

Article

Application of Response Surface Methodology for Fermented Plant Extract from *Syzygium aromaticum* L. (Myrtaceae): Optimisation of Antioxidant Activity, Total Polyphenol Content, and Lactic Acid Efficiency

Edyta Kucharska ^{1,*}, Martyna Zagórska-Dziok ², Paweł Bilewicz ³, Sebastian Kowalczyk ³, Martyna Jurkiewicz ¹, Dominika Wachura ¹, Piotr Miądlicki ⁴, Robert Pelech ¹

¹ Department of Chemical Organic Technology and Polymeric Materials, Faculty of Chemical Technology and Engineering, West Pomeranian University of Technology in Szczecin, Pulaski Ave. 10, 70-322 Szczecin, Poland; edyta.kucharska@zut.edu.pl (E.K.); martyna.jurkiewicz@zut.edu.pl (M.J.); dominika.wachura@zut.edu.pl (D.W.); robert.pelech@zut.edu.pl (R.P.)

² Department of Technology of Cosmetic and Pharmaceutical Products, Medical College, University of Information Technology and Management in Rzeszow, Rzeszów, Poland, mzagorska@wsiz.edu.pl (M.Z.-Dz.)

³ Dancoal Sp. z o.o., Prosta Ave. 35, 72-100 Goleniów; Poland; pb@dancoal.pl (P.B.); sk@dancoal.pl (S.K.)

⁴ Engineering of Catalytic and Sorbent Materials Department, West Pomeranian University of Technology, Pulaski Ave. 10, 70-322, Szczecin, Poland, piotr.miadlicki@zut.edu.pl (P.M.)

* Correspondence: edyta.kucharska@zut.edu.pl; Tel.: +48-888-615-273

Studies on the effect of microorganism type on changes in antioxidant activity (AA), total polyphenol content (TPC) and lactic acid efficiency (LAc) - Table S1.

Table S1. Studies of the effect of the type of microorganism (*L. reuteri* MI_0168, *L. salivarius* LY_0652, *L. brevis* LY_1120, *L. acidophilus* MI-0078, *L. rhamnosus* MI-0272, and *L. plantarum* MI-0102) on changes in: antioxidant activity (AA), total polyphenol content (TPC), and lactic acid efficiency (LAc).

Fermentation time (days)	<i>L. reuteri</i> MI_0168		
	AA	TPC	LAc
	mmol Tx/L	mmol GA/L	%
1	22.01±0.07	10.6±0.09	41
5	23.12±0.08	10.8±0.08	53
9	32.10±0.06	11.5±0.06	79
10	32.10±0.09	11.5±0.07	94
11	32.10±0.09	11.5±0.09	82
	<i>L. salivarius</i> LY_0652		
1	22.11±0.09	10.70±0.04	42
5	23.21±0.08	10.91±0.09	51
9	32.22±0.08	11.60±0.07	58
10	32.22±0.06	11.60±0.09	65
11	32.22±0.05	11.60±0.05	60
	<i>L. brevis</i> LY_1120		
1	22.20±0.03	10.61±0.02	39
5	23.30±0.04	10.81±0.00	46
9	32.31±0.05	11.50±0.06	72
10	32.31±0.07	1150±0.03	69

11	32.31±0.09	11.50±0.09	69
<i>L. acidophilus</i> MI-0078			
1	22.10±0.03	10.71±0.03	38
5	23.02±0.03	10.92±0.03	67
9	32.11±0.03	11.43±0.03	69
10	32.11±0.03	11.43±0.03	75
11	32.11±0.03	11.43±0.03	69
<i>L. rhamnosus</i> MI-0272			
1	23.03±0.03	10.71±0.02	52
5	23.20±0.03	10.90±0.01	76
9	33.82±0.03	11.60±0.09	90
10	33.81±0.03	11.60±0.09	96
11	33.80±0.03	11.60±0.03	96
<i>L. plantarum</i> MI-0102			
1	22.10±0.09	10.61±0.07	44
5	23.00±0.03	10.70±0.03	64
9	32.20±0.03	11.30±0.07	88
10	32.20±0.04	11.30±0.01	76
11	32.20±0.07	11.30±0.00	76

Mean ± SD (n = 6)

Studies of the effect of the initial amount of sugars on changes in antioxidant activity (AA), total polyphenol content (TPC), and lactic acid efficiency (LA_e) - Table S2.

