ISSN: 2307-4124 (Online)
2308-7943 (Print)

JOURNAL OF

FOOD CHEMISTRY & NUTRITION

ESci Journals
www.escijournals.net

Published By:
ESci Journals Publishing

Journal of
Food Chemistry
&
Nutrition

Vol. 03 No. 01, 2015

Published By:
ESci Journals Publishing
Office S-183, Malikabad Arcade, 6th Road Rawalpindi, Pakistan.
Available online at:
http://www.escijournals.net/JFCN

Mamoona Anwer
Managing Editor,
Journal of Food Chemistry and Nutrition
P-157 Green View Colony Faisalabad,
Pakistan.

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Available Online at ESci Journals
Journal of Food Chemistry and Nutrition
ISSN: 2307-4124 (Online), 2308-7943 (Print)
http://www.escijournals.net/JFCN

CHARACTERIZATION OF NUTRIENTS IN CAROTENOID-ENRICHED FULL FAT SOY FLOUR AND RICE BRAN PRODUCED BY RED YEAST FERMENTATION

[a,b] Ananda K. Nanjundaswamy, [a]Praveen V. Vadlani

[a] Bioprocessing and Renewable Energy Laboratory, Bioprocessing and Industrial Value Added Program (BIVAP), 1980 Kimball Ave., Department of Grain Science and Industry, Kansas State University, Manhattan, K.S., 66506 USA.

[b] Department of Agriculture, School of Agriculture, Research, Extension and Applied Sciences (AREAS), Alcorn State University, 1000 ASU Dr., Lorman, MS, 39096 USA.

A B S T R A C T

Carotenoids are used as feed additives for improved animal health and to produce quality animal products. Fermentation of corn whole stillage, rice bran, soybean flour etc by carotenogenic or red yeasts can result in carotenoid-enriched animal feed. Usually, the prescribed dietary dosage of carotenoids like astaxanthin and β-carotene is 1-120µg/g feed. In a previous study, *Phaffia rhodozyma*-fermented full fat rice bran and *Sporobolomyces roseus*-fermented full fat soy flour resulted in highest astaxanthin yield of 80µg/g feed and β-carotene of 836µg/g feed respectively. The aim of this study was to qualitatively and/or quantitatively evaluate the nutrition profiles of these two fermented products. In both products, there was reduction in crude fiber, crude protein and amino acids whereas the crude fat content was enhanced in rice bran and reduced in soy flour respectively; the levels of some amino acids like hydroxyproline, hydroxylysine and ornithine were enhanced; oleic acid increased by 83% in *S. rosues*-fermented soy flour whereas stearic acid was enhanced by 389% in *P. rhodozyma*-fermented rice bran; and trypsin inhibitor was reduced to undetectable levels in carotenoid-enriched soy flour. Both fermented substrates contained 1 to 3% glucans and, 2.4 to 5.7% mannans, and glucosamine ranging from 0.13 to 4.6%. In addition to high levels of carotenoids, red yeast fermentation of both soy flour and rice bran yielded a suite of nutrients and the final product could be used to make 'feed blends' to provide adequate nutrients based on the dietary requirements of the animals.

Keywords: Glucan, glucosamine, mannan, *Phaffia rhodozyma, Sporobolomyces roseus*.

Abbreviations: ADF Acid Detergent Fiber. ATCC American Type Culture Collection. DDGS. distillers dried grain with soluble. K Potassium. MOS Mannan Oligosaccharide. NDF Neutral Detergent Fiber. N Nitrogen. P Phosphorous. S sulfur. TI Trypsin inhibitor.

INTRODUCTION

Yeast and yeast-based products that are typically rich in proteins, vitamins and minerals have been used as animal feed additives and are known to promote animal health resulting in improved quality of animal products. Supplementation of active dried brewer's yeast *Saccharomyces cerevisiae* in various animal feeds is known to improve immune response, confer disease resistance and offer protection from pathogens (Bontempo *et al.,* 2006; Burgents *et al.,* 2004; Li and Galtin III 2005), improve milk yield in dairy cattle (Desnoyers *et al.,* 2009; Robinson and Erasmus 2009; Wang *et al.,* 2009) and enhance animal growth and feed conversion (Dominguez-vara *et al.,* 2009; Olivia-Teles and Goncalves 2001; Holtshausen and Beauchemin 2010; Moallem *et al.,* 2009; Mohamed *et al.,* 2009; Tripathi and Karim 2010). Several other yeasts like *Rhodosporidium paludigenum* (Yang *et al.,* 2010), *Candida* sp (Mahnken *et al.,* 1980; Sajeevan *et al.,* 2006; Sarlin and Philip 2011), *Phaffia rhodozyma* (Akiba *et al.,* 2001; Bjerkeng *et al.,* 2007; Johnson *et al.,* 1980; Sanderson and Jolly 1994), *Debaryomyces hansenii* (Sarlin and Philip 2011) and *Yarrowia lipolytica* (Hatlen *et al.,* 2012) are also beneficial to animal growth and performance when supplemented into animal feeds. Organic forms of minerals like selenium, chromium, iron or zinc for animal nutrition

* Corresponding Author:
Email ID: ananda@alcorn.edu

can be provided by *S. cerevisiae* (Dominguez-vara *et al.,* 2009; Fokkink *et al.,* 2009; Schrauzer 2006; Wang *et al.,* 2009), *Candida* sp., *Kluyveromyces* or *Pichia* sp. (Paš *et al.,* 2007; Roepcke *et al.,* 2011). Finally, yeast cell wall polysaccharides like β-D glucans and α-D-mannans (Mannan Oligosaccharide MOS) are also beneficial to animal health.

Carotenoids producing *P. rhodozyma* yeast cells are additives in poultry and aquaculture feeds (Jacobson *et al.,* 2003; Johnson *et al.,* 2010) and are beneficial to animal health (Amar *et al.,* 2004; Bjerkeng *et al.,* 2007; Sanderson and Jolly 1994; Takimoto *et al.,* 2007). According to the U.S. Food and Drug Administration, the dried and killed *P. rhodozyma* cells are permitted as a salmonid feed colorant to provide up to 80mg/kg of astaxanthin in the finished feed (USFDA; 21 CFR Section 73.355; Barrows *et al.,* 2003). To provide natural carotenoids in animal feeds, Ananda and Vadlani (2010a) developed the carotenoid fermentation of corn whole stillage, a coproduct of corn ethanol predominantly used as animal feed. Monoculture and mixed culture fermentation of red yeasts *P. rhodozyma* and *Sporobolomyces roseus* of corn whole stillage not only provided carotenoids but also enriched crude fat and polyunsaturated fatty acid by up to 81% and contained 77%-less fiber (Ananda and Vadlani 2010b). Similar carotenoid enrichment of several animal feeds like soybean products, rice bran and wheat bran, resulted in highest astaxanthin and β-carotene concentrations of 80 µg/g and 836 µg/g in *P. Rhodozyma*-fermented full fat rice bran and *S. roseus*-fermented full fat soy flour respectively (Ananda and Vadlani 2011). The aim of this study was to qualitatively and quantitatively characterize nutrients in the highest β-carotene producing *S. roseus*-fermented full fat soy flour and highest astaxanthin producing *P. rhodozyma*-fermented full fat rice bran. The effect of red yeast fermentation on anti-nutritional factor namely trypsin inhibitor (TI) in soybean flour and levels of yeast cell wall polysaccharides in the resultant animal feed were also evaluated.

MATERIALS AND METHODS

The samples generated for Ananda and Vadlani (2011) were nutritionally profiled in this study. The details of sample preparation, media preparation and fermentation conditions are outlined in Ananda and Vadlani (2010a, 2011).

Nutrition Analysis: Nutrition composition analyses of the fermented samples and controls were conducted to include total amino acid profile, total fatty acid profile, crude fat and protein, NDF and ADF and P, S and K. Further, samples were also profiled for glucosamine, glucose and mannose and the latter two were used to calculate yeast cell wall polysaccharides—glucans, mannans respectively according to Friemund *et al.* (2005) and soy flour samples were sampled for anti-nutritional factor, trypsin inhibitor. Samples from two replicates were pooled before analysis. Statistical analyses is not provided since the main objective of this study was to quantitatively and qualitatively estimate the nutrients in the highest astaxanthin yielding *P. rhodozyma*-fermented full fat rice bran and highest β-carotene yielding *S. roseus*-fermented full fat soy flour. Nutrient estimates from other treatments are provided only as a reference. About 5 g of each representative sample from each treatment was analyzed at Agricultural Experiment Station Chemical Laboratories, University of Missouri (Columbia, MO) for %NDF (JAOAC 56, 1352-1356, 1973), %ADF (AOAC Official Method 973.18 (A-D), 2006), total amino acid profile (AOAC Official Method 982.30E (a, b, c), chapter 45.3.05 (17)), total fatty acid profile (AOAC Official Method 996.06, AOCS Official Method Ce2-66, AOAC Official Method 965.49, AOAC Official Method 969.33 (17)), crude fat (acid hydrolysis, AOAC Official Method 954.02 (17)) and crude protein (Kjeldahl method, AOAC Official Method 984.13 (A-D) (17)). Estimation of % P, K and S was conducted at the Analytical Laboratory, Department of Animal Science and Industry, Kansas State University (Manhattan, KS).

