Bioactive compounds in food technology, with a special focus on their contribution to antioxidant properties and color stability

Habilitation in Food Engineering

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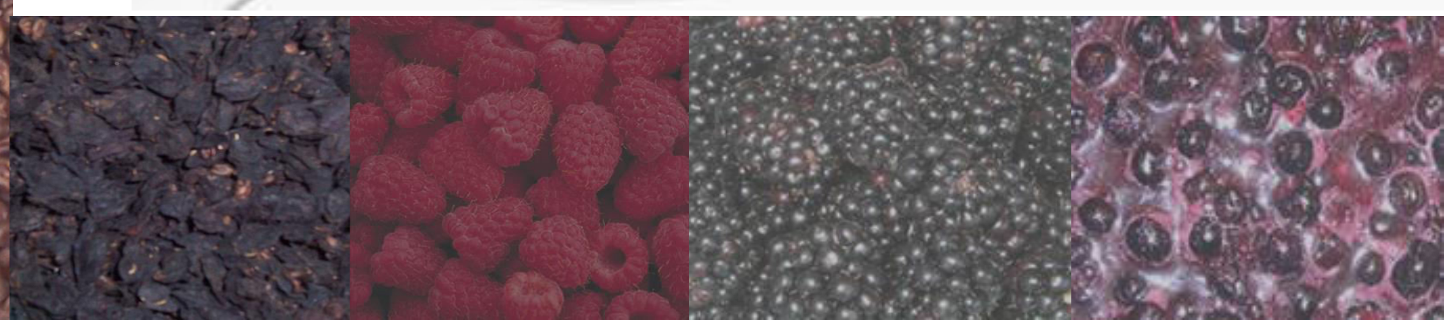
3rd of April 2014, Timisoara



About me:

1990-1995: ”POLITEHNICA” University of Timisoara
Faculty of Industrial Chemistry
Specialization: ***Engineering of Natural Products Processing***
- Fermentative industries
Bachelor in Chemistry profile / Final mark: 9.35
Diploma paper entitled: ***“Influence of some filtering materials on the beer wort quality”***

1995-1996: **"POLITEHNICA" University of Timisoara**
Faculty of Industrial Chemistry and Environment Engineering
Specialization: ***Checking and approving of natural processed products***
Magister/Master in Chemistry profile / Final mark: 9.83
Dissertation thesis entitled: ***"Drying kinetics of brewery yeast"***

- **1996 – present:** **Banat's University of Agricultural Sciences and Veterinary Medicine from Timisoara, Faculty of Food Processing Technology**

- **1996-2002:** **Banat's University of Agricultural Sciences and Veterinary Medicine from Timisoara, Faculty of Food Processing Technology**

PhD Thesis entitled: ***"Research regarding the modification of some chemical compounds in the case of some cereals germination. Possibilities for capitalization of germinated cereals"***

PhD Supervisor: **Prof. dr. Ionel Jianu**

Public presentation **on 21st of November 2002**

PhD degree: **April 2003**

The Habilitation Thesis consists of *three main parts*:

(I) Scientific, academic and professional achievements;
(II) Career evolution and development plans;
(III) References.

Part I is divided in two sections:

- ***Section I. Scientific achievements***
- ***Section II. Professional and academic achievements***

and describes **the most important scientific results**, proving relevance and originality, published in ***10 selected ISI quoted papers*** and the main professional and academic achievements, all referring to the period **2003-2013**, **after receiving the PhD degree.**

Part I/Section I
Scientific achievements

1. Scientific achievements concerning the effect of bottle aging on chromatic and antioxidant properties of red wines

The targets of this research direction are:

i. **Red wine color analysis during aging using selective UV-VIS methods, including also the evaluation of wine "*chemical age*" and "*the degree of anthocyanins ionization* ";**
ii. **Assessment the contribution of copigmentation and polymeric pigments to the stabilization of red wine color during aging;**
iii. **Evaluation the changes in antioxidant properties of red wine in response to bottle-aging.**

As a result of this research, 2 ISI quoted papers have been published, as follows:

P1. Poiana M.A., Dobrei A., Stoin D., Ghita A. ***The influence of viticultural region and the ageing process on the color structure and antioxidant profile of Cabernet Sauvignon red wines***. Journal of Food, Agriculture and Environment. **2008**, 6(3&4):104-108.

P2. Dobrei A., **Poiana M.A.**, Sala F., Ghita A., Gergen I. ***Changes in the chromatic properties of red wines from Vitis vinifera L. Cv. Merlot and Pinot Noir during the course of aging in bottle***. Journal of Food, Agriculture and Environment. **2010**, 8(2): 20-24.

What was the motivation for this research direction?

✓ ***The effect of bottle aging on red wines antioxidant activity in relation with color evolution is not very well documented.***

✓ ***The changes occurring in the level of monomeric anthocyanins during wines aging should be analyzed with a great attention to fully explain their contribution to the expression of the red wines color as well as to their antioxidant activity.***

✓ ***The selective* UV-VIS methods used for red wine color analysis offer some advantages over standard methods because thay *have the ability to provide more data about the changes in red wine color as a result of different changes in structure of antocyanin pigments.***

✓ During red wines maturation and aging, the monomeric anthocyanins are gradually incorporated into derived polymeric pigments. This phenomenon seems to be of a great importance for red wine color stabilization and keeping its antioxidant properties during evolution.

The influence of aging time on color and antioxidant properties of Cabernet Sauvignon red wine

Aim

The aim of the study presented* in *selected paper 1, was to obtain correlated information about the changes occurred in the color of dry red wine* Cabernet Sauvignon *originating from Recas and Minis vineyards related to the change in their antioxidant properties in response to bottle aging for 30 months.

The samples were analysed as young wines and after **6, 12, 18, 24 and 30 months of bottle-aging** in terms of color structure, expressed by contribution of monomeric, copigmented and polymeric pigments (%MA, %CA and %PP) to the total wine color, as well as regarding the content of total monomeric antocyanins (TMA) and "*chemical age*" indices (I1 and I2). Antioxidant profile of red wines was assessed on the base of total antioxidant activity using ferric reducing antioxidant power (FRAP) assay and free radical scavenger activity determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay.

Significant results

Table 1. Changes in TMA, color structure and "*chemical age*" during red wine Cabernet Sauvignon aging

Wine sample	Total color (AU)	MA (%)	CA (%)	PP (%)	I1	I2	TMA ($mg\cdot L^{-1}$)
0-CS-R	**7.91**	**75.89**	**12.18**	**11.93**	**0.18**	**0.12**	**167.33**
6-CS-R	7.62	58.79	15.67	25.54	0.30	0.22	138.73
12-CS-R	7.14	48.25	11.31	40.44	0.40	0.38	122.16
18-CS-R	6.88	33.45	8.87	57.68	0.58	0.49	111.81
24-CS-R	6.51	25.1	8.51	66.39	0.66	0.61	104.33
30-CS-R	**6.37**	**16.7**	**8.02**	**75.28**	**0.75**	**0.68**	**97.34**
0-CS-M	**9.08**	**72.03**	**18.83**	**9.14**	**0.11**	**0.08**	**221.16**
6-CS-M	8.81	56.47	20.31	23.22	0.30	0.19	194.65
12-CS-M	8.51	44.85	14.52	40.63	0.42	0.38	162.73
18-CS- M	8.27	36.57	10.31	53.12	0.53	0.42	143.11
24-CS-M	8.04	30.4	8.77	60.83	0.61	0.46	137.14
30-CS-M	**7.71**	**24.08**	**7.41**	**68.51**	**0.68**	**0.62**	**129.88**

The "*chemical age*" expresses "the *variations in the aging characteristics*" of a red wine based on two indices (I1 and I2). These indices show the relationship between polymeric pigments and wine anthocyanins. It was noticed a significant evolution in "*chemical age*" once the evolution of color structure towards more stable forms regarding the chemical structure.

Table 2. The impact of aging time on antioxidant profile of red wines

Wine sample	FRAP (mM $Fe^{2+} \cdot L^{-1}$)	DPPH (mM Trolox $\cdot L^{-1}$)
0-CS-R	**30.87**	**9.28**
6-CS-R	25.82	9.57
12-CS-R	20.16	11.12
18-CS-R	17.13	13.21
24-CS-R	15.83	13.46
30-CS-R	**14.12**	**14.12**
0-CS-M	**39.64**	**10.16**
6-CS-M	30.24	11.27
12-CS-M	26.16	12.83
18-CS- M	24.81	13.87
24-CS-M	20.05	15.17
30-CS-M	**18.37**	**16.53**

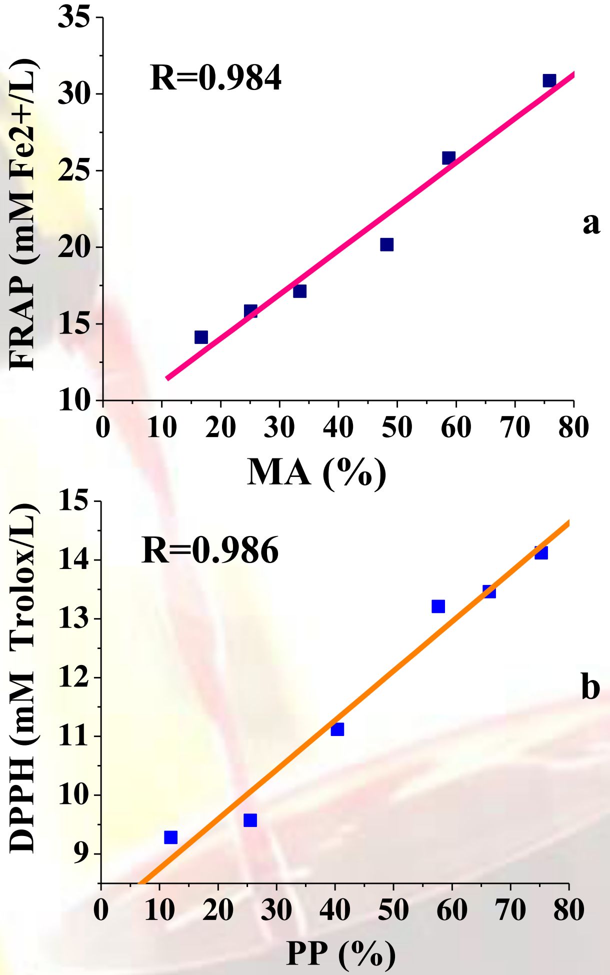


Figure 1. Linear correlation
(a) FRAP versus MA; (b) DPPH versus PP for CS-R

The FRAP values recorded in response to aging are strongly correlated with the fraction of color due to MA. During bottle aging, by decreasing of FRAP values it was noticed a significant increase in radical scavenging ability. DPPH values were highly correlated with the fraction of color due to PP (%).