Table S2. Studies of the effect of the initial amount of sugars on changes in: antioxidant activity (AA), total polyphenol content (TPC), and lactic acid efficiency (LA_e).

Fermentation time (days)	Initial sugar content 1.60%		
	AA	TPC	LA _e
	mmol Tx/L	mmol GA/L	%
1	20.30±0.07	8.78±0.03	68
5	20.98±0.03	9.56±0.01	77
9	29.53±0.02	10.21±0.04	74
10	29.53±0.03	10.21±0.06	72
11	29.53±0.08	10.21±0.03	68
Initial sugar content 3.20%			
1	23.03±0.03	10.74±0.03	32
5	23.83±0.01	10.97±0.02	45
9	33.90±0.04	11.60±0.03	89
10	33.90±0.03	11.60±0.04	95
11	33.90±0.04	11.60±0.05	95
Initial sugar content 4.60%			
1	23.15±0.03	10.82±0.03	32
5	24.31±0.07	10.89±0.05	49
9	34.98±0.03	11.68±0.03	74
10	34.98±0.08	11.68±0.09	75
11	34.98±0.03	11.68±0.03	73

Mean ± SD (n = 6)

Studies on the effect of plant raw material content on changes in antioxidant activity (AA), total polyphenol content (TPC) and lactic acid efficiency (LA_e) Table S3.

Table S3. Studies on the effect of plant raw material content changes: antioxidant activity (AA), total polyphenol content (TPC) and lactic acid efficiency (LA_e).

Fermentation time (days)	Content of raw plant material 0.32%		
	AA	TPC	LA _e
	mmol Tx/L	mmol GA/L	%
1	1.73±0.02	2.98±0.03	42
5	2.37±0.02	3.14±0.04	49
9	3.77±0.04	3.76±0.04	80
10	3.77±0.03	3.76±0.03	91
11	3.77±0.06	3.76±0.06	87
	Content of raw plant material 0.80%		
1	2.17±0.05	3.84±0.01	43
5	3.01±0.03	4.00±0.07	54
9	4.73±0.03	4.62±0.07	58
10	4.73±0.09	4.62±0.02	93
11	4.73±0.07	4.62±0.03	93
	Content of raw plant material 1.60%		
1	7.42±0.02	5.33±0.03	41
5	8.02±0.04	5.49±0.04	56
9	10.51±0.05	6.19±0.04	97
10	10.51±0.01	6.19±0.05	92
11	10.51±0.04	6.19±0.05	92
	Content of raw plant material 3.20%		
1	12.28±0.00	7.60±0.00	37
5	13.04±0.01	7.76±0.03	56
9	19.94±0.04	8.62±0.02	71
10	19.94±0.07	8.62±0.06	95
11	19.94±0.03	8.62±0.03	92
	Content of raw plant material 6.40%		
1	22.99±0.03	10.74±0.03	53
5	23.87±0.01	10.97±0.07	89
9	34.02±0.02	11.60±0.09	93
10	34.02±0.04	11.60±0.02	93
11	34.02±0.03	11.60±0.02	93