RESULTS

The nutrition profiles of maximum carotenoid yielding *S. roseus*-fermented soy flour and *P. rhodozyma*-fermented rice bran were of interest. Overall, yeast fermentations resulted in reduction of protein and fiber in soy flour and rice bran, and enhancement of fat in rice bran (Tables 1 and 2) and reduction in crude fat in fermented soy flour samples (Table 1). In fact, *S. roseus*-fermented soy flour exhibited the least reduction in crude protein, fat, and its fiber reduction was three times lesser than that of *P. rhodozyma*-fermented soy flour (Table 1). *P. rhodozyma*-fermented rice bran exhibited the highest reduction in crude protein and crude fiber, and the least increase in crude fat (Table 2). Trypsin-inhibitor in the control (unfermented and unautoclaved *ie.,* raw) soy flour was 49,500 TIU/g and was reduced by 85% to 7,550 TIU/g by autoclaving alone (without any fermentation), and to indeterminate levels in both *S. roseus* and *P. rhodozyma* treatments (Table 1). Yeast polysaccharides like mannans and glucans absent in control soy flour were detected in the fermented samples with around 2.5% mannan and glucan each in *S. roseus* fermentation.

Table 1. Nutrition profile of *S. roseus*-fermented full fat soy flour (FFSF) which produced maximum β-carotene*.

Components [a]	Control	Mixed culture	*P. rhodozyma*	*S. roseus*
%Crude Protein [b]	35.81	30.98 (↓13.5%)	22.87 (↓36%)	30.95 (↓13.5%)
%Crude Fat [c]	16.26	14.2 (↓12%)	9.67 (↓41%)	14.1 (↓12%)
%Crude fiber	5.23	4.87 (↓12%)	3.34 (↓36%)	4.59 (↓7%)
%NDF	9.72	10.49 (↑8%)	7.3 (↓25%)	10.34 (↑6%)
%ADF	5.79	7.44 (↑28.5%)	2.64 (↓54%)	5.18 (↓10.5%)
%N	5.7	5.0 (↓12%)	3.7 (↓35%)	5.0 (↓12%)
%P	0.45	0.56 (↑24%)	0.4 (↓11%)	0.56 (↑24%)
%K	1.64	1.55 (↓5.5%)	1.19 (↓27%)	1.54 (↓6%)
%Mannan	-	3.23	1.01	2.38
% Glucann	-	3.52	2.43	2.48
%Glucosamine	-	0.3	1.96	4.61
Trypsin Inhibitor (TIU/g) [g]	49,500 [d] 7,550 [e]	1,456 (↓81%) [f]	n.d	n.d

*836.55µg/g as detailed in Ananda and Vadlani (2011).

[a]Numbers in parentheses indicate the % increase (↑) or decrease (↓) compared to the control; Maximum increase or decrease is boldfaced; n.d not-detected; [b]Kjeldahl; [c]Acid hydrolysis; [d]Trypsin inhibitor in unautoclaved control sample of full fat soy flour; [e]Trypsin inhibitor in autoclaved control sample of full fat soy flour reduced by 85% compared to unautoclaved control; [f]% reduction compared to autoclaved control sample [e]; [g]TIU/g converted to mg/g according to Stauffer (1990).

Table 2. Nutrition profile of *P. rhodozyma*-fermented full fat rice bran (FFRB) which produced maximum astaxanthin*.

Components [a]	Control	Mixed culture	*P. rhodozyma*	*S. roseus*
%Crude Protein [b]	13.46	12.32 (↓8%)	12.1 (↓10%)	12.78 (↓5%)
%Crude Fat [c]	15.91	25.94 (↑63%)	20.64 (↑30%)	24.78 (↑56%)
%Crude fiber	7.71	6.31 (↓18%)	5.81 (↓25%)	5.97 (↓23%)
%NDF	18.35	13.48 (↓26.5%)	13.53 (↓26%)	12.85 (↓30%)
%ADF	9.59	6.49 (↓32%)	6.31 (↓34%)	5.8 (↓40%)
%N	2.2	2.0 (↓9%)	1.9 (↓14%)	2.0 (↓9%)
%P	1.95	1.68 (↓14%)	1.74 (↓11%)	1.71 (↓12%)
%K	1.34	1.53 (↑14%)	1.26 (↓6%)	1.27 (↓5%)
%Mannan	-	2.75	1.1	2.5
% Glucann	-	5.65	4.77	4.93
%Glucosamine	-	0.13	0.37	0.42

*80.42 µg/g in Ananda and Vadlani (2011).

[a]Numbers in parentheses indicate the % increase (↑) or decrease (↓) compared to the control; Maximum increase or decrease is boldfaced; [b]Kjeldahl; [c]Acid hydrolysis.

The amino sugar, glucosamine found lacking in the control was found to be the highest in *S. roseus* treatment at 4.6% (Table 1). Among all three treatments, least amount of mannan (1.1%), and glucan (4.7%) were found in *P. rhodozyma*-fermented rice bran with 0.37% glucosamine (Table 2).

The least amino acid reduction of 19% was seen in *S. roseus*-fermented soy flour and (Table 3) whereas a maximum reduction of 17% in amino acid content was seen in *P. rhodozyma* fermented rice bran (Table 4). In both substrates, the highest reduction in total amino acids was seen in *P. rhodozyma* fermentation.

Table 3. Amino acid profile of profile of *S. roseus*-fermented full fat soy flour (FFSF) which produced maximum B-carotene*.

Amino acids [a]	w/w%			
	Control	Mixed culture	*P. rhodozyma*	*S. roseus*
Taurine	0.05	0.06	0.05	0.06
Hydroxyproline	0.06	0.25	0.44	0.23
Aspartic Acid	3.73	2.87	1.9	2.92
Threonine	1.28	1.18	1.12	1.17
Serine	1.33	1.21	1.14	1.18
Glutamic Acid	5.86	4.91	1.39	4.68
Proline	1.64	1.29	0.77	1.34
Lanthionine	0.17	0.15	0.78	0.16
Glycine	1.5	1.52	0.99	1.58
Alanine	1.53	1.45	0.91	1.46
Cysteine	0.53	0.6	0.29	0.61
Valine	1.83	1.41	1.52	1.41
Methionine	0.47	0.37	0.26	0.37
Isoleucine	1.66	1.08	1.29	1.09
Leucine	2.68	1.82	1.7	1.82
Tyrosine	1.23	0.86	0.7	0.88
Phenylalanine	1.74	1.06	1.08	1.07
Hydroxylysine	0.01	0.13	0	0.22
Ornithine	0.03	0.23	0.06	0.24
Lysine	2.29	1.63	1.4	1.64
Histidine	0.98	0.76	0.72	0.79
Arginine	2.48	1.91	1.5	2.01
Tryptophan	0.43	0.33	0.27	0.35
Total	33.51	27.08 (↓19%)	20.28 (↓39%)	27.28 (↓19%)

*836.55µg/g as detailed in Ananda and Vadlani (2011). [a]Numbers in parentheses indicate the % decrease (↓) compared to the control and the maximum decrease is boldfaced.

Table 4. Amino acid profile of *P. rhodozyma*-fermented full fat rice bran (FFRB) which produced maximum astaxanthin*.

Amino acids [a]	w/w%			
	Control	Mixed culture	*P. rhodozyma*	*S. roseus*
Taurine	0.01	0.03	0.02	0.02
Hydroxyproline	0.05	0.18	0.17	0.2
Aspartic Acid	1.09	1.03	0.92	1.07
Threonine	0.46	0.55	0.52	0.54
Serine	0.46	0.55	0.49	0.56
Glutamic Acid	1.63	1.25	1.02	1.38
Proline	0.52	0.52	0.47	0.57
Lanthionine	0.06	0.06	0.08	0.07
Glycine	0.72	0.74	0.65	0.83
Alanine	0.81	0.74	0.67	0.75
Cysteine	0.27	0.25	0.2	0.29
Valine	0.75	0.68	0.66	0.67
Methionine	0.24	0.19	0.19	0.19

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Isoleucine	0.48	0.44	0.44	0.43
Leucine	0.9	0.84	0.79	0.83
Tyrosine	0.38	0.34	0.3	0.35
Phenylalanine	0.54	0.46	0.42	0.46
Hydroxylysine	0.03	0.08	0.03	0.06
Ornithine	0.01	0.02	0.01	0.02
Lysine	0.67	0.66	0.62	0.65
Histidine	0.41	0.3	0.31	0.3
Arginine	1.11	0.66	0.63	0.67
Tryptophan	0.1	0.1	0.07	0.11
Total	11.7	10.67 (↓9%)	9.68 (↓17%)	11.02 (↓6%)

*80.42 µg/g in Ananda and Vadlani (2011). [a]Numbers in parentheses indicate the % decrease (↓) compared to the control and the maximum decrease is boldfaced.

