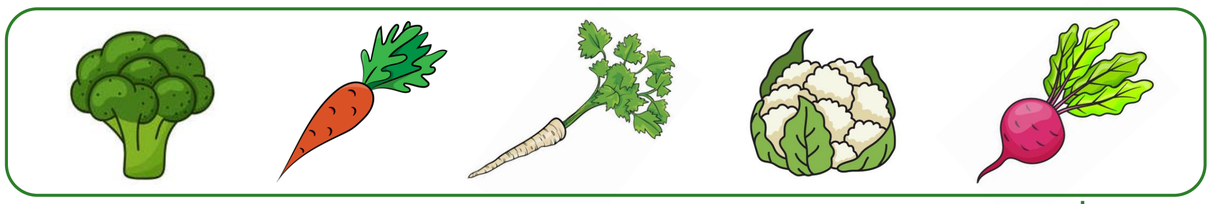
The variety of food **products available for specific consumers**, such as diabetics, constantly needs to be improved. It is particularly important to provide them with products of high nutritional quality. When designing and producing such products, it is also worth paying attention to their environmental aspects.

At the **agricultural production** stage, approximately 15% of the raw materials are never used immediately after harvesting. The use of such vegetables, which are not suitable for direct consumption according to commercial requirements, is therefore of ecological importance and fits in within the ***zero waste*** trend. This study **aimed** to develop vegetable ball recipes that include an additive with of health-promoting importance for diabetics, and to analyze them.

MATERIALS & METHODS

The raw materials used were vegetables supplied directly from the farm, which were of an off-range nature: carrots, broccoli, parsley, cauliflower, red beet, and other minced vegetables in frozen form. Powdered white mulberry leaf extract (additive: 100 mg, 200 mg, or 350 mg DNJ) (WM-DNJ) was used as a biologically valuable component for diabetics. Fifteen variants were produced, which were bound together with potato starch (5% additive) and which were frozen (-23°C).

These methanolic extracts (0.5 g of lyophilazed sample mixed 50 ml of 80% methanol → kept in the dark 20 hrs → shaked 60 min → ultrasounds 50°C/30 min → centrifuged 3000 rpm/ 15min → filtered 0.45µm PTFE) were characterized by ☐ nutritional value (FoodDataCentral, USDA)[1], ☐ color (L*a*b* method; CR-5, Konica Minolta)[2], ☐ polyphenol content (FCR reagent)[3], ☐ antiradical activity ($ABTS^{\cdot+}$ test[4], $DPPH^{\cdot}$ test[5]).



100 mg DNJ
200 mg DNJ
350 mg DNJ
POTATO STARCH

BLANCHING → HOMOGENISATION → BALLS CREATION → FROZING

VEGEBALLS WITH WM-DNJ ADDITION (% of each component)