The effect of bottle aging on chromatic properties of Merlot and Pinot Noir red wines

Aim

The purpose of the study presented in selected paper 2, was to assess the changes in the color structure of dry red wines Merlot and Pinot Noir from Recas vineyard during bottle aging for two years.

The red wines were investigated as young wines and during aging for 4, 10, 18 and 24 months in terms of color density (CD), tonality (T), contribution of yellow or brown pigments, red pigments and blue pigments to the wine color, the color structure expressed by contribution of monomeric, copigmented and polymeric pigments (%MA, %CA and %PP) to the total wine color, TMA content, "*chemical age*" indices (I1 and I2) and the "*degree of ionization of anthocyanins*" (α).

Scientific contributions of the author to the current state-of-knowledge

The following remarks help to update the current state of knowledge:

- Grape variety and aging time play a great role on both: color stabilization and antioxidant profile of red wine.

- The red wine color stabilization during aging supposes the gradual conversion of monomeric anthocyanins to polymeric forms.

- MA contributed in a highest measure to the young red wines color. Contrary, the most part of the aged wines color was due to PP.

- During bottle-aging, the copigmented stacks act as a source of free flavylium ions in response to consumption of free anthocyanins. Thus, the contribution of copigmentation to the red wine color decreased over time.

- The color of PP may be the driving force which is behind the CD of aged red wine.

- The FRAP values significantly decreased during aging being strongly correlated with MA(%). Contrary, the values recorded for DPPH increased by bottle-aging. These values were highly correlated with PP(%).

- "*Chemical age*" gives a measure of the extent to which polymeric pigments have replaced the monomeric anthocyanins during wine aging.

- Red wines vary in their aging characteristics depending on the grape variety and vineyard: some wines appear to age faster, while others require more time of aging before reaching their optimum quality.

- The chromatic profile of red wines can be directed by setting of aging time.

- The obtained results are important in order to predict the evolution of red wine color during bottle aging.

2. Scientific achievements concerning the impact of processing and storage on antioxidant characteristics and color of fruit and gelled fruit products

In this field, I have contributed with studies on the following topics:

i. **impact of *Individual Quick Freezing* (IQF) and long-term frozen storage on color stability and antioxidant properties of some wild berries;**

ii. **effect of thermal processing and storage on antioxidant characteristics and color quality of some low-sugar jam from various fruit rich in antocyanins;**

iii. **improving the color stability and antioxidant properties of gelled fruit products using different doses and types of pectin.**

As a result of this study, 4 ISI quoted papers have been published, as follows:

P3. Poiana M.A., Moigradean D., Raba D., Alda L., Popa M. ***The effect of long-term frozen storage on the nutraceutical compounds, antioxidant properties and color indices of different kinds of berries***. Journal of Food, Agriculture and Environment. **2010**, 8(1):54-58, ISSN 1459-0255.

P4. Poiana M.A., Moigradean D., Dogaru D., Mateescu C., Raba D., Gergen I. ***Processing and storage impact on the antioxidant properties and color quality of some low sugar fruit jams***. Romanian Biotechnological Letters. **2011**, 16(5):6504-6512.

P5. Poiana M.A., Alexa E., Mateescu C. ***Tracking antioxidant properties and color changes in low-sugar bilberry jam as effect of processing, storage and pectin concentration.***. Chemistry Central Journal., **2012**, 6:4.

P6. Poiana M.A., Munteanu M.F., Bordean D.M., Gligor R., Alexa E. ***Assessing the effects of different pectins addition on color quality and antioxidant properties of blackberry jam***. Chemistry Central Journal. **2013**, 7:121.

What were the reasons for addressing this research direction?

The *main reason* that drove me towards this research direction was to find solutions for improving the retention of bioactive compounds and color in fruit and gelled fruit products.

IQF (*Individual Quick Freezing)* is one of the simplest and least time-consuming ways to preserve berries, but *freezing and* long-them frozen storage might affect anthocyanins, polyphenols, vitamin C, color quality and antioxidant properties of fruits.

Frozen berries can be further processed into various shelf-life products such as jam, jellies, puree and juice available to consumers all year round.

Fruit processing and long term storage of fruit products result in deterioration of anthocyanins, affecting the color of the final products. In the same time, the antioxidant properties of these products are affected by losing of water-soluble antioxidants, such as phenolics, or by interactions with non-phenolics compounds.

Recent studies have proven that some hydrocolloids, such as pectin, corn starch, and sodium alginate *could improve the color stability* in gel model systems due to electrostatic interactions between flavylium cations - positive charged - and the dissociated carboxylic groups of the pectin, **while other hydrocolloids showed adverse effects or did not show any influence.**

Pectin is a high value functional food ingredient ***primarily used in food industry as a gelling agent for jellies, jams and spreads.***

During jam processing, gel formation involves the formation **of three-dimensional networks** on the base of **pectin chains associations**. **The ability of pectin to form gel depends on the molecular size and DE [DE<50%: low methoxyl pectin (LMP); DE >50%: high methoxyl (HMP)].**

The hydrogen bonds between the pectin chains are the main factors responsible for stabilization of a **HMP network**, *Figure 2*.

In addition, **hydrophobic interactions** of the methyl ester groups are essential in gel formation.

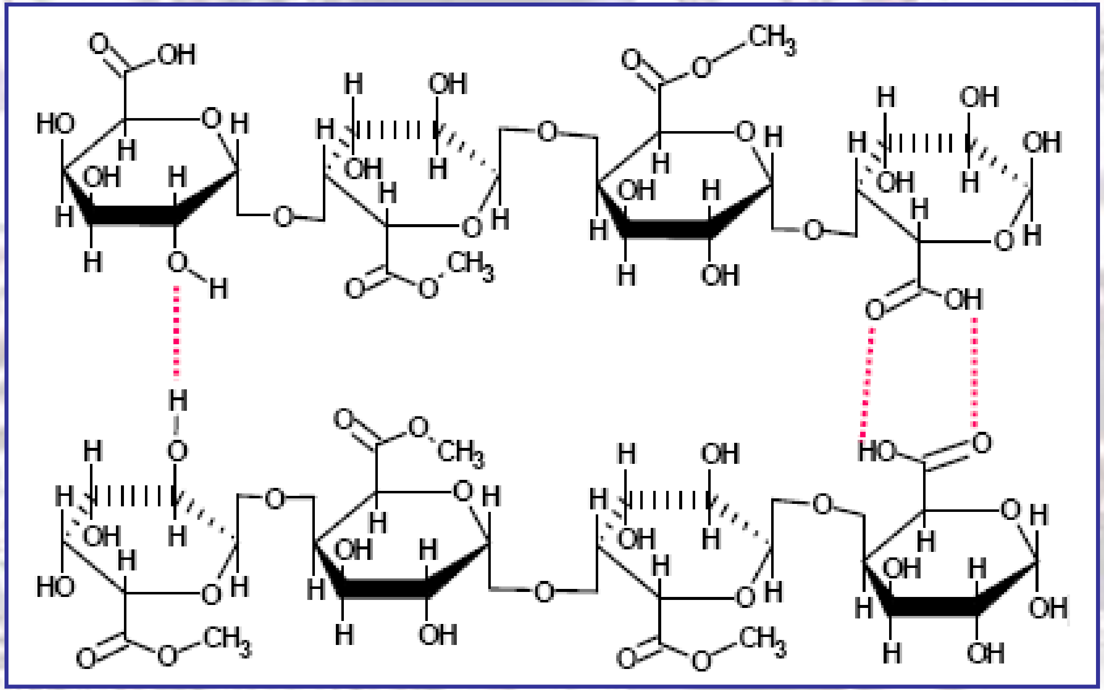
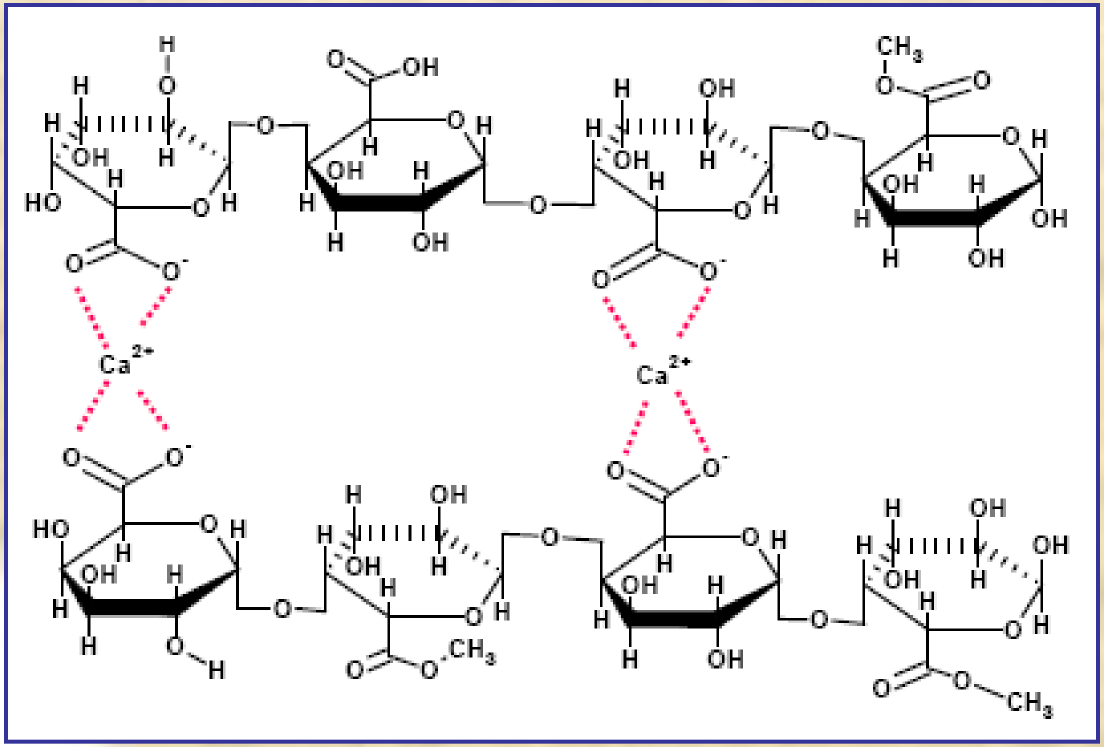


Figure 2
The binding mechanism for connecting of HMP chains during gel formation

The gelling mechanism in jam obtained with LMP is based on the clustering of the pectin chains and occurring of **some cavities between them** as a result of bended shape of the pectin chains. The gelling mechanism involves the formation of a network of **ionic cross bindings via calcium bridges between the carboxyl groups belonging to different chains located in close proximity**, *Figure 3.*



In jam obtained with LMAP, supplementary links by hydrogen bonds occur as a result of the presence of amid groups. In this case, the clustering of pectin chains is more controlled than for LMP.