Tables 5 and 6 outline the fatty acid profiles in carotenoid-enriched full fat soy flour and rice bran respectively. Even though percent crude fat was reduced in the fermented soy flour samples compared to the control there was enhancement of several fatty acids (Table 5). The most abundant fatty acids accounting to more than 2% of total fat in full fat soy flour were linoleic acid, oleic acid, palmitic acid, linolenic and stearic acid in that order and the order remained unchanged even in the fermented treatments albeit changes in concentrations of fatty acids compared to the control (Table 5).

Table 5. Fatty acid profile of profile of *S. roseus*-fermented full fat soy flour (FFSF) which produced maximum B-carotene*.

Fatty Acid a (% of total fat)	Control	Mixed culture	P. rhodozyma	S. roseus
Myristic (14:0)	0.16	0.63	0.13	0.74
Myristoleic (14:1)	0	0	0	0
(C15:0)	0.03	0.16	0.07	0.14
Palmitic (16:0)	10.78	14.0	12.33	13.94
Palmitoleic (16:1)	0.1	0.9	0.11	0.98
(17:0)	0.12	0.11	0.17	0.1
(17:1)	0.07	0.11	0.08	0.11
Stearic (18:0)	4.68	2.48	6.29	2.15
Elaidic (18:1t9)	0.04	0.12	0.06	0.12
Oleic (18:1n9)	17.99	33.17	22.28	33.09
Vaccenic (18:1n7)	1.3	0	0.93	0
Linoleic (18:2)	53.3	38.41	48.18	38.51
Linolenic (ω18:3)	9.46	5.78	6.98	6.12
(ω18:4)	0.03	0	0.03	0
Arachidic (20:0)	0.42	0.34	0.51	0.29
(20:1n9)	0.15	0.4	0.12	0.36
(20:3 ω3)	0	0	0	0
Arachidonic (20:4n6)	0	0	0	0
Arachidonic (20:4 ω3)	0	0	0	0
(20:5 ω3; EPA)	0	0	0	0
Docosanoic (22:0)	0	0	0.01	0
Erucic (22:1n9)	0	0.07	0.01	0.07
(22:5 ω3; DPA)	0	0	0	0
(22:6 ω3; DHA)	0	0.08	0.02	0.08
Lignoceric (24:0)	0.16	0.56	0.27	0.62
Nervonic (24:1n9)	0	0.04	0	0.04
Crude Fat (by acid hydrolysis)	16.26	14.2 (↓12%)	9.67 (↓41%)	14.1 (↓12%)

*836.55µg/g as detailed in Ananda and Vadlani (2011). [a] in parentheses indicate the % decrease (↓) compared to the control and the maximum reduction is boldfaced.

Among the abundant fatty acids, palmitic acid and oleic acid levels were enhanced in all yeast treatments with maximum enhancement of 31% palmitic acid and 84% oleic acid in *S. roseus*-fermented soy flour (and mixed fermentation) compared to control. Interestingly, *S. roseus*-fermented soy flour (and mixed culture fermentation) showed spectacular enhancement of fatty acids accounting less than 1% of total fat: 880% yield enhancement for palmitoleic acid, 363% of myristic acid, 200% eladic acid and 288% lignoceric acid (Table 5). In the case of rice bran, three fatty acids namely oleic, linoleic and palmitic in that order accounted for 92% of total fat in full fat rice bran (Table 6). The abundant fatty acids in control rice bran were oleic acid>linoleic acid>palmitic acid>stearic acid>linolenic acid which was similar to that in mixed culture and *S. roseus* fermentation. However, in *P. rhodozyma* fermentation the order remained the same except that linoleic acid was greater than oleic acid (Table 6). Although *P. rhodozyma*-fermented rice bran exhibited 63% enhancement of crude fat, only a few of the major fatty acids like stearic acid and linoleic acid were enhanced by 389% and 9% respectively.

Table 6. Fatty acid profile of *P. rhodozyma*-fermented full fat rice bran (FFRB) which produced maximum astaxanthin*.

Fatty Acid [a] (% of total fat)	Control	Mixed culture	*P. rhodozyma*	*S. roseus*
Myristic (14:0)	0.49	0.6	0.18	0.58
Myristoleic (14:1)	0	0	0	0
(C15:0)	0.04	0.07	0.07	0.07
Palmitic (16:0)	16.35	15.62	16.42	14.96
Palmitoleic (16:1)	0.21	0.78	0.18	0.8
(17:0)	0.06	0.09	0.22	0.08
(17:1)	0.05	0.11	0.07	0.13
Stearic (18:0)	1.75	2.93	8.56	2.12
Elaidic (18:1t9)	0.05	0.13	0.08	0.13
Oleic (18:1n9)	40.68	44.58	31.03	46.82
Vaccenic (18:1n7)	0	0	0	0
Linoleic (18:2)	34.86	28.76	38.09	27.68
Linolenic (ω18:3)	1.42	2.29	1.15	2.46
(ω18:4)	0.04	0	0	0
Arachidic (20:0)	0.76	0.57	0.87	0.54
(20:1n9)	0.54	0.51	0.33	0.56
(20:3 ω3)	0	0	0	0
Arachidonic (20:4n6)	0	0	0	0
Arachidonic (20:4 ω3)	0	0	0	0
(20:5 ω3; EPA)	0	0	0	0
Docosanoic (22:0)	0	0	0	0
Erucic (22:1n9)	0.04	0	0.03	0
(22:5 ω3; DPA)	0	0	0	0
(22:6 ω3; DHA)	0.16	0.11	0.1	0.11
Lignoceric (24:0)	0.85	0.87	0.76	0.89
Nervonic (24:1n9)	0.03	0.03	0	0.05
Crude Fat (by acid hydrolysis)	15.91	25.94 (↑**63** %)	20.64 (↑30%)	24.78 (↑56%)

*80.42 µg/g in Ananda and Vadlani (2011). [a]Numbers in parentheses indicate the % increase (↑) compared to the control and the maximum increase is boldfaced.

DISCUSSION

Direct incorporation of carotenoid feed supplements like astaxanthin and β-carotene by red yeast fermentation of corn whole stillage was demonstrated by Ananda and Vadlani (2010a). Similar fermentation of nine agricultural products used as animal feed found that *S. roseus*-fermented full fat soy flour and *P. rhodozyma*-fermented full fat rice bran respectively yielded the highest β-carotene and astaxanthin (Ananda and Vadlani 2011). Overall, carotenoid-

fermented corn whole stillage (98 to 279 µg/g; Ananda and Vadlani (2010a)), *S. roseus*-fermented full fat soy flour (837µg/g) or *P. rhodozyma*-fermented full fat rice bran (80µg/g) contained carotenoids well over the prescribed dietary dosage of 1 to 120µg/g feed (An *et al.,* 2006; Hayek 2000) which can be used to make feed blends to provide the appropriate quantity of carotenoids. Carotenoid production in fermented-corn whole stillage, *S. roseus*-fermented full fat soy flour or *P. rhodozyma*-fermented full fat rice bran was accompanied by reduction in crude fiber and crude protein with varying levels of reduction. Contrastingly, yeast fermented rice bran enhanced crude fat similar to that observed in corn whole stillage (Ananda and Vadlani, 2010b), but was decreased in full fat soy flour. So, to provide adequate amount of carotenoids and other nutrients, *S. roseus*-fermented full fat soy flour or *P. rhodozyma*-fermented full fat rice bran can be used in 'feed blends' based on the dietary requirements of the animals (Ananda and Vadlani 2010a, 2011).

Irrespective of the effect of yeast fermentation on crude fat, the relative abundance of fatty acid composition of *P. rhodozyma* remained similar: the most abundant fatty acids were linoleic acid> oleic acid> palmitic acid>stearic acid>linolenic acid in soy flour, rice bran and whole stillage (Ananda and Vadlani 2010b). This was similar to that observed in commercial *P. rhodozyma* cells described in Sanderson and Jolly (1994). The abundance of fatty acids in *S. roseus*, unlike *P. rhodozyma* was variable: for example, in soy flour fermentation the order of fatty acid abundance was linoleic acid>oleic acid>palmitic acid>stearic acid whereas in rice bran the order was oleic acid>linoleic acid>palmitic acid> linolenic acid>stearic acid and in corn whole stillage (Ananda and Vadlani 2010b) it was vaccenic acid>linoleic acid>palmitic acid. Libkind *et al.* (2008) found that linoleic acid>oleic acid>palmitic acid were the major fatty acids in *Sporobolomyces patagonicus* and concluded that growth media influenced the fatty acid composition and abundance of red yeasts which is confirmed from the present study and that of Ananda and Vadlani (2010b). Nutrition profiling of mixed culture fermentation closely resembled that of *S. roseus* in all three substrates including whole stillage carotenoid fermentation outlined in Ananda and Vadlani (2010b). Fermentation media composition seems to influence *S. roseus* fatty acid composition more than that in *P. rhodozyma*.