Mean ± SD (n = 6),

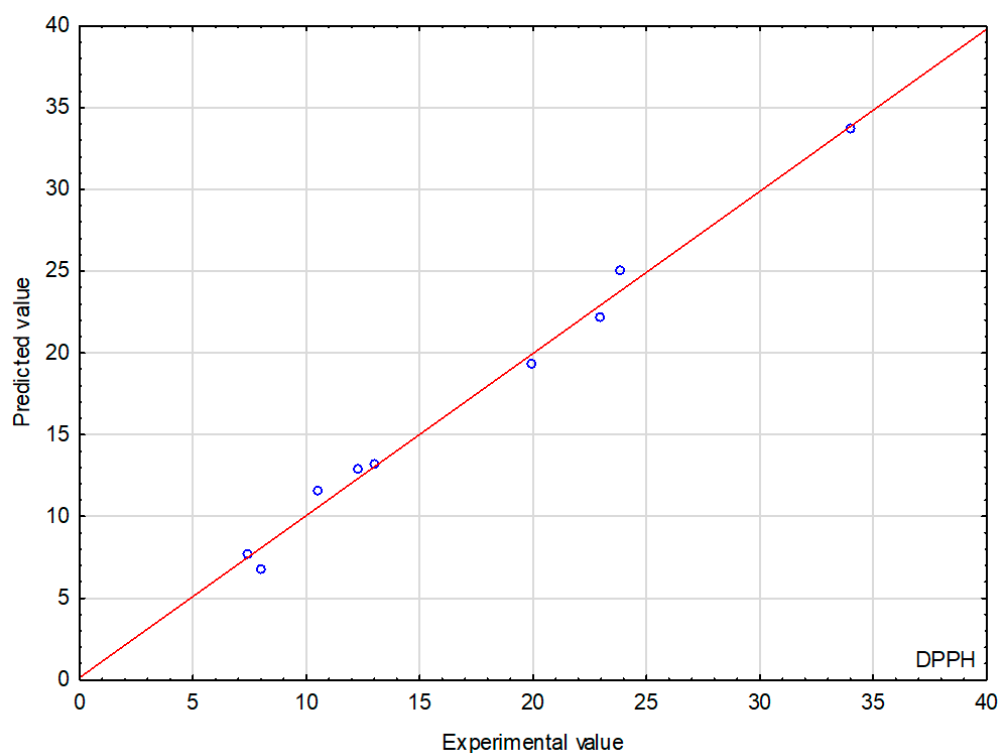


Figure S1. A scatter plot of observed and approximated values during the interaction of the process parameters under study: raw material content - reaction time (changes in AA). Constant parameters of the process: *L. rhamnosus* strain MI-0272; initial sugar content: 3.20%; inoculum content: 3.20%.

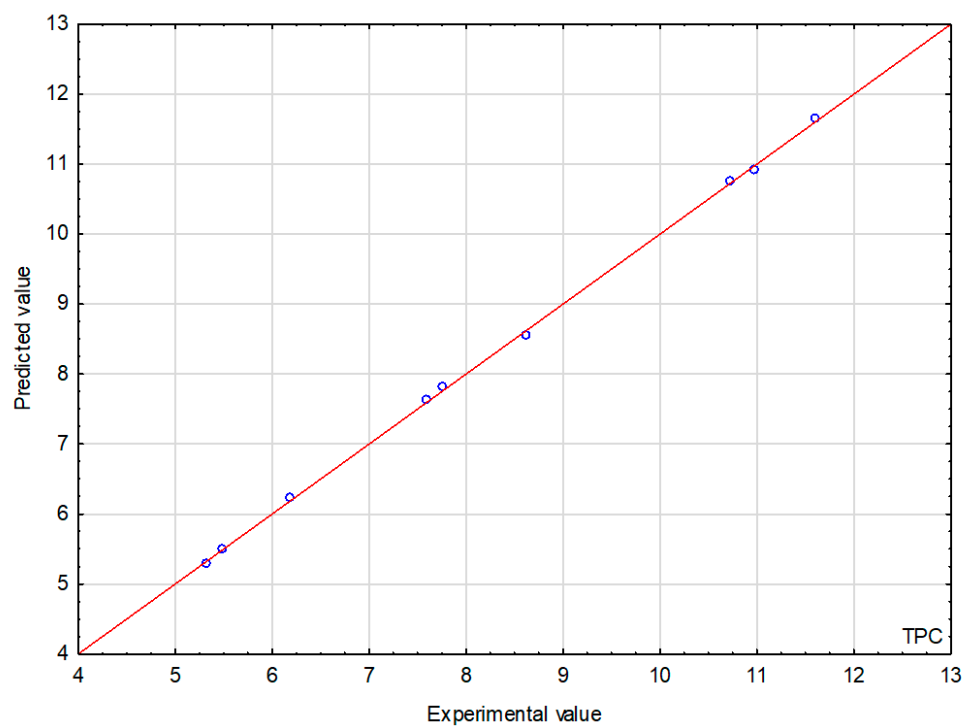


Figure S2. A scatter plot of observed and approximated values during the interaction of the process parameters under study: raw material content - reaction time (changes in TPC). Constant parameters of the process: *L. rhamnosus* strain MI-0272; initial sugar content: 3.20%; inoculum content: 3.20%.