Figure 3
The binding mechanism for connecting of LMP chains during gel formation

As a result of gel formation based on different types of chain associations, biologically active compounds from fruit jam could be protected against degradation by water attack, condensation reactions or thermal destroying.

Impact of freezing and long-term frozen storage on antioxidant properties, bioactive compounds and color indices of berries

Aim

The purpose of the study presented in ***selected paper 3****, was to investigate how Individual Quick Freezing* (IQF) *and long-term frozen storage at -18 ° C for 10 months can affect the retention of antioxidant properties, color and bioactive compounds in* various berries such as: blueberry (*Vaccinium myrtillus*), raspberry (*Rubus idaeus*) and blackberry (*Rubus fruticosus*).

The samples were analyzed fresh, immediately after freezing and after 2, 4, 6, 8 and 10 months of frozen storage in terms of total phenolics content (TP), L-ascorbic acid (L-AsAc) content, antioxidant activity expressed by ferric-reducing antioxidant power, total monomeric anthocyanins content (TMA) and color indices.

Significant results

Table 3. Effect of freezing and long-term frozen storage on TP, L-AsAc, TMA and FRAP values of berries

Berries	FR	Frozen berries					
		0-F	2-F	4-F	6-F	8-F	10-F
L-AsAc (mg·100 g^{-1} FW)							
raspberry	31.55	31.41	29.91	27.15	26.22	25.15	22.13
blueberry	8.20	8.15	7.92	7.68	6.61	6.43	6.22
blackberry	6.63	6.46	5.81	5.46	5.28	4.39	3.97
TP (mg GAE·100 g^{-1} FW)							
raspberry	197.79	197.14	182.23	169.45	153.21	129.75	103.65
blueberry	641.53	640.11	611.43	589.31	550.4	511.22	458.54
blackberry	333.60	331.87	322.47	279.07	242.79	224.27	191.12
FRAP (mM Fe^{2+}·kg^{-1} FW)							
raspberry	40.16	39.21	37.89	35.72	31.38	28.37	24.84
blueberry	58.31	57.94	55.16	53.10	50.44	47.10	44.82
blackberry	49.64	48.73	46.02	43.17	38.46	37.32	32.29
TMA (mg·100 g^{-1} FW)							
raspberry	39.71	41.67	39.95	37.85	37.56	34.85	33.51
blueberry	205.48	207.12	205.14	202.67	198	185.12	180.31
blackberry	193.72	195.89	192.08	191.75	188.4	182.55	178.62

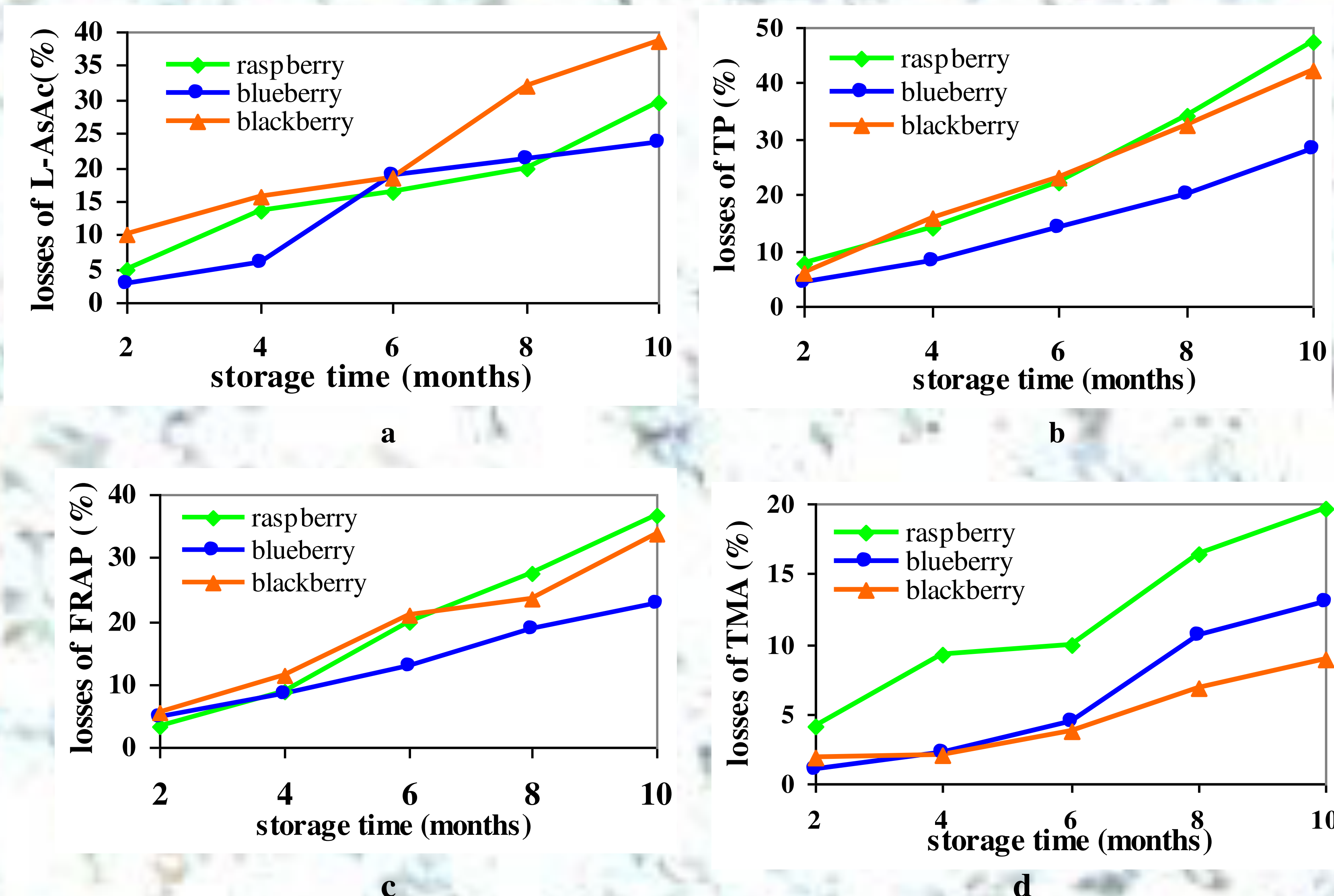


Figure 4. The losses of monitored parameters during long-term storage of frozen fruit (a: L-AsAc; b: TP; c: FRAP and d: TMA)

Table 4. Effect of long-term frozen storage on the color indices of berries

Berries	FR	frozen berries					
		0-F	2-F	4-F	6-F	8-F	10-F
				CD (AU)			
raspberry	7.14	7.09	6.9	6.71	6.05	5.27	5.04
blueberry	11.77	11.68	11.51	11.21	10.85	10.71	10.43
blackberry	12.28	12.21	12.15	11.96	11.8	11.53	11.58
				PC (%)			
raspberry	10.92	11.28	12.03	12.97	15.54	19.35	22.22
blueberry	8.92	9.42	10.17	10.97	12.53	13.45	14.38
blackberry	9.45	9.75	10.12	10.79	11.36	11.97	12.35

Processing and storage impact on antioxidant properties and color of strawberry, sweet cherry and sour cherry jam

Aim

The purpose of the study shown in *selected paper 4*, was to assess the stability of color and antioxidant properties of low-sugar jam from strawberry, sweet cherry and sour cherry in response to thermal processing and storage at 20°C. Changes occurring in investigated parameters were compared among frozen fruit, jam one day after processing and jam in storage for 1, respectively 3 months. Total soluble solids content reached in low-sugar jam was 45°Brix.

Jam samples were analyzed in terms of total phenolics content (TP), L-ascorbic acid (L-AsAc), antioxidant capacity (FRAP), total monomeric anthocianyns content (TMA) and color indices (color density: CD, polymeric color: PC, and percentage of polymeric color: %PC).

The effect of processing and storage on antioxidant properties and color of low-sugar bilberry jam with different pectin concentrations

Aim

The aim of the work presented in selected paper 5 **was to investigate the effect of processing and storage at 20°C on antioxidant properties and color quality of low-sugar bilberry (*Vaccinium myrtillus* L.) jam obtained with low-methoxyl pectin (LMP) applied at different doses, as follows: 0.3, 0.5, 0.7 and 1%.**

Jam samples were analyzed one day after processing and after 1, 3, 5 and 7 months of storage at 20°C in terms of TMA, L-AsAc, TP content, FRAP values and color indices. Also, correlations between investigated parameters were established by regression analysis.