Effect of red yeast fermentation on anti-nutrition factor like trypsin inhibitor: According to the soybean meal specifications mandated by the U.S. National Oilseed Processors Association (NOPA), the permissible limit of trypsin inhibitor (TI) is less than 4mg/g of soybean meal. Typically, raw soybean contains 20.9 to 31.1mg/g of TI, and in low-TI soybean varieties it could be as low as 9.9 mg/g (Herkelman *et al.,* 1992; Vandergrift *et al.,* 1983). Typically, TI interferes with the action of enzymes trypsin and chymotrypsin and impairs protein digestion especially in swine, poultry and fish (Liener 1994; Olli *et al.,* 1994; Palliyeguru *et al.,* 2011; van den Ingh *et al.,* 1991). So, heating soybean especially with moist heat like steaming or autoclaving (Combs *et al.,* 1967, Herkelman *et al.,* 1992; Khattab and Arntfield 2009; Mateos *et al.,* 2002; Reddy and Pierson 199; Vandergrift *et al.,* 1983), microbial fermentations (Barapama and Simard 1994, Hoffman et al., 2003, Khattab and Arntfield 2009; Meijer *et al.,* 1995; Osman 2004) and combination of heating and microbial fermentation (Reddy and Pierson1994) can reduce TI levels: the red yeast fermentation of soybean flour for animal feed not only enriched the feed with carotenoids required for animal health, but also eliminated the antinutritional factor trypsin-inhibitor that can interfere with animal nutrition.

Yeast cell wall components: In this study, carotenoid-enriched soy flour and rice bran animal feed contained 1.01 to 3.23% and 1.1 to 2.75% mannan respectively, and 2.43 to 3.52% and 4.77 to 5.65% glucans respectively. The routinely used dosage for both polysaccharides is 0.1 to 0.25% *ie.,* 1.0 to 2.5kg/ton animal feed in poultry, swine, cattle feed or aquaculture feed based on the animal growth phase (Center for Food and Nutrition Policy TAP Review 2002; Cook *et al.,* 2002). Yeast cell wall polysaccharides like β-D glucans and α-D-mannans promote animal health by immunomodulation, blocking bacterial adhesion in the gut thereby preventing bacterial infections and by adsorbing mycotoxins in animal feed and also by inhibiting their toxic effects, enhance weight gain, improve quality of milk in cattle and enhance feed conversion efficiency (Hayen and Pollmann 2001; Kogan and Kochar 2007; Noeck *et al.,* 2011, Zeković *et al.,* 2005). Since red yeast fermentations of full fat soy flour and rice bran yield 10- to 20-times the recommended dosage of glucans and mannans, the carotenoid-enriched feed can be used to make feed blends to provide

adequate concentration of yeast cell wall nutrients in animal nutrition.

Glucosamine is a structural component of cartilage. Glucosamine is often used as a nutraceutical for horses, pet animals and humans to relieve osteoarthritic conditions although the health benefits largely remain inconclusive (McFarlan *et al.,* 2004; Igarashi *et al.,* 2011; Pearson and Lindinger 2009). Since fungal cell wall chitin is made up of glucosamine, fungal or yeast fermentations of wild or genetically modified strains can yield glucosamine and have the potential to overcome the disadvantages associated with present production methods from crustacean shells (Deng *et al.,* 2012; Hsieh *et al.,* 2007; McFarlan *et al.,* 2004; Zhang *et al.,* 2012). In the present study, the red yeast fermented, carotenoid-enriched soy flour and rice bran contained 0.3 to 4.6% and 0.13 to 0.42% glucosamine respectively, and in both substrates *S*. *roseus* yielded the highest glucosamine levels.

CONCLUSIONS

High levels of carotenoids in *S*. *roseus*-fermented soy flour and *P*. *rhodozyma*-fermented rice bran are accompanied by reduced fiber, protein and amino acids, and respective enhancement or reduction of crude fat; almost complete elimination of antinutritional factor trypsin inhibitor in soy flour; and enrichment of health promoting yeast cell wall polysaccharides. Levels of carotenoids and yeast cell wall polysaccharides produced in excess of the daily dietary needs of animals by red yeast fermentation easily allows production of feed blends to provide adequate nutrients based on animal dietary requirements. *P*. *rhodozyma* and *S*. *roseus* fermentations of commonly used animal feeds are valuable in providing a suite of nutrients that are proven to improve animal health.

ACKNOWLEDGEMENTS

The authors are thankful to the Department of Grain Science and Industry, Kansas State University for funding this project. Special thanks to Dr. Karthik Venkateshan, BioMaterial Lab for his assistance in lyophilization, and Dr. Keerthi Mandyam for critical review and valuable inputs in manuscript preparation. Rice bran was provided by Nutracea Inc., Phoenix, AZ. This article is assigned contribution no. 13-121-J by the Kansas Agricultural Experiment Station, Manhattan, KS 66506.

REFERENCES

AOAC Official Method # 17 Official Methods of Analysis of AOAC INTERNATIONAL, 18th ed.; AOAC INTERNATIONAL: Gaithersburg, MD, USA, 2006.

Akiba, Y., K. Sato, K. Takahashi, K. Matsushita, H. Komiyama, H. Tsunekawa and H Nagao. 2001. Meat color modification in broiler chickens by feeding yeast *Phaffia rhodozyma* containing high concentrations of astaxanthin. J. Appl. Poultry Res. 10:154-161.

Amar, E.C., V. Kiron, S. Satoh and T. Watanabe. 2004. Enhancement of innate immunity in rainbow trout (*Oncorhychus mykiss* Walbaum) associated with dietary intake of carotenoids from natural products. Fish Shellfish Immunol. 16:527-537.

An, G.H., J.Y. Song, W.K. Kwak, B.D. Lee, K.B. Song and J.E. Choi. 2006. Improved astaxanthin availability due to drying and rupturing of the red yeast, *Xanthophyllomyces dendrorhus*. Food Sci. Biotechnol. 15:506-510.

Ananda, N and P.V. Vadlani. 2011. Carotenoid value addition of cereal products by monoculture and mixed culture fermentation of *Phaffia rhodozyma* and *Sporobolomyces roseus*. Cereal Chem. 88:467-472.

Ananda, N and P.V. Vadlani. 2010a. Production and optimization of carotenoid-enriched dried distiller's grains with solubles (DDGS) by *Phaffia rhodozyma* and *Sporobolomyces roseus* fermentation of whole stillage. J. Indus. Microbiol. Biotechnol. 37: 1183-1192.

Ananda, N and P.V. Vadlani. 2010b. Fiber reduction and lipid enrichment in carotenoid-enriched distillers dried grain with solubles produced by secondary fermentation of *Phaffia rhodozyma* and *Sporobolomyces roseus*. J. Agric. Food Chem. 58: 12744-12748.

Barampama, Z. and R.E. Simard 1994. Oligosaccharides, antinutritional factors and protein digestibility of dry beans as affected by processing. J. Food Sci. 59:833-838.

Barrows, J.N., A.L. Lipman and C.J. Bailey. 2003. Color additives: FDA's regulatory process and historical perspectives.

Bjerkeng, B., M. Peisker, K. von Schwartzenberg, T. Ytrestøyl and Åsgård. 2007. Digestibility and muscle retention of astaxanthin in Atlantic salmon, Salmo salar, fed diets with the red yeast *Phaffia rhodozyma* in comparison with synthetic formulated astaxanthin. Aquaculture 269:476-489.

Bontempo, V., A. Giancamillo, G. Savoini, V. Dell' Orto

and C. Domeneghini. 2006. Live yeast dietary supplementation acts upon intestinal morpho-functional aspects and growth in weanling piglets. Anim. Feed Sci. Technol. 129:224-236.

Burgents, J.E., K.G. Burnett and L.E. Burnett. 2004. Disease resistance of Pacific white shrimp, *Litopenaeus vannamaei*, following the dietary administration of a yeast culture food supplement. Aquaculture 231:1-8.

Center for Food and Nutrition Policy (CFNP) TAP Review. 2002. Yeast Derivatives. Center for Food and Nutrition Policy (CFNP), Virginia Tech-Alexandria August 2002.