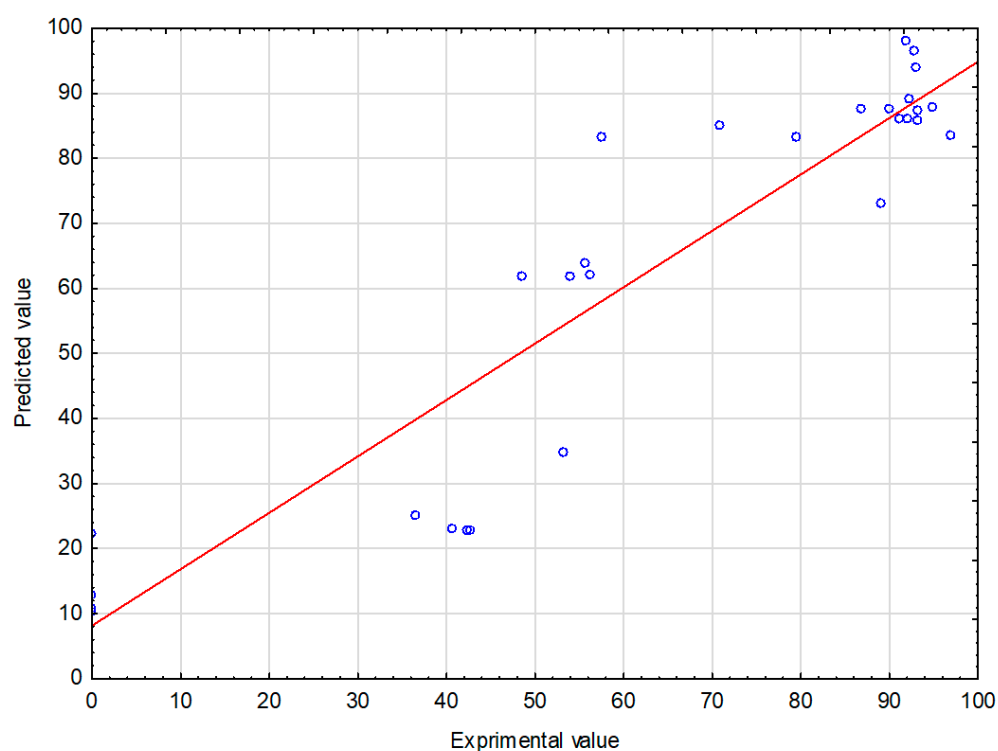


Figure S3. A scatter plot of observed and approximated values during the interaction of the process parameters under study: raw material content - reaction time (changes in LA_e). Constant parameters of the process: *L. rhamnosus* strain MI-0272; initial sugar content: 3.20%; inoculum content: 3.20%.