Significant results

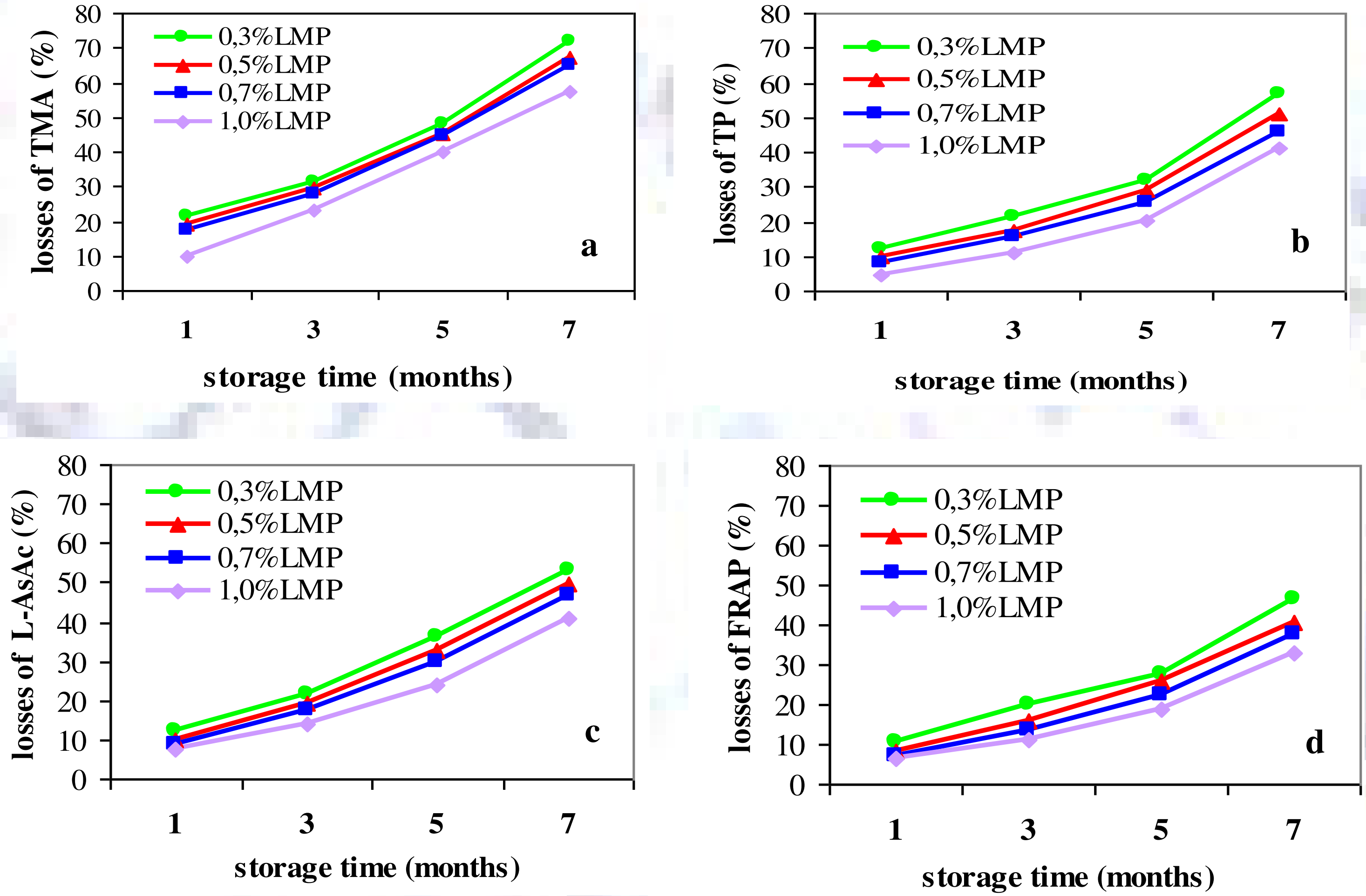


Figure 5. The relative losses of investigated parameters in response to jam storage at 20°C (a: TMA; b: TP; c: L-AsAc; d: FRAP)

Table 5. Changes in the jam color quality in response to LMP concentration and storage period

Samples	storage time (months)				
	0	1	3	5	7
			CD (AU)		
1.0% LMP	**11.82±0.88^{a,A}**	**11.64±0.62^{a,A}**	**11.21±0.77^{a,A}**	**10.53±0.86^{a,A}**	**10.07±0.77^{a,A}**
0.7% LMP	11.68±0.83^{a,A}	11.28±0.78^{a,A}	10.92±0.80^{a,A}	10.24±0.78^{a,A}	9.81±0.78^{a,A}
0.5% LMP	11.47±0.64^{a,A}	11.03±0.68^{a,A}	10.37±0.62^{a,A}	9.95±0.70^{a,A}	9.55±0.82^{a,A}
0.3% LMP	**11.25±0.81^{a,A}**	**10.51±0.86^{a,A}**	**10.08±0.83^{a,A}**	**9.52±0.65^{a,A}**	**9.31±0.73^{a,A}**
			PC (%)		
1.0% LMP	**9.98±0.65^{a,A}**	**10.91±0.65^{a,A}**	**13.02±0.71^{b,A}**	**17.00±0.78^{c,A}**	**22.14±1.21^{d,A}**
0.7% LMP	10.70±0.85^{a,A}	12.07±0.72^{a,A}	14.38±0.64^{b,A}	20.90±1.15^{c,B}	24.26±1.12^{d,A}
0.5% LMP	11.94±0.87^{a,A}	13.69±0.70^{a,B}	16.68±0.78^{b,B}	23.82±0.98^{c,C}	28.38±1.33^{d,B}
0.3% LMP	**13.78±1.11^{a,B}**	**16.46±0.86^{a,C}**	**19.54±0.93^{b,C}**	**28.47±1.44^{c,D}**	**33.51±1.77^{d,C}**

PC (%) increased, while CD decreased in response to jam storage, depending on LMP level. At the end of storage, the highest value of %PC and the lowest value of CD were recorded in jam samples obtained with the lowest level of LMP.

For major losses of TMA only minor changes were found for CD, proving the stability of jam color during long-term storage and also, the stability of color provided by PP formed in response to storage.

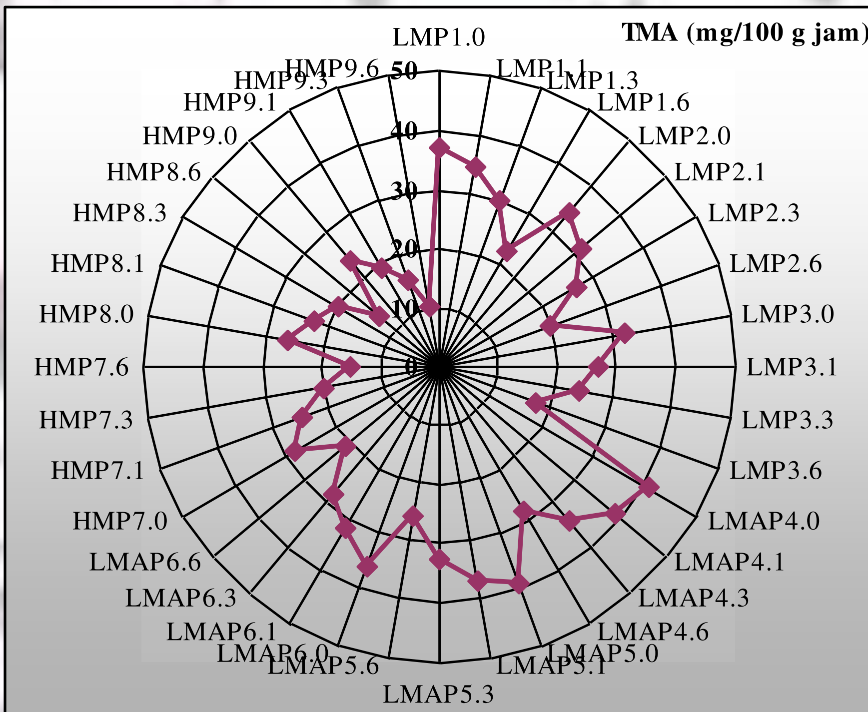
The impact of pectin type and dose on color quality and antioxidant properties of blackberry jam

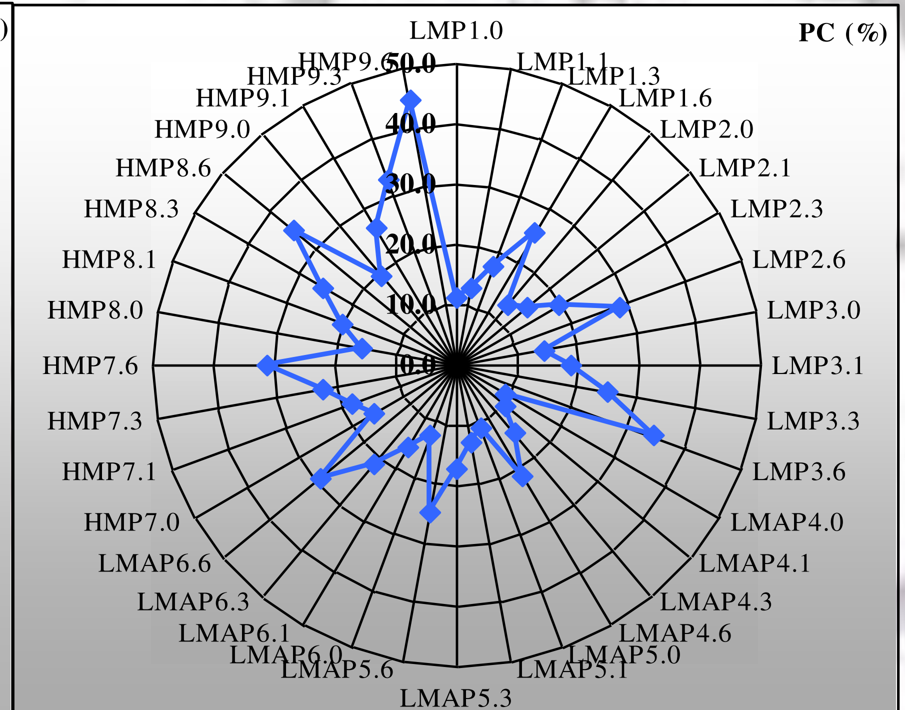
Aim

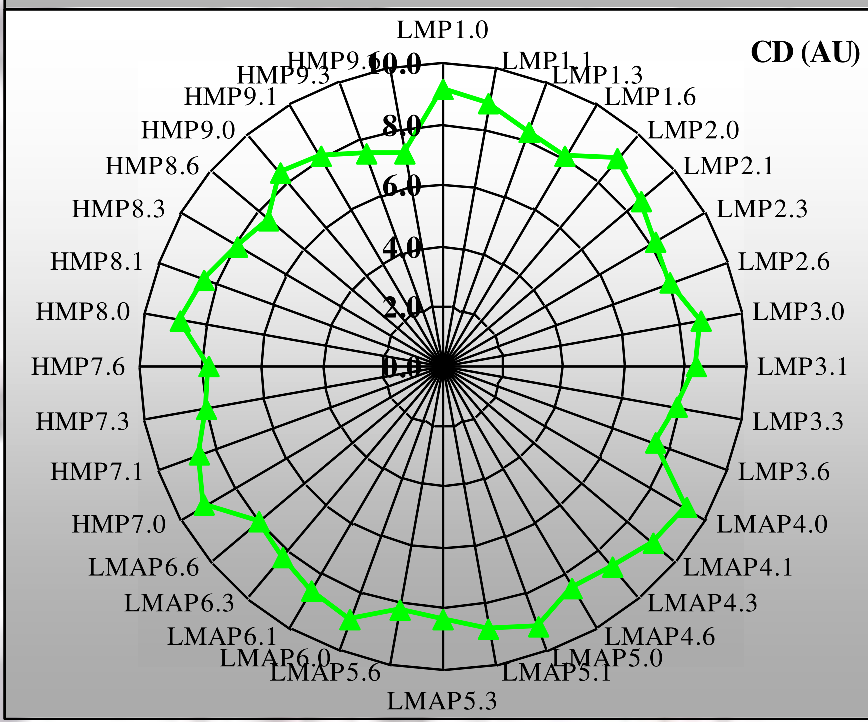
In the last years pectin and other hydrocolloids have been studies for improving the color stability and **retaining** of bioactive compounds in gelled fruit products.

The study shown in ***selected paper 6*** has been directed to explore the effects of pectin type (HMP: high-methoxyl pectin, LMP: low-methoxyl pectin and LMAP: low-methoxyl amidated pectin) and dosage (0.3, 0.7 and 1.0%) on color and antioxidant properties of blackberry jams after processing and during 6 months of storage at ambient temperature.

Jam samples were investigated in terms of TMA, FRAP values, TP, CD and PC (%).