Combs, G.E., R.G. Conness, T.H. Berry and H.D. Wallace. 1967. Effect of raw and heated soybeans on grain, nutrient digestibility, plasma amino acids and other blood constituents of growing swine. J. Anim. Sci. 26:1067.

Cook, M.T., P.J. Hayball, W, Hutchinson, B. Nowak and J.D. Hayball. 2002. Administration of a commercial immunostimulant preparation, Eco-ActivaTM as a feed supplement enhances macrophage respiratory burst and the growth rate of snapper (*Pagrus auratus*), Sparidae (Bloch and Schneider) in winter. J. Fish Shellfish Immunol. 12:1-13.

Deng, M., J.D. Angerer, D. Cyron, A.D. Grund, T.A. Jerrell, C. Leanna, O. Mathre, R. Rosson, J. Running, D. Severson, L. Song and S. Wassink. 2012. Process and materials for production of glucosamine and N-acetylglucosamine. US Patent no. 8124381.

Desnoyers, M., S. Giger-Reverdin, G. Bertin, C. Duvaux-Ponter and D. Sauvant. 2009. Meta-analysis of the influence of *Saccharomyces cerevisiae* supplementation on ruminal parameters and milk production of ruminants. J. Dairy Sci. 92:1620-1632.

Domínguez-Vara, I.A., S.S. González-Muñoz, J.M. Pinos-Rodríguez, J.L. Bórquez-Gastelum, R. Bárcena-Gama, G. Mendoza-Martínez, L.E. Zapata and L.L. Landois-Palencia. 2009. Effects of feeding selenium-yeast and chromium-yeast to finishing lambs on growth, caracass characteristics and blood hormones and metabolites. Anim. Feed Sci. Technol. 152:42.

Fokkink WB, Hill TM, Bateman II HG, Aldrich JM, Schlotterbeck RL (2009) Selenium yeast for dairy calf feeds. Anim. Feed Sci. Technol. 153:228-235.

Freimund, S., S. Janett, E. Arrigoni and R. Amado. 2005. Optimized quantification method for yeast derived 1, 3 beta-D glucann and alpha D mannan. European Food Res. Technol. 220: 101-105.

Hatlen, B., G.M. Berge, J.M. Odom, H. Mundheim and B. Ruyter. 2012. Growth performance, feed utilization and fatty acid deposition in Atlantic salmon *Salmo salar* L., fed graded levels of high-lipid/high-EPA *Yarrowia lipolytica* biomass. Aquaculture 364-365:39-47.

Hayek, M.G. 2000. Process for enhancing immune response in animals using b-carotene as a dietary supplement. US Patent no. US6133323.

Hayen, G.D. and D.S. Pollmann. 2001. Animal feeds comprising yeast glucan. US Patent No. 6,214,337.

Herkelman, K.L., G.L. Cromwell, T.S. Stahly, T.W. Pfiffer and D.A. Knabe. 1992. Apparent digestibility of amino acids in raw and heated conventional and low-trypsin-inhibitor soybeans for pigs. J. Anim. Sci. 70:818-826.

Hoffman, E.M., S. Muetzel and K. Becker. 2003. The fermentation of soybean meal by rumen microbes in vitro reveals different kinetic features for the inactivation and the degradation of trypsin inhibitor protein. Anim. Feed Sci. Technol. 106:189-197.

Holtshausen, L. and K.A. Beauchemin. 2010. Supplementing barley-based dairy cow diets with *Saccharomyces cerevisiae*. Prof. Anim. Scientist 26:285-289.

Hsieh, J.W., H.S. Wu, H.W. Yu and S.S. Wang. 2007. Determination and kinetics of producing glucosamine using fungi. Biotechnol. Progr. 23:1009-1016.

Igarashi, M., K. Sakamoto and I. Nagaoka. 2011. Effect of glucosamine, a therapeutic agent for osteoarthritis, on osteoblastic cell differentiation. Int. J. Mol. Med. 28:373-379.

Jacobson, G.K., S.O. Jolly, J.J. Sedmak, T.J. Skatrud and J.M. Wasileski. 2003. Astaxanthin over-producing strains of *Phaffia rhodozyma*, methods for their cultivation and their use in animal feeds. US Patent No. US 2003/0049241.

Johnson, E.A., H. Yang, B. Geldiay-Tuncer, W.T. Hall, D. Schreiher and K. Ho. 2010. Process for *in vivo* production of astaxanthin and *Phaffia rhodozyma* yeast of enhanced astaxanthin content. US Patent No. US 7723066.

Johnson, E.A., T.G. Villa and M.J. Lewis. 1980. *Phaffia rhodozyma* as an astaxanthin source in salmonid

diets. Aquaculture 20:123-134.

Khattab, R.Y. and S.D. Arntfield. 2009. Nutritional quality of legume seeds as affected by some physical treatments 2. Antinutritional Factors. LWT-Food Sci. Technol. 42:1113-1118.

Kogan, G. and A Kocher. 2007. Role of yeast cell wall polysaccharides in pig nutrition and health protection. Livestock Sci 109:161-165.

Li, P. and D.M. Galtin III. 2005. Evaluation of the prebiotic GroBiotic-A and brewer's yeast as dietary supplements for sub-adult hybrid striped bass (*Morone chrysops* × *M. saxatilis*) challenged *in situ* with *Mycobacterium marinum*. Aquaculture 248:197-205.

Libkind D, Arts MT, Van Broock M (2008) Fatty acid composition of cold-adapted carotenogenic basidiomycetous yeasts. Revista Argentina de Microbiologia 40:193-197.

Liener, IE (1994) Implications of antinutritional components in soybean foods. Critical reviews in food science and nutrition, 34(1):31-67.

Mahnken, C.V.W., J. Spinelli and W.F. Waknitz. 1980. Evaluation of an alkane yeast (*Candida* sp.) as a substitute for fish meal in Oregon Mosit Pellet: Feeding trials with coho salmon (*Oncorhynchus kisutch*) and rainbow trout (*Salmo gairdneri*). Aquaculture 20:41-56.

Mateos, G.G., M.A. Latorre and R. Lazaro. 2002. Processing soybeans. American Soybean Association. Animal Fee and Nutrition PR/FE 137.

McFarlan, S.C., W.A. Schroeder, L.E. Fosdick and J.A. Bohlmann. 2004. Production of amino sugars. US Patent No. US2005/0239173.

Meijer, M.M.T., W.T.J. Spekking, L. Sijtsma and J.A.M. de Bont. 1995. Inactivation of proteinaceous protease inhibitors of soybeans by isolated fungi. Indus. Crops Prod. 4:147-154.

Moallem, U., H. Lehrer, L. Livshitz, M. Zachut and S. Yakoby. 2009. The effects of live yeast supplementation to dairy cows during the hot season on production, feed efficiency and digestibility. J. Dairy Sci. 92:343-351.

Mohamed, M.I., Y.A. Maareck, S.S. Abdel-Magid and I.M. Awadalla. 2009. Feed intake, digestibility, rumen fermentation and growth performance of camels fed diets supplemented with a yeast culture or zinc bacitracin. Anim. Feed Sci. Technol. 149:341-345.

Noeck, J.E., M.G. Holt and J. Oppy. 2011. Effects of supplementation with yeast culture and enzymatically hydrolyzed yeast on performance of early lactation dairy cattle. J. Dairy Sci 94:4046-4056.

Olivia-Teles, A. and P. Gonçalves. 2001. Partial replacement of fishmeal by brewers yeast (*Saccharomyces cerevisiae*) in diets for sea bass (*Dicentrarchus labrax*) juveniles. Aquaculture 202:269-278.

Olli, J.J., K. Hjelmeland and A. Krogdhal. 1994. Soybean trypsin inhibitors in diets for Atlantic salmon (*Salmo salar*, L): effects on nutrient digestibilities and trypsin in pyloric caeca homogenate and intestinal content. Comparitive Biochem. Physiol. Part A: Physiology 109:923-928.

Osman, M.A. 2004. Changes in sorghum enzyme inhibitors, phytic acid, tannins and in vitro protein digestibility occurring during Khamir (local bread) fermentation. Food Chem. 88:129-134.

Palliyeguru, M.W., S.P. Rose and A.M. Mackenzie. 2011. Effect of trypsin inhibitor activity in soya bean on growth performance, protein digestibility and incidence of sub-clinical necrotic enteritis in broiler chicken flocks. Brit. Poult. Sci. 52:359-67.

Paš, M., B. Piskur, M. Sustaric and P. Raspor. 2007. Iron enriched yeast biomass-A promising mineral feed supplement. Biores. Technol. 98:1622-1628.

Pearson, W. and M. Lindinger. 2009. Low quality of evidence for glucosamine-based nutraceuticals in equine joint disease: review of in vivo studies. Equine Vet. J. 41:706-712.