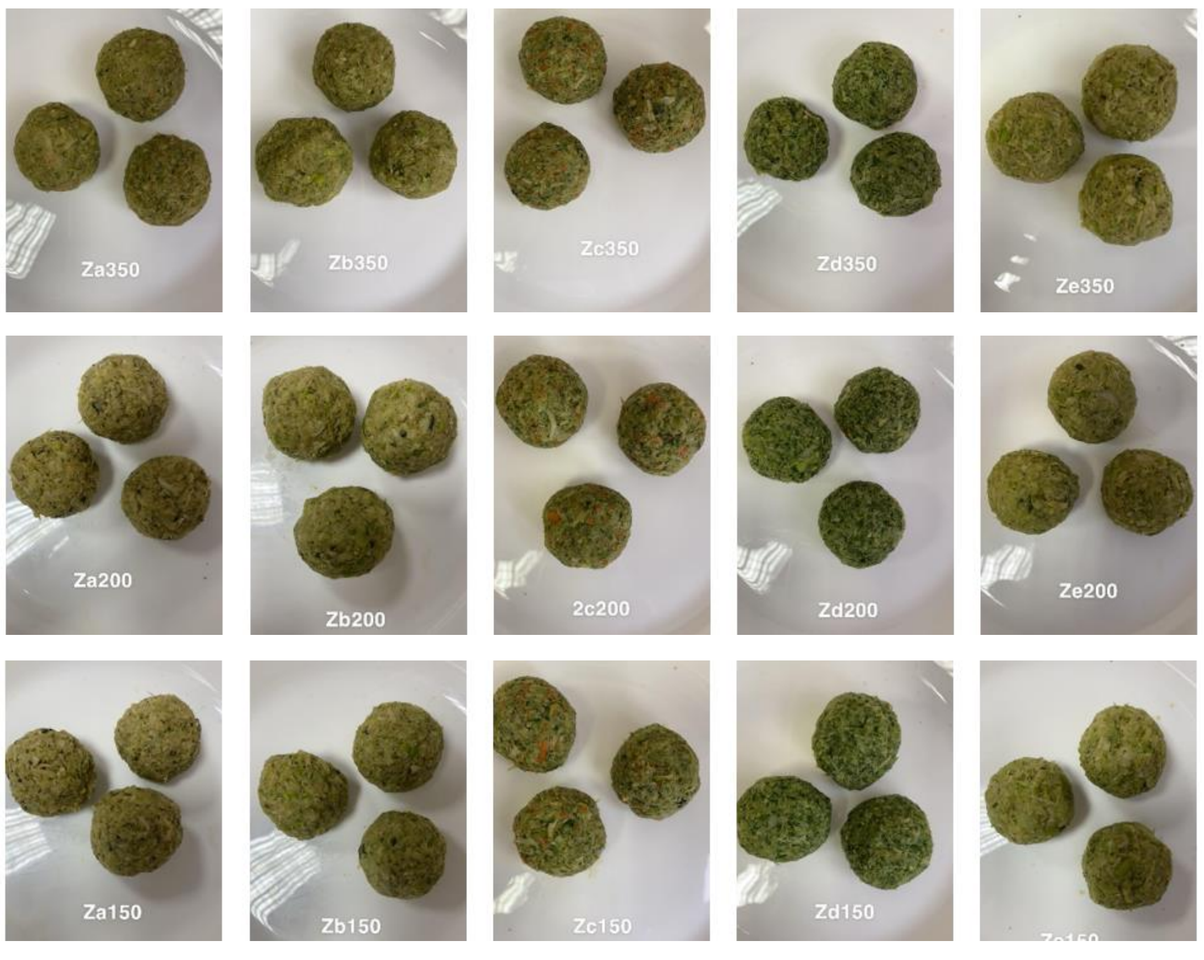
ZA350	broccoli 80% + cauliflower 10% + parsley 10% + starch 5% + 350 mg WM-DNJ
ZB350	broccoli 80% + peas 10% + cauliflower 10% + starch 5% + 350 mg WM-DNJ
ZC350	broccoli 75% + carrot 5% + cauliflower 10% + spinach 10% + starch 5% + 350 mg WM-DNJ
ZD350	broccoli 70% + spinach 20% + cauliflower 10% + starch 5% + 350 mg WM-DNJ
ZE350	broccoli 70% + onion 10% + cauliflower 10% + peas 10% + starch 5% + 350 mg WM-DNJ
ZA200	broccoli 80% + cauliflower 10% + parsley 10% + starch 5% + 200 mg WM-DNJ
ZB200	broccoli 80% + peas 10% + cauliflower 10% + starch 5% + 200 mg WM-DNJ
ZC200	broccoli 75% + carrot 5% + cauliflower 10% + spinach 10% + starch 5% + 200 mg WM-DNJ
ZD200	broccoli 70% + spinach 20% + cauliflower 10% + starch 5% + 200 mg WM-DNJ
ZE200	broccoli 70% + onion 10% + cauliflower 10% + peas 10% + starch 5% + 200 mg WM-DNJ
ZA150	broccoli 80% + cauliflower 10% + parsley 10% + starch 5% + 150 mg WM-DNJ
ZB150	broccoli 80% + peas 10% + cauliflower 10% + starch 5% + 150 mg WM-DNJ
ZC150	broccoli 75% + carrot 5% + cauliflower 10% + spinach 10% + starch 5% + 150 mg WM-DNJ
ZD150	broccoli 70% + spinach 20% + cauliflower 10% + starch 5% + 150 mg WM-DNJ
ZE150	broccoli 70% + onion 10% + cauliflower 10% + peas 10% + starch 5% + 150 mg WM-DNJ

FUTURE WORK / REFERENCES

Authors recommend for such vegetable balls storage tests to be conducted. Moreover, there should be analogous work under industrial conditions carried out to confirm their quality in larger scale.