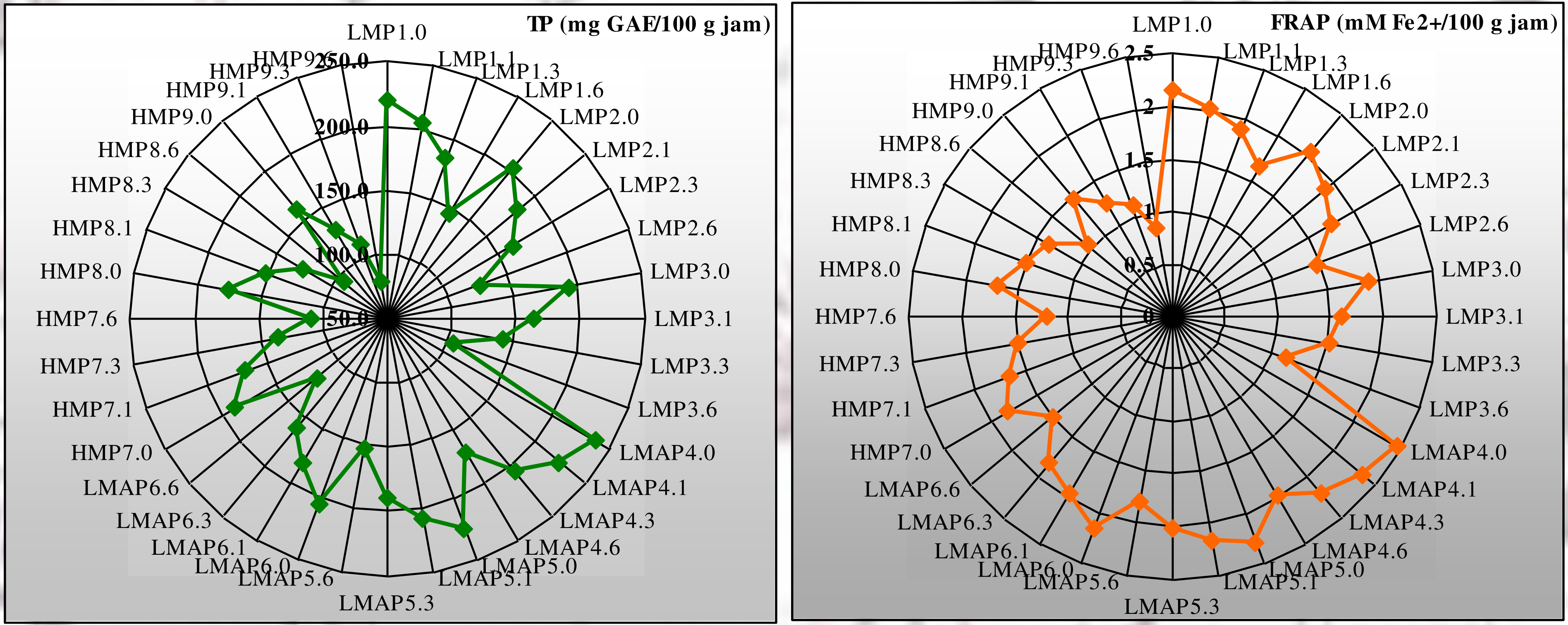




Legend: LMP1: LMP 1%; LMP2: LMP 0.7%; LMP3: LMP 0.3%; LMAP4: LMAP 1%; LMAP5: LMAP 0.7%; LMAP6: LMAP 0.3%; HMP7: HMP 1%; HMP8: HMP 0.7% and HMP9: HMP 0.3%.

In samples labeled as LMP1.0, LMP1.6 and so on, the number after point represents the storage time (e.g. LMP1.0: LMP1 one day post-processing; LMP1.6: LMP1 after 6 months of storage).

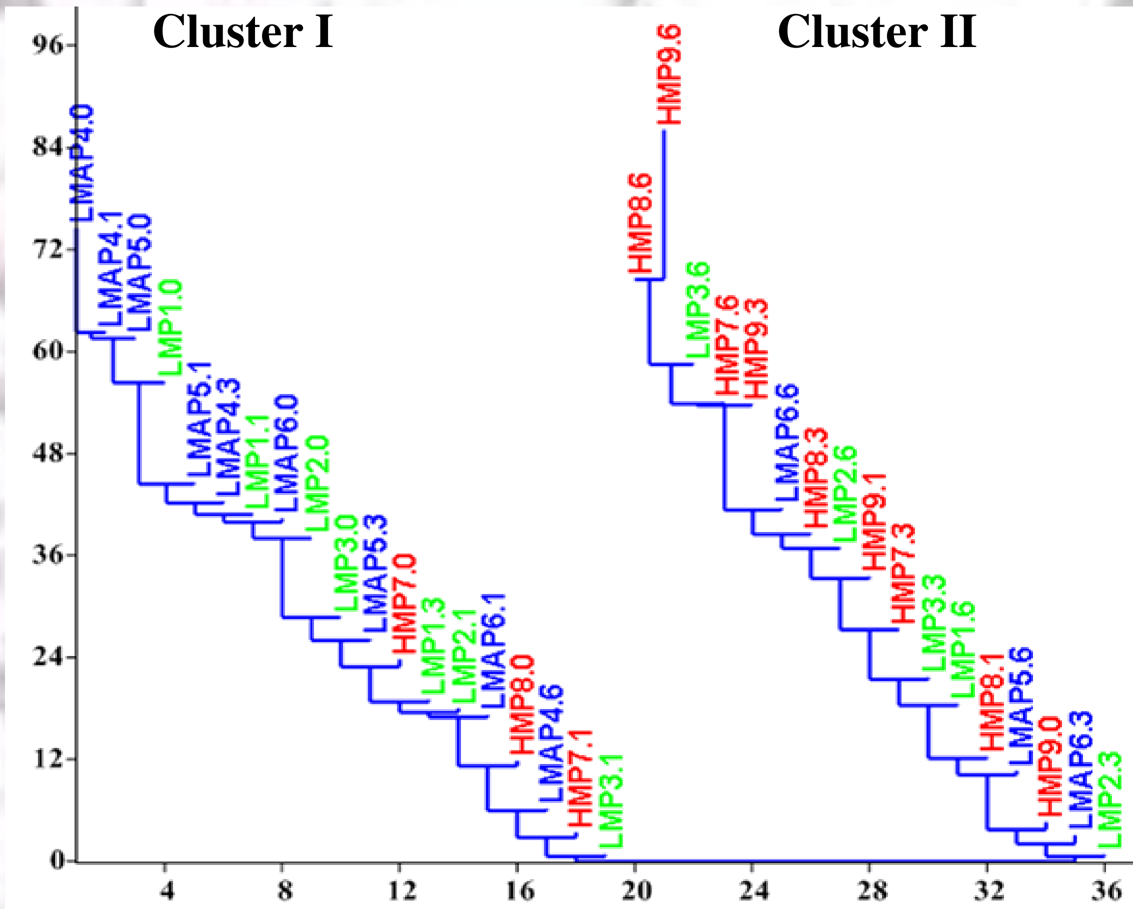
Figure 6
Star representation of TMA, CD and PC % variation during jam storage



Legend: LMP1: LMP 1%; LMP2: LMP 0.7%; LMP3: LMP 0.3%; **LMAP4: LMAP 1%;** LMAP5: LMAP 0.7%; LMAP6: LMAP 0.3%; HMP7: HMP 1%; HMP8: HMP 0.7% and **HMP9: HMP 0.3%.**
In samples labeled as LMP1.0, LMP1.6 and so on, the number after point represents the storage time.

Figure 7
Star chart of TP and FRAP variation during jam storage

The star chart representation of TP variation during jam storage highlights that the highest value of TP it was found in sample LMAP4.0 and the lowest in HMP9.6. The highest value of FRAP corresponds to LMAP4.0 and the lowest to HMP9.6. The sample LMAP4 followed by LMAP5 present the smallest losses of FRAP values at the end of storage.



Legend: LMP1: LMP 1%; LMP2: LMP 0.7%; LMP3: LMP 0.3%; LMAP4: LMAP 1%; LMAP5: LMAP 0.7%; LMAP6: LMAP 0.3%; HMP7: HMP 1%; HMP8: HMP 0.7% and HMP9: HMP 0.3%. In samples labeled as LMP1.0, LMP1.6 and so on, the number after point represents the storage time.

Cluster I

LMAP4.0>LMAP5.0>LMAP4.1>LMP1.0>LMAP5.1>LMAP6.0>LMAP4.3>LMP1.1>LMP2.0>LMAP5.3>LMP3.0>LMAP6.1>LMP2.1>LMP1.3>LMAP4.6>LMAP6.3>HMP7.0>LMP3.1

Cluster II

LMP2.3>HMP8.0>LMAP5.6>HMP7.1>LMP3.3>HMP9.0>HMP8.1>LMP1.6>LMAP6.6>HMP7.3>LMP2.6>HMP8.3>HMP9.1>LMP3.6 >HMP9.3>HMP7.6>HMP8.6>HMP9.6

Figure 8
Representation of Neighbor-Joining Cluster analysis of jams based on TMA, TP and FRAP

From Neighbor-Joining Cluster analysis, *Figure 8,* based on TMA, TP and FRAP it can be noted two clusters:

Cluster I: joining the jam formulations that retain the highest levels of antioxidant parameters

Cluster II: revealing the formulations with largest losses of antioxidant properties in response to storage.

Scientific contributions of the author to the current state-of-knowledge

Regarding the effect of IQF process and long term frozen storage

- **The IQF did not affect the content of bioactive compounds in the investigated wild berries. Contrary, the long-term frozen storage induced significant changes in the content of investigated bioactive compounds and color quality of berries.**
- At the end of 10 month of frozen storage, the smallest losses of antioxidant activity were recorded for blueberries and the highest for raspberries
- The color of raspberries was the most sensitive to long-term frozen storage while the color of blueberry and blackberry was more stable during frozen storage.

Regarding the effect of jam processing and storage

- **Fruit thermal processing led to significant losses in the content of L-AsAc, TP and FRAP values. Moreover, jam storage at 20°C brings along additional alterations of these compounds.**
- The extent of recorded losses was closely related to the fruit species and jam formulation (pectin type and dosage).
- **Anthocyanin pigments from berries were extensively degraded in response to thermal processing and storage with a great impact on colour quality and antioxidant properties.**

- Among strawberry, cherry and sour cherry, the first one exhibited the highest losses of bioactive compounds in response to jam processing. Moreover, strawberry jam showed the lowest tolerance to storage conditions in terms of investigated properties. The best retention of antioxidant properties and color in response to jam processing and storage was recorded for sour cherry jam.