Reddy, N.R. and M.D. Pierson. 1994. Reduction in antinutritional and toxic component in plant foods by fermentation. Food Res. Intl. 27:281-290.

Robinson, P.H. and L.J. Erasmus. 2009. Effects of analyzable diet components on responses of lactating dairy cows to *Saccharomyces cerevisiae* based yeast products: A systematic review of the literature. Anim. Feed Sci. Technol. 149:185-198.

Roepcke, C.B.S., Vandenberghe, L.P.S. and C.R. Soccol. 2011. Optimized production of *Pichia guilliermondi* biomass with zinc accumulation by fermentation. Anim. Feed Sci. Technol. 163:33-42.

Sajeevan, T.P., R. Philip and I.S.B. Singh. 2006. Immunostimulatory effect of a marine yeast *Candida snake* S165 in *Fenneropenaeus indicus*. Aquaculture 257:150-155.

Sanderson, G.W. and S.O. Jolly. 1994. the value of *Phaffia* yeast as a feed ingredient for salmonid fish.

Aquaculture 124:193-200.

Sarlin, P.J. and R. Philip. 2011. Efficacy of marine yeasts and bakers yeast as immunostimulants in *Fenneropenaeus indicus*: A comparative study. Aquaculture 321:173-178.

Schrauzer, G.N. 2006. Selenium yeast: Composition, quality, analysis and safety. Pure Appl. Chem. 78:105-109.

Stauffer, C.E. 1990. Measuring trypsin inhibitor in soy meal: Suggested improvements in the standard method. Cereal Chem. 67(3):296-302.

Takimoto, T., K. Takahashi and Y. Akiba. 2007. Effect of dietary supplementation of astaxantin by *Phaffia rhodozyma* on lipid peroxidation, drug metabolism and some immunological variables in male broiler chicks fed on diets with or without oxidized fat. Br. Poult. Sci. 48:90-97.

Tripathi, M.K. and S.A. Karim. 2010. Effect of individual and mixed live yeast culture feeding on growth performance, nutrient utilization and microbial crude protein synthesis in lambs. Anim. Feed Sci. Technol. 155:163-171.

United States Food and Drug Administration (USDA) Title 21 of the Code of Federal Regulations Section 73.355.

Van den Ingh, T.S.G.A.M., A. Krogdahl, J.J. Olli, H.G.C.J.M. Hendricks and J.G.J.F. Koninkx. 1991. Effects of soybean-containing diets on the proximal and distal intestine in Atlantic salmon (*Salmo salar*): a morphological study. Aquaculture 94:297-305.

Vandergrift, W.L., D.A. Knabe, T.D. Tanksley, Jr. and S.A. Anderson. 1983. Digestibility of nutrients in raw and heated soyflakes for pigs. J Anim. Sci. 57:1215-1224.

Wang, C., Q. Liu, W.Z. Yang, Q. Dong, X.M. Yang, D.C. He, P. Zhang, K.H. Dong and Y.X. Huang. 2009. Effects of selenium yeast on rumen fermentation, lactation performance and feed digestibilities in lactating dairy cows. Livestock Sci 126:239-244.

Yang, S.P., Z.H. Wu, J.C. Jian and X.Z. Zhang. 2010. Effect of marine red yeast *Rhodosporidium paludigenum* on growth and antioxidant competence of *Litopenaeus vannamei*. Aquaculture 309:62-65.

Zeković, D.B., S. Kwiatkowski, M.M. Vrvić, D. Jakovljević and C.A. Moran. 2005. Natural and modified (1-3)-b-D-Glucans in health promotion and disease alleviation. Critical Rev. Biotechnol. 25:205-230.

Zhang, J., L. Liu, J. Li, G. Du and J. Chen. 2012. Enhanced glucosamine production by *Aspergillus* sp. BCRC 31742 based on the time-variant kinetics analysis of dissolved oxygen level. Biores. Technol. 111:507-511.

Available Online at ESci Journals
Journal of Food Chemistry and Nutrition
ISSN: 2307-4124 (Online), 2308-7943 (Print)
http://www.escijournals.net/JFCN

QUALITY EVALUATION OF OIL EXTRACTED FROM CATFISH AND MACKEREL AS COMPARED WITH COMMERCIAL COD LIVER OIL

Abiona O. Oladapo*, Shola H. Awojide
[a] *Department of Chemical Science, Osun State University, Osogbo, Nigeria.*

A B S T R A C T

This study evaluated the quality of oil extracted from catfish and mackerel in comparison with what obtains in commercial cod liver oil. Oil were extracted from two common fishes in Africa (Catfish and Meckerel) and analyzed for Proximate, Physical, Chemical and Mineral contents using standard methods. The fatty acid profiles were also determined with the use of Gas chromatography, while the sensory properties were determined through the use of a 10 man panel. Results revealed from the analysis conducted that there was no significant difference at $P< 0.05$ between the values of the oil extracted from Catfish, Meckerel and the commercial available Codliver oil in majority of the parameters determined. The rate of poverty in most part of Africa makes the diet taken inadequate in terms of nutrition, there is need to take in supplements in order to cater for the deficiencies in the diet. Since Codliver oil which is taken as a food supplements can still not be affordable by some, it is imperative to seek out alternatives. Therefore the oil from Catfish and Meckerel can be used as alternative to Codliver oil.

Keywords: Codliver oil, mackerel oil, catfish oil, fatty acid profile.

INTRODUCTION

Fish farming is the fastest-growing animal based food production sector, particularly in the developing countries – mainly from China and other Asian countries (Green facts, 2004). Africa produces only 1% of world aquaculture fish with Nigeria being the major producer, followed by Egypt, Uganda and Kenya (FAO, 2007).

Every year a considerable amount of total fish catch is discarded as processing leftovers and that include trimmings, fins, frames, head, skin and viscera. Some of the by products are utilized, but the main bulk is dumped as waste, creating both disposal and pollution problems. These wastes have high content of nutritive compounds like protein of high biological value, unsaturated essential fatty acids, vitamins and antioxidants, minerals or trace metals and physiological beneficial amino acids and peptides which is substrate of the fish meal production.

In Nigeria, the consumption of fish has been found to increase due to the nutritional values that can be obtained. Yearly, considerable amount of fish are consumed based on the fact that it is a good source of protein, vitamins and minerals (USDA, 2011).

Fish oil is derived from the tissues of oily fish, which contain the omega-3 fatty acids eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), precursors of certain eicosanoids that are known to reduce inflammation throughout the body, (Moghadasian, 2008; Cleland *et al.,* 2006) and have other health benefits. Marine and freshwater fish oil varies in contents of arachidonic acid, EPA and DHA. L(Innis ,1995) The various species range from lean to fatty and their oil content in the tissues has been shown to vary from 0.7–15.5% (Innis, 1995). They also differ in their effects on organ lipids. Studies have revealed that there is no relation between total fish intake and estimated omega−3 fatty acid intake from all fish and serum omega−3 fatty acid concentrations. (Gruger *et al.,* 1964) Only fatty fish intake, particularly salmonid, and estimated EPA + DHA intake from fatty fish has been observed to be significantly associated with increase in serum EPA + DHA. (Gruger *et al.,* 1964). Fish oil supplements are available as liquids, capsules, and

* Corresponding Author:
Email ID: oludapobiona@yahoo.com

tablets. Research has shown that most of this fish contains oil which often have been used for conditions related to the heart and the blood system (Butcher *et al.,* 2002), it has been found to lower blood pressure or triglycerides level (Glavas, 2002). Fish oil has also been used for preventing heart disease and stroke when taken in the recommended amount (Hooper *et al.,* 2004).

While fish oil can be obtained from eating fish, it can also be gotten by taking fish supplements which are rich in omega-3 fatty acids and provide about 1 gram of omega-3 fatty acids which is about 3.5 ounces of fish (USDA, 2011). Presently, many Americans have turned to omega-3 fish oil supplements (Minis *et al*., 2006). Dietary fish and fish oil supplements have benefits for healthy people and also those with heart disease. Omega-3 fish oil contains both docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (Inga-Britt *et al*., 2004). Omega-3 fatty acids are very important in preventing and managing heart disease. (AHA, 2008; Turkmen *et al*., 2003; Nordov *et al*., 2001).

In Nigeria, fish supplements are sold in stores for those who can afford them but based on the poverty level of most Nigerians leaving in the rural settlement makes it impossible for them to afford the high cost of this oil supplements. It is important to find an alternative source of this nutrient at an affordable cost to low income earners. Therefore it is important to determine the physiochemical, minerals and fatty acid profile of two fishes which are regularly consumed and to compare the quality of the oil from this fishes with commercially sold fish oil. This will ascertain if oil consumed from the fish is adequate enough to maintain a good health.