REFERENCES: [1]USDA https://fdc.nal.usda.gov/; [2]. Zaremba A., Waszkowiak K., Kmiecik D., Jędrusek-Golińska A, Jarzębski M, Szymandera-Buszka K. The selection of the optimal impregnation conditions of vegetable matrices with iodine, Molecules, 2022, 27, 10, 3551. [3]. Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). *Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent* (s. 152–178). [4]. Sharma, O. P., & Bhat, T. K. (2009). DPPH antioxidant assay revisited. Food Chemistry, 113(4), 1202–1205. [5]. Kobus-Cisowska, J., Flaczyk, E., Hęś, M., Kmiecik, D., Kobus-Moryson, M., & Przeor,

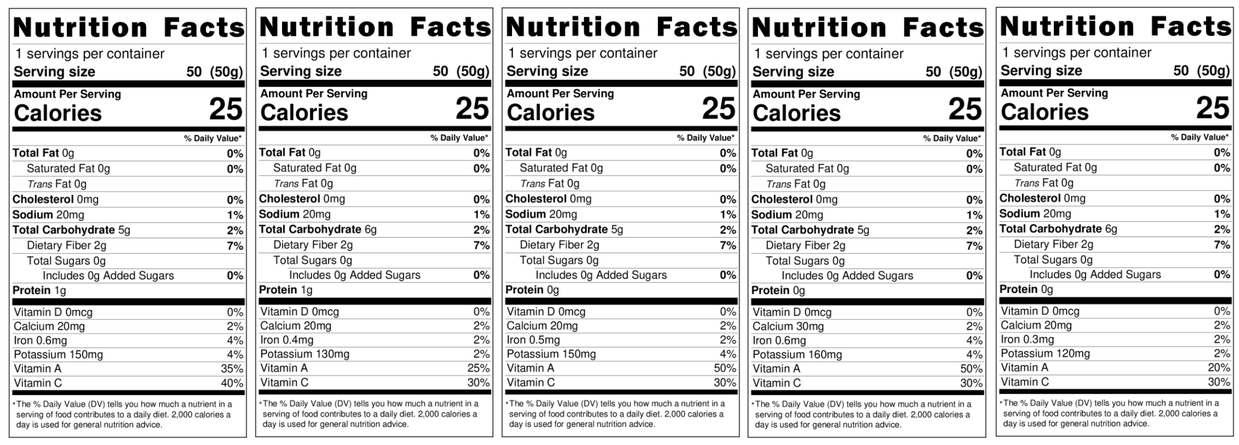
RESULTS



	ZA150	ZB150	ZC150	ZD150	ZE150	ZA200	ZB200	ZC200	ZD200	ZE200	ZA350	ZB350	ZC350	ZD350	ZE350
L*	64.92± 0.64	60.22± 0.32	57.70± 0.33	56.84± 1.11	63.58± 0.91	59.95± 0.86	61.80± 0.61	55.82± 0.28	57.14± 0.98	63.51± 0.96	60.21± 0.53	59.46± 0.54	63.66± 1.09	60.75± 0.58	59.76± 0.26
a*	1.60± 0.10	1.16± 0.21	3.03± 0.12	-0.08± 0.16	1,45± 0.02	2.15± 0.08	1.47± 0.09	3.84± 0.16	0.21± 0.05	1.16± 0.07	2.31± 0.09	1.34± 0.01	2.23± 0.26	-0.22± 0.06	1.03± 0.03
b*	25.41± 0.45	26.10± 0.41	22.97± 0.34	23.67± 0.87	26.36± 0.11	25.23± 0.42	26.38± 0.13	24.26± 0.49	25.36± 0.55	24.01± 0.62	25.54± 0.18	24.12± 0.08	21.32± 0.41	20.63± 0.15	22.89± 0.14