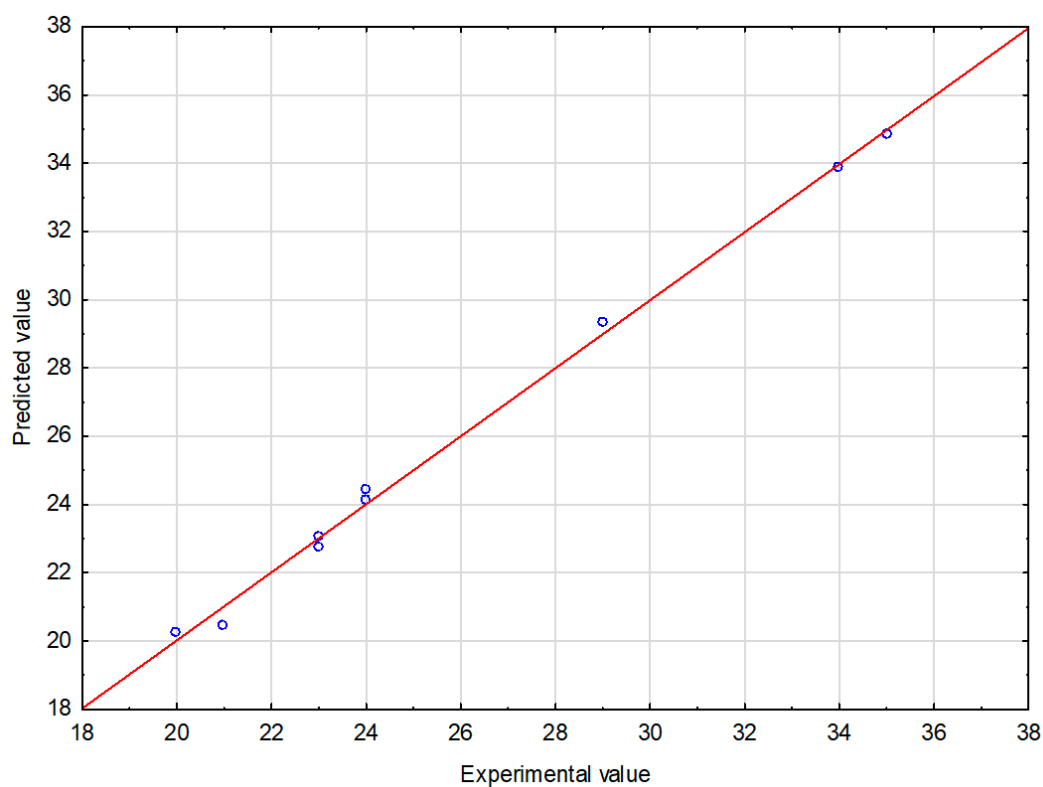


Figure S4. A scatter plot of observed and approximated values during the interaction of the process parameters under study: initial sugar content - reaction time (changes in AA). Constant parameters of the process: *L. rhamnosus* strain MI-0272; raw material content 6.40%; inoculum content: 3.20%.