MATERIALS AND METHODS

Different samples of the Cat fish (specie) and mackerel fish (specie) were bought from Oja Oba market in Osogbo, Osun State market. Commercial fish oil capsules were also purchased from pharmatical stores in Osogbo. The *fish* were identified by Dr. Adeleke of the department of biological science, Osun State University. All chemicals and reagents used were of HPLC grade (highest purity) and purchased from Darmstadt, Germany (Merck). The standard of fatty acids methyl esters were obtained from Sigma Chemical Co (St. Louis, MO, USA).

Material Preparation: The fishes were washed, drained and kept in the refrigerator at a temperature of 4^0C until needed.

Oil Extraction: According to standard method ISO 659 (1998), finely ground fish (about 5g) (particle size =2 mm), were used to obtain oil by Soxhlet extraction using n-hexane for 6 h. The rotary evaporator was used to remove solvent at 40 °C. The oil was dried by nitrogen streaming and stored at 20°C for further analysis.

Determination of Moisture Content: Moisture content of fish was determined by the method of (AOCS, 1993). Five grams of test portion was taken in dish container and dried in an oven at 130°C for 2h. Heated portion was allowed to cool in a desiccator to room temperature and loss of weight determined.

Determination of Protein Content: Kjeldahl digestion method (acid digestion and distillation) was used to determine total protein from seed residues as the nitrogen content of the sample multiplied by nitrogen factor. For the protein calculation nitrogen conversion factor (6.25) was used according to the official standard method (AOCS, 1993).

Determination of Crude Fiber: According to the AOCS official standard method (1993), fiber content was determined using 2.5g defatted fish. The meal residue for digestion was boiled with sulfuric acid solution (0.26 mol/L), followed by washing and separation of insoluble residue, after digestion the residue + sodium hydroxide (0.31mol/L), was boiled followed by washing and separation, with distilled water, and drying. The residue was dried, ashed at 600 °C in a muffle furnace and loss in mass was calculated.

Determination of Ash Content: Powdered fish samples about 0.5 g was ignited and incinerates at 550°C for about 12 h in muffle furnace, and then ash content determined according to standard method of (AOCS, 1993).

Determination of Carbohydrate Content: By the difference of mean values the content of carbohydrate was estimated, i.e. Carbohydrate content = 100 - [%Lipids + %Proteins + %Ash + %Moisture].

Physical evaluation of oil: Refractive index as well as Specific gravity was determined by the method of (AOCS, 1993.

Determination of Peroxide Value: Peroxide value defined as the milliequivlents of active oxygen per kilogram of oil (meq of O2 kg-1) expressed in the unit of milliequivalents, was determined, when potassium iodide reacted with a mixture of oil and chloroform/acetic acid in dark according to the method of (AOCS, 1993).

Determination of Saponification Value: It is the number of KOH required to saponify 1 gram of oil. Saponification value through hydrolysis of ester under alkaline condition was determined according to the method of (AOCS, 1993).

Determination of Iodine Value: The iodine value of oil was determined according to the method of (AOAC, 1997). In which the dissolved oil sample (CCl_4 used as solvent) was mixed with 25ml of Wijís (0.1mol/L) solution and reacted with freshly prepared (10%) potassium iodide solution. The standard potassium thiosulphate (0.1M) was used for titration with liberated iodine from solution. Starch was used as an indicator in this procedure.

Determination of Acid Value: Acid value used to measure the free acids (total amount) found in a given quantity of fat. Number of milligrams of KOH (potassium hydroxide) utilized to neutralizing the free acids found in one gram of the oil sample were determined by the method of (AOCS, 1993).

Determination of Fatty Acid Composition: Standard IUPAC method (Paquot, 1997) was used for the preparation of fatty acid methyl esters and analyze by gas chromatograph (model 8700) Perkin Elmer, fitted with a capillary column SP-2340 polar (60 m x 0.25 mm), and FID (flame ionization detector). As a carrier gas nitrogen (oxygen free) was used at a flow rate of 3.5 mL/min. Injector temperature: 260°C; detector temperature: 270°C, initial oven temperature: 130°C; and final temperature: 220°C with ramp rate: 4°C/min. A sample volume of 2.0 Ï L was injected. Fatty acid methyl esters quantification and identification was carried out by comparing the retention time of peak area with those of pure standards purchased from Sigma Chemical Co (St. Louis, MO, USA), under the same conditions. In lipid fraction the results were expressed as a percentage of individual fatty acids.

Determination of Metal Content: The sample solutions (diluted digest) were subsequently analyzed using Atomic Absorption Spectrophotometer (AAS) (Perkin-Ether model 3030).

Sensory Evaluation: A taste panel evaluation of oil samples was conducted using Cod liver oil as control and a trained panel of 10 members.

Samples were coded with 3-figure random number and presented in random order to each panellist at ambient room condition (25-30^{o}C).The judges were asked to score for colour, taste, flavour and acceptability using a 5-point hedonic scale, where 1 and 5 represent dislike extremely, respectively.

Data Analysis: The mean values (means ±SD) were calculated from replicates of each experiment. Significant differences among means were determined by the analysis of variance (ANOVA) and comparison between means ($P<0.05$) was carried out by statistical package Statistica 7.1 (StatSoft, Inc., Tulsa, OK, USA) software.

RESULT AND DISCUSSION

Table 1 shows the result of the proximate analysis carried out on the samples of mackerel and catfish, the fat content of mackerel (16.44%) was observed to be higher than of catfish (15.26%), there was no significant difference at ($p<0.05$) between the protein content of catfish (20.00%) with the protein content of the mackerel (19.19%). The data compares favourably in general with the data of Thurston *et al.,* 1959.

The ash content observed in catfish (2.13%) was higher than that observed in mackerel (1.44%) this difference which may be due to volume of minerals retained by the catfish. The value of moisture content of mackerel was 57.46% while that of catfish was (55.26%) this values are not significant difference. Catfish contain a higher proportion of carbohydrate than mackerel fish and this ranged from 7.27% for catfish to 5.47% for mackerel. Similar result was reported by Stansby, 1954.

Table 1. Proximate analysis composition.

Parametres	Fat	Protein	Ash	Moisture	Carbohydrate
Fish type	(%)	(%)	(%)	(%)	(%)
Cat fish	15.26±0.013^{a}	20.00±0.013^{a}	2.13±0.013^{a}	55.26±0.012^{a}	7.27±0.016^{a}
Mackerel	16.44±0.006^{a}	19.19±0.008^{a}	1.44±0.013^{b}	57.46±0.005^{a}	5.47±0.013^{b}

Values are means of for determinations ± S.D.

The values for the physical properties of each sample are recorded in Table 2. There was no significant difference in the values of the specific gravity of the three oil samples. The value of the refractive index of the three oil samples where significant not difference, this values ranges between 1.441 for Cod liver oil to 1.457 for Catfish oil. The Colour of the three oil samples were different, Cod liver oil was light yellow in colour, Catfish oil was Golden yellow

while that of Mackerel was dark brown. Same was reported by Ramakrishnan *et al*. (2013). The difference may be due to the fact that Cod liver was refined and mackerel fish was exposed to temperature above 40^0C or due to the formation of brown pigments from the reaction of carbonyls produced from oxidation of polyunsaturated fatty acids with amino acids and proteins. The saponification value of mackerel oil was the highest (233.93 mg/g) followed by cod liver oil (233.58 mg/g) while catfish oil has the least value (233.21 mg/g) (Table 3) the values are not significantly different at P< 0.05. Saponification value is the number of milligrams of potassium hydroxide required to neutralize the fatty acid resulting from the complete hydrolysis of 1g of the samples. Catfish oil having the least saponification value is less prone to rancidity.

Table 2. Physical properties.

Samples	Specific gravity@20^0c	Refractive index @20^0c	Colour
Codliver oil	0.851±0.006[a]	1.441±0.001[a]	Light yellow
Catfish oil	0.854±0.001[a]	1.457±0.001[a]	Golden yellow
Mackerel oil	0.853±0.001[a]	1.451±0.001[a]	Dark brown

Values are means of for determinations ± S.D.

Table 3. Chemical properties of the oil.

Samples	Saponification Value (mg/g)	Iodine value (g/100g)	Peroxide Value (meq)	Free Fatty Acid Value (mg/g)
Codliver oil	233.58±0.013[a]	85.95±0.006[a]	20.59±0.024[a]	1.0096±0.00[a]
Catfish oil	233.21±00.13[a]	84.33±0.008[a]	20.18±0.013[a]	1.063±0.00[a]
Mackerel oil	233.93±0.007[a]	85.80±0.03[a]	20.58±0.01[a]	1.122±0.00[a]

Values are means of for determinations ± S.D.

