ANTIOXIDANT EFFICACY OF CRANBERRY PRESS CAKE EXTRACTS ON THE OXIDATION OF MECHANICALLY SEPARATED TURKEY

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Introduction

Lipid oxidation is a major cause of quality deterioration in muscle foods (*1*) Oxidation could be retarded by the addition of antioxidants exogenously to food systems (*2*). Due to the safety and toxicity concerns related to synthetic food antioxidants (*3*), consumers prefer the use of natural antioxidants in food products. Cranberry press cake is an under utilized by-product of cranberry processing industry. The press cake contains a number of phenolic compounds which could be used as potential food antioxidants(*4*).

Objectives

The objective of our research was to prepare extracts from powdered cranberry press cake and test their antioxidant efficacy in controlling the oxidation of mechanically separated turkey (MST). The antioxidant efficacy of cranberry press cake extracts were also compared with a chloroform extract of cranberry powder.

Methodology

Antioxidant extracts from powdered cranberry press cake was prepared using two extraction methods, solvent extraction (*5*) and Microwave Assisted Solvent Extraction (MASE) (*6*). Five different extraction solvents, 100% acetone, 50% acetone, 100% ethanol, 50% ethanol and water were used. The antioxidant extracts were evaporated, freeze dried and tested for their efficacy on MST at 0.15% based on the muscle weight. Antioxidant extract from cranberry powder (90MX from Ocean Spray Cranberries) was prepared by extraction using (1:1) chloroform and methanol. The chloroform phase was separated, evaporated, freeze dried and tested for its antioxidant efficacy on MST at 0.01%, 0.05%, 0.1% and 0.2% of the muscle weight. Ethanol was used as the antioxidant carrier solvent. The total phenolic content of the antioxidant extracts were determined as quercetin equivalents. Oxidation of MST was monitored by the measurement of thiobarbituric acid reactive substances (TBARS) and lipid peroxides.

Results & Discussion

Irrespective of the method of extraction, the press cake extracts prepared using, 100% ethanol, 100% acetone, 50% ethanol or 50% acetone, significantly ($p<0.01$) increased the oxidative stability of MST compared to the control when oxidation was measured in terms of TBARS (**Table 3, 5)** and lipid peroxides (**Table 4, 6**). The water extracts of cranberry press cake prepared by MASE or solvent extraction did not have any significant ($p>0.01$) effect in controlling the oxidation of MST. Among all the press cake extracts, the microwave extract (MASE) prepared using 100% ethanol and the solvent extract prepared using 100% acetone, were most effective in inhibiting lipid oxidation. When compared to the control which oxidized in 5 days, the MASE extract prepared using 100% ethanol and added at 0.15% of muscle weight could inhibit TBARS formation for up to 12 days and a solvent extract prepared using 100% acetone could inhibit oxidation for around 11 days. In comparison, a chloroform extract prepared from cranberry powder could inhibit TBARS formation for up to 20 days at 0.05% level and 35 days at 0.1% level while the control was completely oxidized in 15 days (**Table 7)**. Although, at similar levels of usage, the cranberry powder extract was more effective than the cranberry press cake extracts in inhibiting the oxidation of MST, the yield of the press cake extracts was much higher compared to the powder extracts (**Table 2)**. Among the different press cake extracts, the overall effectiveness in controlling the oxidation of MST in terms of TBARS measurements were: 100% acetone, MASE 100% ethanol> 100% ethanol > 50% ethanol, 50% acetone, MASE 50% ethanol, MAE 100% acetone, MASE 50% acetone > water, MASE water, where water, ethanol and acetone indicate the solvents used for extraction. However, when the total phenolic content of the press cake extracts were measured as quercetin equivalents (QE), the decreasing order of quercetin equivalents were 100% acetone > MASE 100% acetone > 100% ethanol, 50% ethanol, MASE 100% ethanol, MASE 50% acetone > 50% acetone > water and MASE water (**Table 1**). The water extracts had the lowest phenolic content of around 0.022 QE/g of extract while the acetone extract had the maximum phenolic content of 0.53 QE/g of extract. The difference in the quercetin equivalent of the extracts and their corresponding antioxidative efficacy indicate that the total phenolic content may not be a good parameter to estimate the antioxidant efficacy of the press cake extracts.