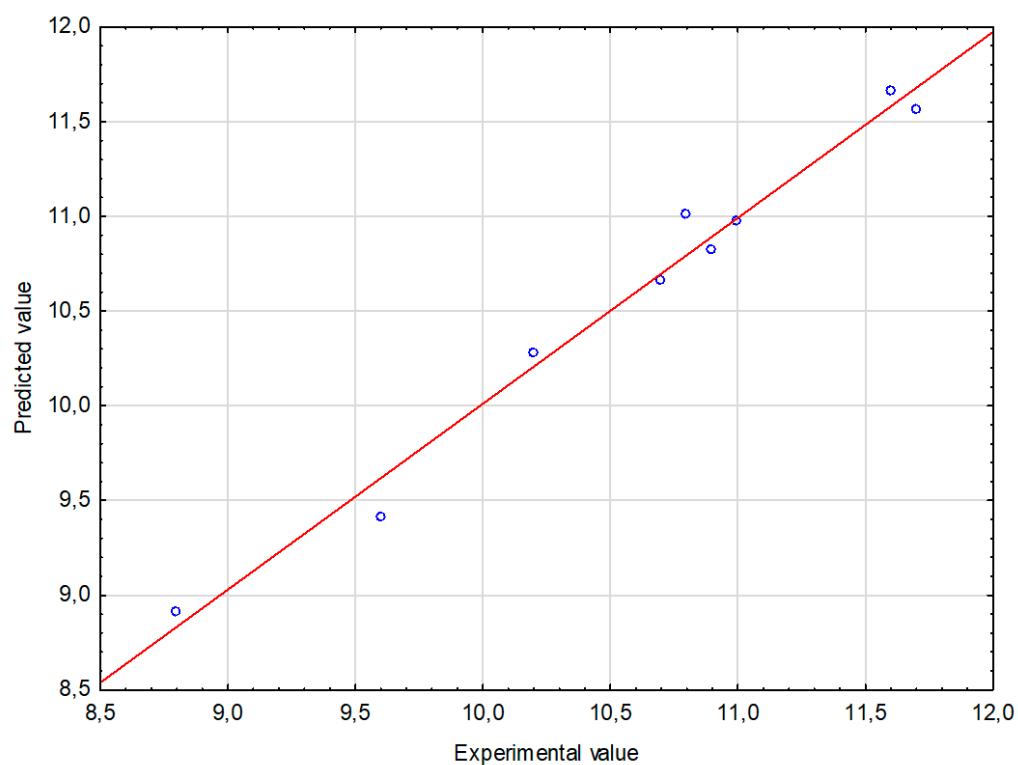


Figure S5. A scatter plot of observed and approximated values during the interaction of the process parameters under study: initial sugar content - reaction time (changes in TPC). Constant parameters of the process: *L. rhamnosus* strain MI-0272; raw material content 6.40%; inoculum content: 3.20%.

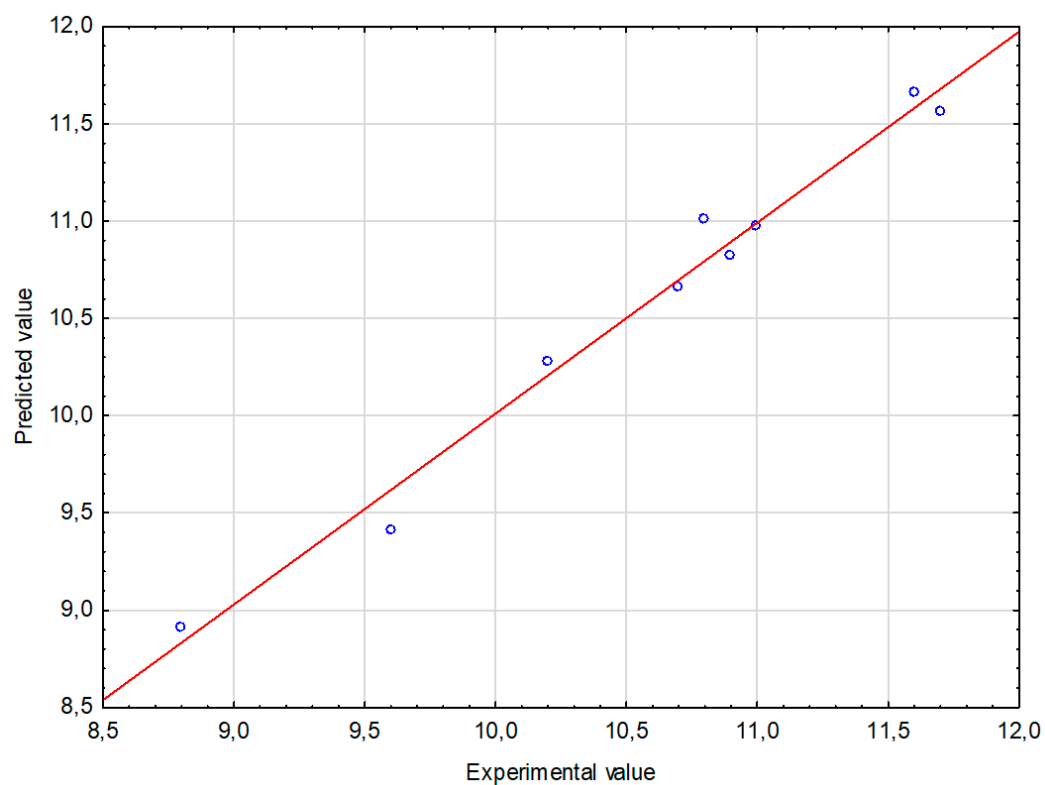


Figure S6. A scatter plot of observed and approximated values during the interaction of the process parameters under study: initial sugar content - reaction time (changes in LA_e). Constant parameters of the process: *L. rhamnosus* strain MI-0272; raw material content 6.40%; inoculum content: 3.20%.