- **CD of jam samples decreased by increasing of storage time, whereas the percent of polymeric color increased.**

- **There is a close connection between the increasing of PC(%) and the decreasing of TMA due to their gradual inclusion in polymeric pigments matrix during jam storage.**

- **The rate of the color loss was much slower than the rate of TMA degradation suggesting that the color of polymeric pigments replaced a part of the color lost due to anthocyanins degradation.**

- **PP show antioxidant properties, which compensate for a part of antioxidant capacity lost as a results of monomeric anthocyanins destruction during storage.**

- **Pectin was involved in the color stabilization of gelled fruit products.**

- **The best stabilization of jam color in response to thermal processing and storage was achieved by LMAP followed by LMP and HMP.**

- **Low-esterified pectins have proven better stabilizing effects on anthocyanins in fruit gelled products than high-esterified pectins. Among the jams obtained with pectins having similar DE, the best retention was noticed by using of amidated pectin.**

- **The retention of bioactive compounds and jam color stability were strongly dependent on pectin type and dosage. A high level of bioactive compounds in jam could be related to a high dose of pectin.**

- **LMAP to a level of 1% is the most indicated for processing of bilberry and blackberry jam with the highest antioxidant properties and color stability.**

3. Scientific achievements concerning the capitalization of some by-products from food processing

This research discusses the potential of some by-products of wine and fruit processing industry as a source of valuable compounds.

The targets of this research direction are, as follows:

i. **obtaining of crude freeze-dried extracts rich in polyphenolic compounds from pomace and grape seeds;**
ii. **assessing the inhibitory potential of freeze-dried grape seeds extract against oxidative lipid degradation occurring in sunflower oil used in some food thermal applications;**
iii. **obtaining and characterization of some oils from fruit processing by-products.**

As a result of this research, 2 ISI quoted papers have been published, as follows:

P7. **Poiana M.A.** ***Enhancing oxidative stability of sunflower oil during convective and microwave heating using grape seed extract.*** International Journal of Molecular Sciences. **2012**, 13(7): 9240-9259.

P8. Popa V.M., Bele C., **Poiana M.A.,** Dumbrava D., Raba D.N., Jianu C. ***Evaluation of bioactive compounds and of antioxidant properties of some oils obtained from food industry by-products***. Romanian Biotechnological Letters, **2011**, 16(3):6234-6241.

What was the motivation that drove me toward this research direction?

Using of agro-food industry by-products as a source of bioactive compounds represents nowadays an efficient and environmentally friendly way for their valorisation as potential natural food additives or supplements with high nutritional value.

Wine industry generates every year huge amounts of grape pomace which is considered an important low-cost raw material used for extraction of value-added compounds such as polyphenols.

The natural extracts obtained from wine industry by-products could be used as potential antioxidants to improve the oxidative stability of edible oils subjected to various food thermal applications which require high temperatures.

The thermal treatments of oil induces compositional changes by decomposition of polyunsaturated, monounsaturated and saturated fatty acids.

Lipid oxidation is the main degradation process occurring during heating of edible oils at high temperatures.

Another by-product discusses in this part is represented by kernels resulted from fruit processing.

Seeds of apricot, peach and plum resulted in large quantities as by-products from fruit canning industry. ***Fruit kernels are considered as a potential non-traditional source which can be exploited for oil obtaining due to its high content in oleic and linoleic acid.***

In addition to lipid fraction, these oils contain different bioactive compounds such as **β-carotene** (provitamin A) and **tocopherols** in four vitamin E congeners called α–tocopherol (α–T), β–tocopherol (β–T), γ–tocopherol (γ–T), and δ–tocopherol (δ–T).

These natural antioxidants are important inhibitors against lipid oxidation in food and biological systems.

Assessment of inhibitory effect of grape seeds extract on lipid oxidation occurring in sunflower oil during some thermal applications

Aim

The research presented in ***selected paper 7*** has been done to exploit the potential of freeze-dried grape seed extract (GSE) derived from Merlot grapes variety GSE, as natural additive, **compared to synthetic antioxidant butylated hydroxytoluene (BHT) in order to inhibit the lipid oxidation in sunflower oil used in some food thermal applications** (e.g. **convective heating and microwave exposure** up to 240 min under simulated frying conditions).

The progress of lipid oxidation was monitored by chemical indices: peroxide value (PV), p-anisidine value (p-AV), conjugated dienes and trienes (CDs, CTs), inhibition of oil oxidation (IO) and TOTOX value.

Additionally, total phenolic content (TP) was evaluated in oil samples before and after heating for highlighting the changes in their content relative to the extent of lipid oxidation.

Significant results

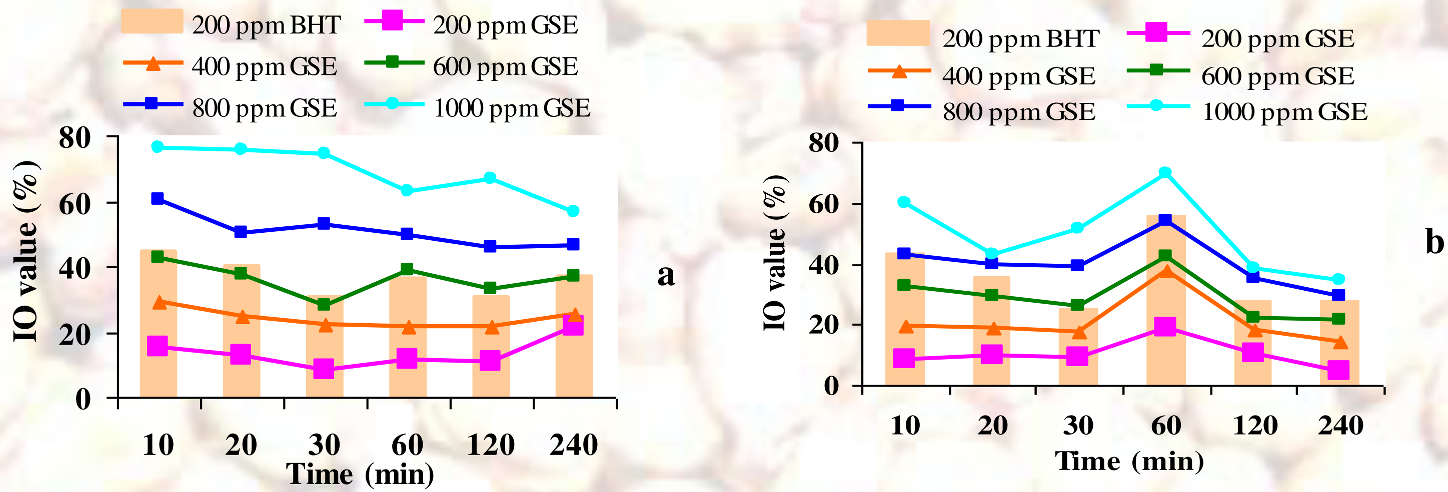


Figure 9. Inhibitory effect of GSE and BHT on primary lipid oxidation during oil heating (a: convective heating; b: microwave heating)

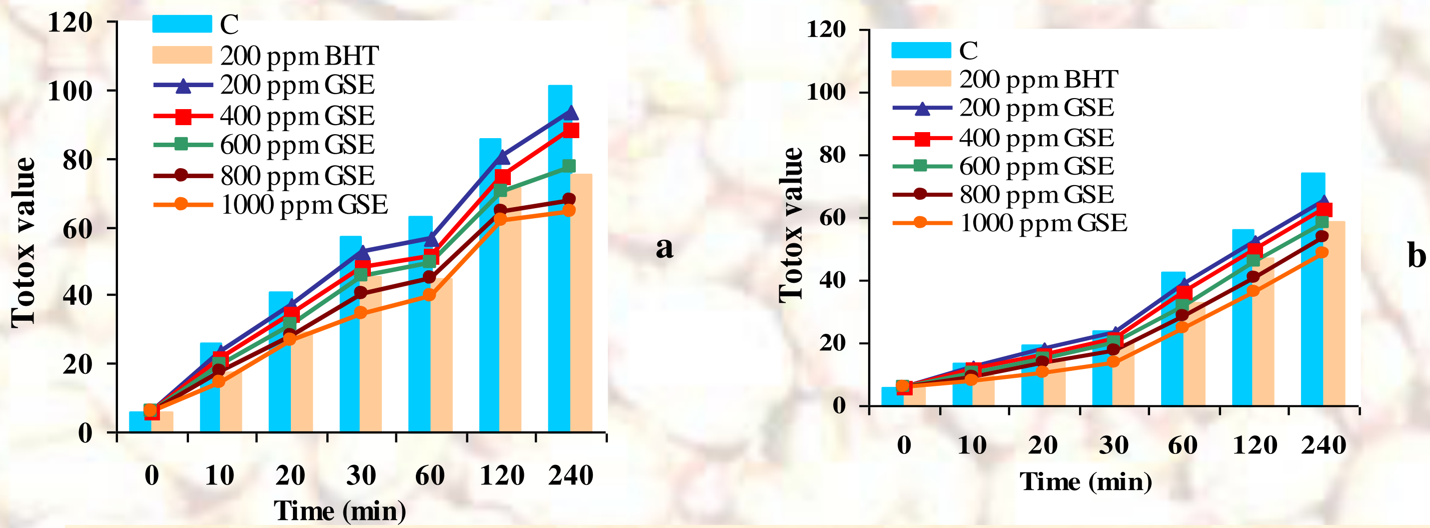


Figure 10. Impact of GSE and BHT on TOTOX value during sunflower oil heating (a: convective heating; b: microwave heating)

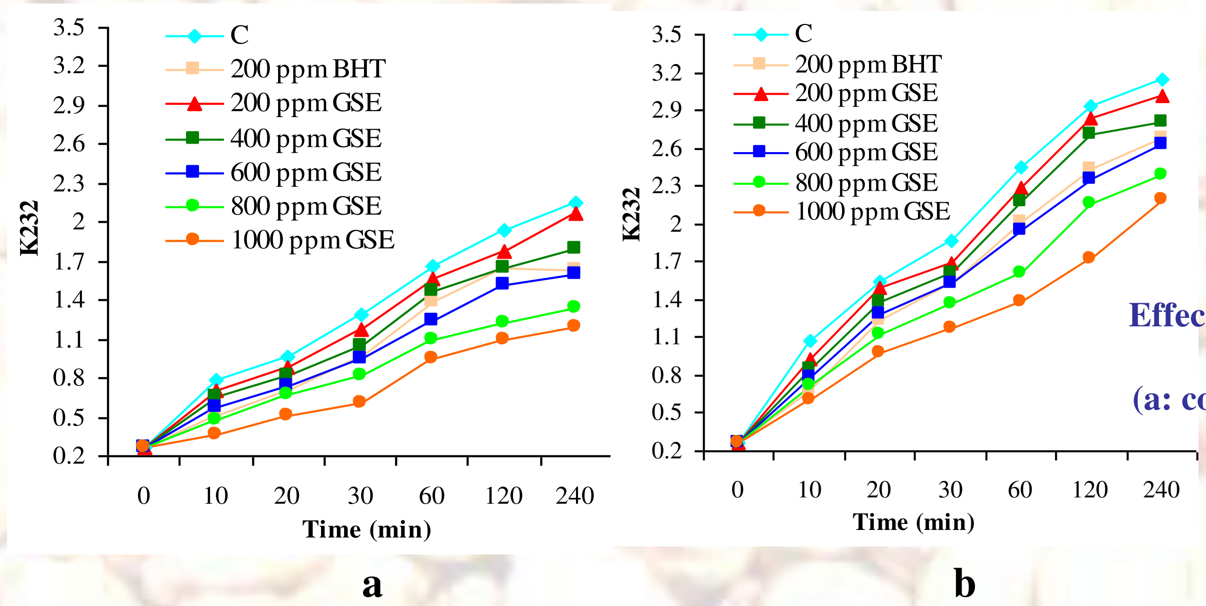


Figure 11
Effect of supplementation with GSE and BHT on K232 during oil heating (a: convective heating; b: microwave heating)