Between the two extraction methods, MAE and solvent extraction, the addition of water to the organic solvents increased the yield of the MAE extracts (**Table 2**). Hence, for the same amount of starting material i.e. powdered cranberry press cake, the extracts obtained using MAE could protect more amount of MST compared to the extracts obtained using simple solvent extraction.

Conclusions

Among all the cranberry press cake extracts obtained using solvent extraction and MAE, the two extracts obtained using 100% acetone extraction and 100% ethanol MASE extraction, inhibited the oxidation of MST most in terms of TBARS measurement. When water was present in the organic extraction solvents, the antioxidative potential of the extracts were similar irrespective of the method of extraction. However, the yield of the press cake extracts using MASE was higher than that prepared using solvent extraction.

The water extracts were the least inhibitive of all the extracts in inhibiting the oxidation of MST. At a similar level of usage, extracts prepared from cranberry powder was more effective in inhibiting the oxidation of MST compared to press cake extracts. However, when the cost of the starting raw material is considered, cranberry press cake is much cheaper than cranberry powder (*4*). Moreover, the yield of the press cake extracts was much higher than that of powder extracts. Hence, on an economy of scale, cranberry press cake may be a useful raw material for the preparation of food grade antioxidant extracts.

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Tables and Figures

Table 1. Quercetin Equivalents of Cranberry Press Cake Powder Extracts: Microwave Assisted Solvent Extraction (MASE) vs. Simple Solvent Extraction[a]

Solvents used for extraction	Quercetin equivalents (mmole/ g of extract)	
	MASE	Solvent extraction
Ethanol (100%)	0.30 ± 0.03	0.24 ± 0.09
Ethanol (50%)	0.12 ± 0.12	0.28 ± 0.01
Acetone (100%)	0.53 ± 0.08	0.40 ± 0.04
Acetone (50%)	0.27 ± 0.03	0.23 ± 0.10
Water	0.022 ± 0.01	0.024 ± 0.01
Chloroform:Methanol*	–	0.23 ± 0.00

[a] n = 2

MASE: Microwave assisted solvent extraction at 125^{o}C (10 min ramp, 10 min hold)

*Cranberry powder was extracted using 1:1 chloroform and methanol. The chloroform phase was used for determining the yield.

Table 2. Yields of Cranberry Press Cake Powder Extracts: Microwave Assisted Solvent

Extraction (MASE) vs. Simple Solvent Extraction

Solvent used for extraction	Yield in terms of dry powder weight (%)	
	MASE	Solvent extraction
Ethanol (100%)	2.13	2.17
Ethanol (50%)	7.75	2.35
Acetone (100%)	2.99	2.92
Acetone (50%)	3.70	2.51
Water	17.6	9.97
Chloroform:Methanol*	–	0.3

MASE: Microwave Assisted Extraction at 125◦C (10 min ramp, 10 min hold)

*Cranberry powder was extracted using 1:1 chloroform and methanol. The chloroform phase was used for determining the yield.

Table 3. Effect of various extracts of powdered cranberry press cake obtained by MASE on the TBARS measurement of MST[a].

	TBARS (μmole/ kg of MST)					
		100%	50%	100%	50%	
Days	Control	EtOH	EtOH	Acetone	Acetone	Water
0	3.3 ± 0.8	2.9 ± 0.2	4.3 ± 0.4	3.2 ± 0.4	3.4 ± 0.5	2.4 ± 0.5
3	5.1 ± 0.8	3.6 ± 1.7	3.5 ± 2.1	4.0 ± 1.2	5.1 ± 0.8	4.3 ± 0.7
7	3.9 ± 0.1	3.5 ± 0.1	8.1 ± 1.1	6.47 ± 0.9	8.4 ± 3.2	19.8 ± 0.2
9	20.8 ± 0.2	6.5 ± 1.6	18.8 ± 2.1	11.9 ± 1.3	16.3 ± 0.3	41.5 ± 4.2
12	30.4 ± 0.0	9.0 ± 2.8	44.2 ± 11	37.9 ± 2.3	42.0 ± 2.8	–
14	–	25.2 ± 11	–	–	–	–
16	–	43.9 ± 6.0	–	–	–	–

[a] n = 2

All extracts were added at 0.15% of the muscle weight. MST: Mechanically separated turkey; MASE: Microwave assisted solvent extraction; EtOH: Ethanol; Control: MST; Solvents used for extraction: 100% ethanol, 50% ethanol (1:1 ethanol and water), 100% acetone, 50% acetone (1:1 acetone and water) and water.