	150 mg WM-DNJ					200 mg WM-DNJ					350 mg WM-DNJ				
	ZA	**ZB**	**ZC**	**ZD**	**ZE**	**ZA**	**ZB**	**ZC**	**ZD**	**ZE**	**ZA**	**ZB**	**ZC**	**ZD**	**ZE**
Phenolic compounds	1.38^{a} ±0.02	1.15^{a} ±0.04	2.53^{b} ±0.09	2.30^{b} ±0.06	2.15^{b} ±0.09	2.41^{c} ±0.03	3.19^{d} ±0.06	2.51^{c} ±0.02	1.25^{a} ±0.03	1.54^{b} ±0.01	2.97^{c} ±0.04	2.32^{b} ±0.07	1.99^{a} ±0.06	2.79^{b} ±0.07	2.62^{b} ±0.08
$DPPH^{\cdot}$ test	2.81^{b} ±0.03	2.50^{a} ±0.11	3.24^{c} ±0.12	3.03^{c} ±0.09	3.37^{c} ±0.12	2.98^{b} ±0.02	2.22^{a} ±0.04	3.17^{b} ±0.06	3.74^{c} ±0.06	3.09^{b} ±0.06	2.99^{a} ±0.03	2.83^{a} ±0.19	3.17^{a} ±0.07	3.27^{a} ±0.10	3.24^{a} ±0.06
$ABTS^{+\cdot}$ test	$11,99^{a}$ ±0.10	14.41^{b} ±0.18	17.77^{c} ±0.83	32.75^{e} ±0.55	19.75^{d} ±1.73	21.49^{b} ±0.83	17.57^{a} ±0.93	19.79^{a} ±0.87	45.38^{c} ±1.49	18.81^{a} ±1.17	18.73^{a} ±0.77	18.60^{a} ±0.53	25.99^{c} ±0.38	34.92^{d} ±1.29	20.45^{b} ±0.65

^{a}, ^{b}, ^{c}, ^{d} – statistical differences between variants, variance analysis (α=0,05)



Nutrition Facts (identical for all five variants)

1 servings per container
Serving size 50 (50g)
Amount Per Serving
Calories 25

	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 5g	2%
Dietary Fiber 2g	7%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 1g	
Vitamin D 0mcg	0%
Calcium 20mg	2%
Iron 0.6mg	4%
Potassium 150mg	4%
Vitamin A	35%
Vitamin C	40%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Nutrition Facts (identical for all five variants)

1 servings per container
Serving size 50 (50g)
Amount Per Serving
Calories 25

	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 6g	2%
Dietary Fiber 2g	7%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 1g	
Vitamin D 0mcg	0%
Calcium 20mg	2%
Iron 0.4mg	2%
Potassium 130mg	2%
Vitamin A	25%
Vitamin C	30%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Nutrition Facts (identical for all five variants)

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Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 5g	2%
Dietary Fiber 2g	7%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 0g	
Vitamin D 0mcg	0%
Calcium 20mg	2%
Iron 0.5mg	2%
Potassium 150mg	4%
Vitamin A	50%
Vitamin C	30%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

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Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 5g	2%
Dietary Fiber 2g	7%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 0g	
Vitamin D 0mcg	0%
Calcium 30mg	2%
Iron 0.6mg	4%
Potassium 160mg	4%
Vitamin A	50%
Vitamin C	30%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Nutrition Facts (identical for all five variants)

1 servings per container
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	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 20mg	1%
Total Carbohydrate 6g	2%
Dietary Fiber 2g	7%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 0g	
Vitamin D 0mcg	0%
Calcium 20mg	2%
Iron 0.3mg	2%
Potassium 120mg	2%
Vitamin A	20%
Vitamin C	30%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

CONCLUSION

The vegetable balls provided were characterized by an energy in the range of 20-30 kcal/ 100 g and a fiber content of approximately 7%. Their polyphenol content was measured using the Folin reagent, oscillated at 1.111 - 3.236 mg GAL/ g d.m.; the scavenging activity of $ABTS^{\cdot+}$, at a level 11.920 - 45.168 mM Tx/ g d.m.; and scavenging activity against $DPPH^{\cdot}$ at the level 2.182 - 3.791 mM Tx/g d.m., depending on the formulation. To summarize up, this study showed that the proposed usage of off-the-range vegetables in the formulation of vegetable balls is justified, providing an interesting new product for discerning consumers.