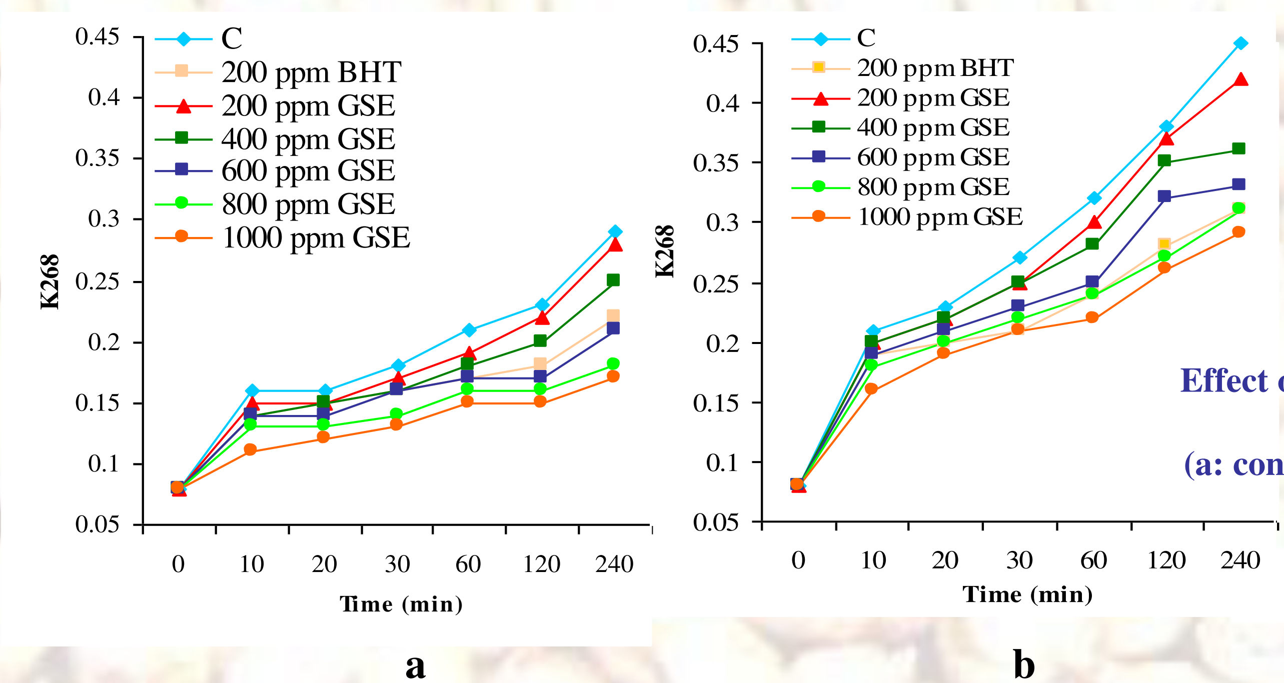


Figure 12
Effect of supplementation with GSE and BHT on K268 during oil heating (a: convective heating; b: microwave heating)

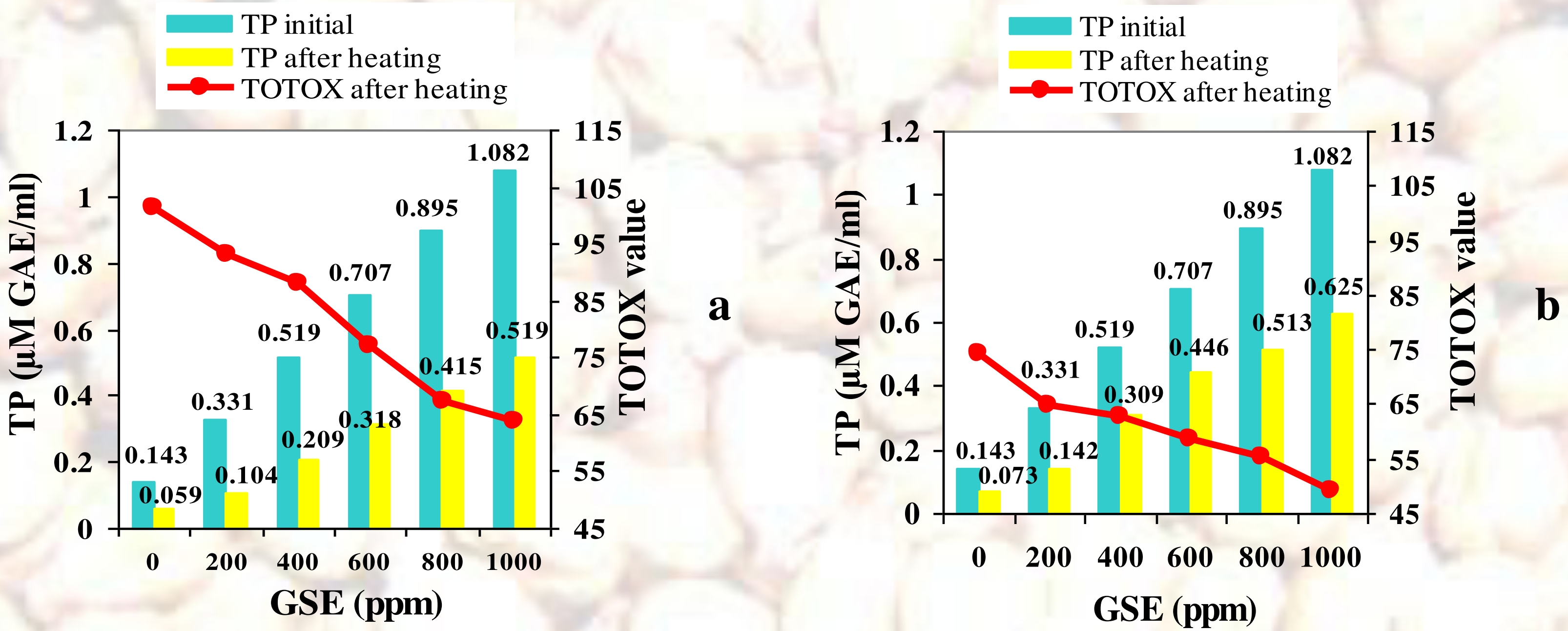


Figure 13. Impact of heating on TP content in oil samples with GSE related to TOTOX value (a: convective heating; b: microwave heating)

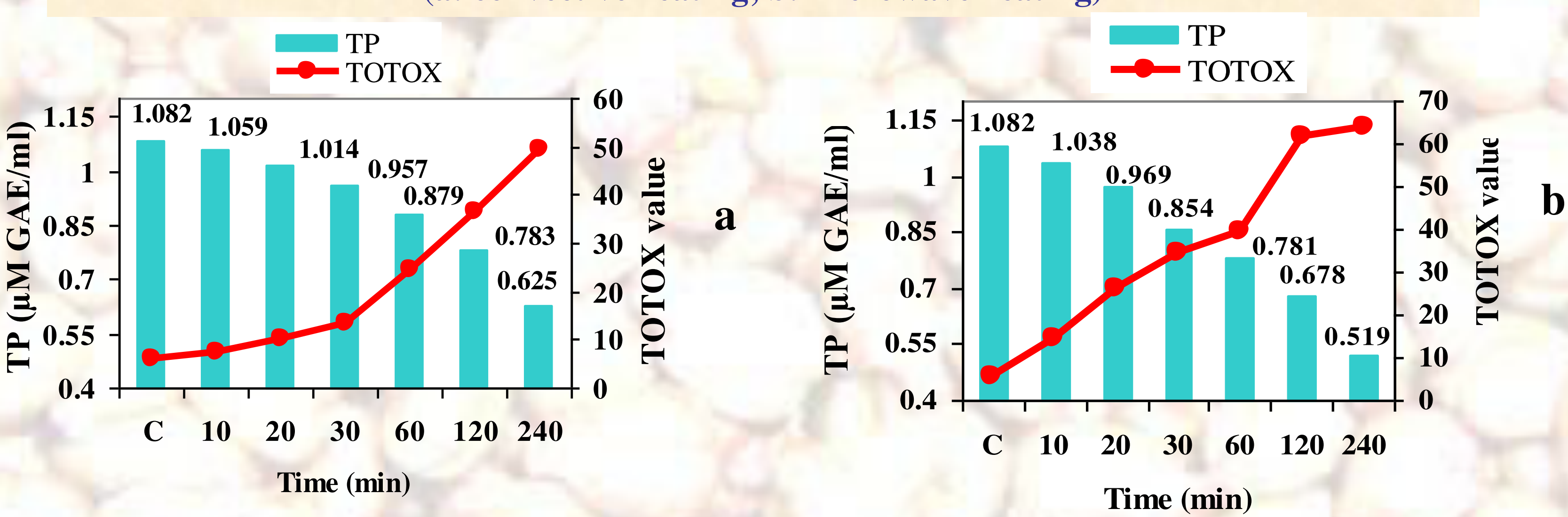


Figure 14. Alterations of TP in oil with GSE (1000 ppm) related to TOTOX value during heating (a: convective heating; b: microwave heating)

Assessing the antioxidant properties and some bioactive compounds of fruit kernel oils obtained from fruit processing by-products

Aim

The objective of the study presented in ***selected paper 8 was to exploit the potential of apricot and plum kernels, resulted as by-products in fruit canning industry*** to obtain crude oils as well as to investigate the kernel oils in terms of antioxidant capacity and some bioactive compounds content such as: β-carotene, α–, β–, γ– and δ–tocopherols (α–T, β–T, γ–T, δ–T) and total phenolics.