Table 4. Effect of various extracts of powdered cranberry press cake obtained by MASE on the lipid peroxide measurement of MST.

	Lipid peroxide (mmole/ kg of MST)					
		100%	50%	100%	50%	
Days	Control	EtOH	EtOH	Acetone	Acetone	Water
0	0.063	0.095	0.062	0.141	0.064	0.074
3	0.083	0.126	0.124	0.117	0.132	0.152
7	0.20	0.17	0.19	0.18	0.26	0.66
9	0.50	0.20	0.22	0.22	0.23	0.58
12	0.53	0.53	0.59	0.54	0.48	–
14	–	0.65	–	–	–	–

All extracts were added at 0.15% of the muscle weight. Abbreviations: See Table 3.

Table 5. Effect of various extracts of powdered cranberry press cake obtained by solvent extraction on the TBARS measurement of MSTa.

	TBARS (μmole/ kg of MST)					
		100%	50%	100%	50%	
Days	Control	EtOH	EtOH	Acetone	Acetone	Water
0	3.3 ± 0.8	3.5 ± 0.8	4.6 ± 1.1	3.3 ± 0.6	3.8 ± 0.8	2.7 ± 0.2
3	5.1 ± 0.8	3.6 ± 0.8	2.8 ± 0.7	3.5 ± 0.4	2.8 ± 1.0	3.6 ± 0.5
7	3.9 ± 0.1	5.7 ± 0.2	6.2 ± 0.9	4.7 ± 0.1	5.0 ± 0.5	16.2 ± 0.5
9	20.8 ± 0.2	9.6 ± 2.1	18.2 ± 0.4	6.8 ± 0.7	12.2 ± 2.1	33.9 ± 2.9
12	30.4 ± 0.0	25.6 ± 1.9	52.3 ± 9.3	14.0 ± 2.3	34.8 ± 11	–
14	–	34.6 ±0.9	–	19.0 ± 3.1	–	–
16	–	–	–	40.0 ± 1.2	–	–

[a] n = 2

All extracts were added at 0.15% of the muscle weight. MST: Mechanically separated turkey; EtOH: Ethanol; Control: MST; Solvents used for extraction: 100% ethanol, 50% ethanol (1:1 ethanol and water), 100% acetone, 50% acetone (1:1 acetone and water) and water.

Table 6. Effect of various extracts of powdered cranberry press cake obtained by solvent extraction on the lipid peroxide measurement of MST.

	Lipid peroxide (mmole/ kg of MST)					
		100%	50%	100%	50%	
Days	Control	EtOH	EtOH	Acetone	Acetone	Water
0	0.063	0.077	0.059	0.097	0.056	0.058
3	0.083	0.123	0.097	0.136	0.088	0.134
7	0.20	0.20	0.21	0.21	0.25	0.60
9	0.50	0.21	0.21	0.21	0.22	0.59
12	0.53	0.56	0.47	0.61	0.57	–
14	–	0.66	–	0.58	–	–

All extracts were added at 0.15% of the muscle weight. Abbreviations: See Table 5.

Table 7. Effect of different concentration of cranberry powder extracts prepared using chloroform: methanol (1:1) solvent extraction on the TBARS measurement of MSTa.

	TBARS (μmole/ kg of MST)				
Days	Control	0.01%	0.05%	0.1%	0.2 %
14	29.61 ±5.12	8.3 ± 1.8	1.7 ± 0.8	1.2 ± 0.1	1.5 ± 0.1
18	–	24.5 ± 7.1	1.9 ± 0.1	1.8 ± 0.6	2.0 ± 0.3
21	–	39.2 ± 15.3	8.9 ± 2.7	2.1 ± 0.3	1.8 ± 0.0
27	–	–	44.0 ± 3.4	4.6 ± 1.7	3.6 ± 2.0
34	–	–	90.8 ± 6.8	5.2 ± 1.6	2.3 ± 0.0
42	–	–	–	86.5 ± 7.3	6.2 ± 3.0

a n = 2

MST: Mechanically separated turkey; Extracts were added to MST based on the muscle weight. Amount added = 0.01%, 0.05%, 0.1% and 0.2%.