Plum *(Prunus domestica) and* apricot *(Prunus armeniaca)* kernels were purchased at a small-scale fruit canning factory (season 2004, 2005 and 2006) from Western Romania.

Scientific contributions of the author to the current state of knowledge

Regarding the inhibitory effect of grape seeds extract on lipid oxidation in sunflower oil used in food thermal applications

- The potential of GSE to enhance the oxidative stability of sunflower oil during thermal applications was dose-dependent in the studied range: 200–1000 ppm.
- Oil supplementation with GSE to a level in the range 600–800 ppm inhibited the lipid oxidation in a similar manner to BHT, while a level of GSE over 800 ppm provided better protection against thermo-oxidative degradation of sunflower oil more than BHT.
- The extent of lipid oxidation was greater in samples heated in microwave oven than in convective heating.
- TP content of oil samples significantly contributed to inhibitory potential of GSE against lipid oxidation developed in the heating time. The total antioxidant capacity is inversely related to the extent of lipid oxidation in the investigated conditions.
- GSE is a very effective inhibitor against lipid oxidation in oil samples subjected to thermal applications at high temperatures and can be recommended as a potential natural antioxidant for edible oils industry.

Regarding the plum and apricot kernel oil quality

- The apricot and plum kernels represent a potential source of valuable oil containing high amounts of tocopherols, β-carotene and phenolics compounds. The content of these compounds was strongly dependent on the harvest year and fruit species.

- The correlation between FRAP and TP content reveal a high dependence of these parameters.

- TP content is a potential candidate as a selection criterion for antioxidant activity of fruit kernel oil, but antioxidant activity of these oils is not limited only to phenolics compounds.

- Both kernel oils showed very characteristic tocopherol pattern in which β+γ–T is the predominating one. α and δ–T were detected in minor amounts in both kernel oils. Lack of separation of β– and γ–T using RP–HPLC method, did not introduce major error in the quantification of these isomers because vegetable oils contain small quantities of β–T as compared to γ–T.

4. Scientific achievements concerning the use of some natural bioactive compounds for prevention and control of mycotoxin production in cereals

The research activity on this topic were performed for achieving the objectives of the project SEE-ERA.NET PLUS, ERA 139/01 **[http://www.cereals-mycotoxins.ro],** implemented in the period 2010-2012, with theme: "***Systems to reduce mycotoxin contamination of cereals and medicinal plants in order to preserve native species and traditional products in Romania-Serbia-Croatia***" in which I was involved as researcher.

The targets of this research are following:

i. **assessing the mycotoxin contamination of cereals and medicinal herbs in the west aria of Romania;**
ii. **evaluating the inhibitory potential of some natural extracts and essential oils on mycotoxins production in cereals.**

As a result of this research, 2 ISI quoted papers have been published.

P9. Alexa E., **Poiana M.A., Sumalan R.M.** *Mycoflora and ochratoxin A control in wheat grain using natural extracts obtained from wine industry by-products*. International Journal of Molecular Sciences. **2012**, 13(4):4949-4967.

P10. Sumalan R.M., Alexa E., **Poiana M.A.** *Assessment of inhibitory potential of essential oils on natural mycoflora and Fusarium mycotoxins production in wheat*. Chemistry Central Journal. **2013**, 7:32.

What were the main reasons for performing this research?

The most important groups of mycotoxins which can be found in cereals used for food and feed consumption are: aflatoxins, ochratoxins, trichothecenes (deoxynivalenol, nivalenol), zearalenone and fumonisins.

Nowadays, there is highlighted the need to use the natural bioactive substances for prevention and control the mycotoxins accumulation in cereal grains.

The natural antioxidants have proven some effects on fungal growth and mycotoxin production.

***Resveratrol*, a valuable polyphenol from grape skins and seeds, was investigated for its inhibitory effect on *Fusarium* species and mycotoxins production.**

Also, *essential oils from different herbs and aromatic plants and natural formulas with antioxidant activity* have been investigated as potential inhibitors against fungus development and mycotoxin production

Impact of treatment with natural extracts from wine industry by-products on ochratoxin A production in wheat grain

Aim

The aim of the research detailed in ***selected paper 9*** **was to evaluate the potential of two freeze-dried crude extracts obtained from wine industry by-products (grape pomace extract**: **GPE** and **grape seeds extract: GSE** derived from Cabernet Sauvignon grapes variety, Recas winery, harvest year 2010) compared to a synthetic food antioxidant (BHT), in order to control ochratoxin A (OTA) production in naturally contaminated wheat.

The wheat samples were treated with different concentrations of GPE, GSE and BHT (500, 1000, 2500 ppm) and kept in storage conditions (temperature 20°C, aw =0.85) for 7, 14, 21 and 28 days. Then , the samples were analyzed in terms of fungal population and OTA content (by enzyme-linked immunosorbent assay using ELISA-RIDASCREEN tests).

The effect of treatment with essential oils on Fusarium mycotoxins production in wheat grain

Aim

In the study presented in ***selected paper 10* it was investigated the inhibitory potential of some essential oils *derived from aromatic herbs and spices*:** *Melissa officinalis* (O1), *Salvia officinalis* (O2), *Coriandrum sativum* (O3), *Thymus vulgaris* (O4) *Mentha piperita* (O5) and *Cinnamomum zeylanicum* (O6) against *Fusarium* mycotoxins production in relation with their antioxidants properties.

For this purpose, wheat samples were treated with six essential oils at three levels (500, 1000 and 2000 ppm) and incubated for 5 and 22 days at 25°C (aw =0.9). The mycotoxins were analyzed by enzyme-linked immunosorbent assay (ELISA).

Scientific contributions of the author to the current state-of-knowledge

- **OTA production was significantly inhibited by addition of natural freeze-dried extract** (GSE and GPE) obtained from wine-industry by-products.

- **GPE displayed a better effect to control OTA synthesis than GSE**, although GPE does not have the highest polyphenols content, i.e. antioxidant capacity. We advanced the idea that the antifungal activity of natural extracts could be related not only to the level of antioxidant agents, but also to the profile of their polyphenolic compounds.

- **GPE and GSE are able to provide fungicidal and fungistatic protection and also, to control the OTA production in wheat grain at least similar to BHT.**

- **The treatment with essential oils from aromatic herbs and spices led to inhibition of *Fusarium* mycotoxins production (DON and FUMO) in wheat grain**.

- The best control on FUMO production was noted for essential oil from **cinnamon**, followed by essential oils from **peppermint** and **thyme**.

- The highest inhibition of fungal growth in response to treatment with essential oil was registered after 5 days and the inhibitory effect decreased after 22 days, probably due to the high volatility of essential oils.

- **There was not recorded a good correlation between *Fusarium* mycotoxins inhibition and antioxidant activity of essential oils** suggesting that, the antioxidant properties of essential oils have not a crucial role in the expression of antimycotoxin effect. Besides phenolic compounds from essential oils, there are other compounds involved in the expression of their inhibitory potential on *Fusarium* mycotoxins production.

Part I/Section II
Academic and professional achievements

Section II briefly presents the main professional and academic achievements after the Ph.D.

Overall, in the last 10 years, I published 23 articles in ISI quoted journals (*10* as *first author*, 1 as *corresponding author* and 12 as *co-author*), 7 books to CNCSIS recognized publishing houses, 4 book chapters and 2 practical work textbooks.

Also, I coordinated several research projects. In the last few years, I have completed a bilateral project Romania-Greece and a project funded by private sector.

I participated as researcher in the team of 7 national projects, 1 international research project and I have been short-term expert, responsible for curriculum analysis, in a POSDRU project.

PART II
Career evolution and development plans

The purpose of this part is to summarize and give an overview of the main ways for my further professional development.

The scientific development plans in my interest field is heading towards the same issues previously mentioned.

I will continue the research work related to bioactive compounds - antioxidant properties in food technology for a better assessment of some aspects concerning the impact of different factors, treatments, processing methods on these characteristics.

Also, in the next years, I plan to grow my research on several key directions.

For this purpose, the following research topics will be continued or will be developed:

- Studies concerning the possibility to enhance the color stability of fruit products by different copigments or cofactors addition.
- The identification of factors impacting on the level of polyphenolic compounds and polymeric pigments in red wines.
- Assessing the influence of different pre-treatments and techniques used to obtain berries juice on their polyphenolic compounds.
- Evaluation the effect of pre-treatments and drying methods on anthocyanins from various berries.
- Studies on improving the extraction of bioactive compounds from different agro wastes.
- The use of FTIR spectroscopy for monitoring the lipid oxidation during thermal processing and storage of vegetable oils.

The research activity for solving of previous research themes will be funded by national and European programs as well as by setting of some contracts with private sector.

A successful activity for this purpose is not possible without a solid team. **The consolidation of research team will be one of the main objectives for the next years**. The results could be significantly enhanced if the interdisciplinary research team will be enlarged with PhD students coordinated as a result of the Habilitation Thesis.

The strategies applied for my future career development will be focused on increasing the scientific visibility of our university in international community.

This will be possible by involving in common research projects, exchange of Master or PhD students, exchange of researchers and publishing of some scientific materials.

Improving the cooperation with researchers and professors from different research centres and universities both from EU countries and Romania **will be a priority** of the research group.

As a form of exploitation of the results obtained in the research activity, new courses content will be created to cover topics that are of interest and there are not included in the existing courses.

Additionally, I intend to prepare a teaching program closely related to the needs and motivation of students. I'm fully aware that the main purpose of the teaching/learning process is to provide to learners a set of knowledge and skills used by them to meet their needs of knowledge and communication.

Therefore, I intend to adopt a dynamic form of teaching which can meet multiple objectives and also, can be easily adapted to the teaching needs.

I will be focused to enhance the teaching qualities and also, I will try to give to my students the opportunity to get more involved in the activities which could develop their interests.

An important aspect in my future mentoring activity is the suggestion of appropriate books for master and PhD students, recommendation to study research articles and providing advice, support and guidance throughout this study.

Finally, it has to be underlined that my active role will increase in the future and the main indicators to quantify my professional evolution will be researches, lectures, and practical works developed in the mentioned directions.

In order to fulfil the ones previously mentioned, the following future actions will be taken:

- Applying the project proposals in research and teaching directions.
- Including the results obtaining from research in the teaching programs, mainly for Master and PhD.
- The consolidation of research team by including of Master and PhD students.
- Creating and also, developing of collaborations with national and international partners working in the same field.
- Publishing the books and articles in specialized journals (especially ISI quoted) together with other researchers and professors on the topics in our field of interest.
- Participation with new research topics to international symposiums.
- Improving the cooperation with the economic field, especially in practical research directions.

Thank you for your attention!

Presentation of the Habilitation Thesis

3rd of April, 2014 / “Politehnica” University of Timisoara

Avenue V. Parvan no. 6, Room B17