On the other hand, the iodine value of cod liver oil (85.95 g/100g) was the highest followed by mackerel oil (85.80 g/100g) while Cat fish oil has the least value (Table 3). The values are not significantly different at P< 0.05. The iodine value shows the number of iodine absorbed by 100g of the oil. The higher the iodine value, the higher the degree of un-saturation and the better the oil.

The peroxide value obtained from the oil samples ranged from 20.18meq/kg for the catfish oil to 20.5meg/kg for the cod liver oil. Cod liver oil has the highest value of peroxide (20.59meq/kg) followed by mackerel oil (20.58meq/kg) and catfish oil (20.18meq/kg), the lower the peroxide value, the lower the ability of the oil to go rancid. The free fatty acid (FFA) obtained from the analysis ranged from 1.0096 % for the Cod liver oil 1.122 % catfish oil (1.063%) and cod liver oil (1.0096%). FFA measures the extent the decomposition of lipase action and decomposition is accelerated by heat and light. The lower the FFA value, the better the oil as the lipase content of the oil is low. The FFA values for the three different oils were significantly not different at P< 0.05.

The mineral profile of fish oil samples are shown in table 4. Mackerel fish oil had the highest content of calcium (5.60 mg/100g) followed by Cod liver oil (5.50 mg/100g) while Catfish oil has a value of 3.79mg/100g. The calcium content may be useful in the formation of bone and teeth. The result revealed that, Cod liver oil as well as Mackerel fish is more suitable for people who have deficiencies in calcium.

Table 4. Mineral Profile (mg/g) of the oil sample.

	Catfish oil	Codliver oil	Mackerel oil
Calcium (mg/g)	3.97±0.01[b]	5.60±0.40[a]	5.50±0.30[a]
Potassium (mg/g)	269.91±0.24[a]	212.04±2.28[a]	265±0.22[a]
Iron (mg/g)	1.80±0.00[a]	1.20±0.01[b]	1.85±0.01[a]
Copper (mg/g)	1.09±0.04[a]	0.80±0.6[a]	0.83±0.05[a]
Phosphorus (mg/g)	220.00±2.60[a]	232.00±6.16[a]	235±6.20[a]
Zinc (mg/g)	0.80±0.00[a]	0.40±0.02[a]	0.91±0.01[a]

The potassium content of catfish (269.9 mg/100g) was the highest and the value was not significantly different from that of cod liver oil (265mg/100g) but significantly different from that of Mackerel fish (212.04mg/100g) at P< 0.05. Potassium is responsible for regulating of pH, osmolality and in cell membrane transfer.

The copper, Iron and Phosphorus content of the three oils were not significantly different at P< 0.05 (Table 4). Copper is found in all body tissue, larger amount in liver, brain, heart and the kidney while Iron is a component of haemoglobin and myoglobin this is important in oxygen transfer while phosphorus plays an important role in the energy changes of the body. The value of Zinc content of cod liver oil (0.91mg/100g) was significantly not different from that of Catfish oil (0.80mg/100g) but significantly different from that of Mackerel fish oil (0.40mg/100g). Zinc is present in most tissues with higher amount in liver, voluntary muscles and bone. It may be of importance in nucleic acid metabolism (Lyon, 1972).

From table 5, the total value of saturated fatty acid was significantly not different, but Catfish oil had the lowest value of 24.30%. Saturated fatty acid has little use in the body; the value obtained revealed the suitability of the oils from the two fishes when compared to value obtained for Cod liver oil.

There was no difference in the concentration of the total unsaturated fatty acid of the three different oils. Since unsaturated fatty acid are useful for the body, particularly in the ability to lower the level of undesired lipid component on the blood streams. The result revealed the suitability of the oil extracted from the two fishes in the lowering of undesired lipid component. Significant differences were observed in the values of Linoleic acid in Cod liver oil and oil extracted from the two fishes. Linoleic acids are designed essential fatty acids because their absence in human diet has been associate with health problem such as skin and stunted growth.

Table 5. Fatty acid profile (%).

	Codliver oil	Catfish oil	Mackerel oil
Myristic 14:0	4.23	1.30	3.78
Palmitic 16:0	9.17	18.90	15.94
Stearic 18:0	11.16	4.10	7.30
Oleic 18:1	34.98	52.90	53.20
Linoleic 18:2	30.28	17.10	13.78
Linolenic 18:3	2.80	0.80	1.99
Total saturated	24.56	24.30	27.02
Total Unsaturated	68.06	70.8	68.97

Table 6 show the Sensory score for analysis carried out on taste, colour, flavour and general acceptability. The scores obtained for cod liver oil were colour (7.4), taste (7.1), flavour (5.7), acceptability (7.4), the scores obtained for catfish were colour (7.2), taste (7.6), flavour (6.5), acceptability (6.3) while those for mackerel oil sample were colour (6.5),taste (5.1),flavour (6.3),acceptability (6.1).This result showed a little significant compared with the standard sample A. Catfish was preferred for its taste and flavour but cod liver was preferred in terms of colour and this may be due to the refining of the oil.

Table 6. Sensory evaluation.

Quality	A	B	C	Order of pref
Taste	7.1b	7.6a	5.1d	BAC
Colour	7.4a	7.2b	6.4c	ABC
Flavour	5.7b	6.5a	6.9a	CBA
Acceptability	7.4a	6.3b	6.1b	ABC

The oil samples were coded as follow.

Cod liver oil – A (Standard) Catfish oil –B Mackerel oil –C.

CONCLUSION

In conclusion, results obtained have shown that there was significant difference in the values obtained from the Cod liver oil and those of Catfish oil and mackerel oil in most of the parameters determined which shows that the oil from Catfish and mackerel because of its availability to the low income earners in Africa, it is easily affordable and can as well perform the roles of the oil of Cod liver oil in man and so can be used as a substitute to imported Cod liver oil.

ACKNOWLEDGEMENT

The authors would like to thank the staff of the Lipid laboratory, Ladoke Akintola University of Technology, Ogbomosho.

REFERENCES

AOCS. 1993. Official methods & recommended practices of the American Oil Chemists Society, 4th edn. Champaign, IL, Official Method Ai 275.

AOAC. 2005. Association of Official Analytical Chemists, official methods of analysis. 18th Ed., Gaithersburg, MD, USA.

Cleland, L., M. James and M. Proudman. 2006. "Fish oil: What the prescriber needs to know". *Arthritis Research & Therapy* 8 (1): 679–81.

Green, P., H. Hermesh, A. Monselise, S. Marom, G. Presburger amd A. Weizman. 2006. "Red cell membrane omega-3 fatty acids are decreased in nondepressed patients with social anxiety disorder". European Neuropsychopharmacology 16 (2): 107–13.

Gruger, E. H., R.W. Nelson and M.E. Stansby. 1964. "Fatty acid composition of oils from 21 species of marine fish, freshwater fish and shellfish". *Journal of the American Oil Chemists Society* 41 (10): 662–667.

Hooper, L., R.L. Thompson and R.A. Harrison. 2004. Omega 3 fatty acids for prevention and treatment of cardiovascular disease. The Cochrane Database of Systematic Reviews

Inga-Britt, G.O., B.O.E. Margaretta and V. Bergt. 2004. Moderate amounts of N-3 fully acid enriched seafood products. J.Hum. Nurt.Dietetic, 17:490-499.

Innis, S.M., F.M. Rioux, N. Auestad and R.G. Ackman. 1995. "Marine and freshwater fish oil varying in arachidonic, eicosapentaenoic and docosahexaenoic acids differ in their effects on organ lipids and fatty acids in growing rats.". *The Journal of nutrition* 125 (9): 2286–93.

Küpper F.C., L.J. Carpentera and G.B. McFiggans. 2008. "Iodide accumulation provides kelp with an inorganic antioxidant impacting atmospheric chemistry". Proceedings of the National Academy of Sciences of the United States of America 105 (19): 6954–8.

Minis, R., I. Haq, P.R. Jackson, W. Yeoad and L. Ramsay. 2006. Oily fish and fish oil supplements in the prevention of coronary heart diseases.J. Hum. Nutr.Dietetics,5:449-459

Moghadasian, M.H. 2008. "Advances in Dietary Enrichment with N-3 Fatty Acids". *Critical Reviews in Food Science and Nutrition* 48 (5): 402–10.

Naliwaiko, K., R.L.F. Araújo, R.V. Da-Fonseca, J.C. Castilho, R. Andreatini, M.I. Bellissimo, B.H. Oliveira, and E.F. Martins. 2004. "Effects of Fish Oil on the Central Nervous System: A New Potential Antidepressant Nutritional Neuroscience 7 (2): 91–9.

Nordov, A.R., F. Marchioli, H. Arnesen and J. Videback. 2001. N-3 Polyunsaturated fatty acid Cardiovascular diseases lipid, 36: 127-129

Philibert, A., C. Vanier, N. Abdelouahab, H.M. Chan and D. Mergler. 2006. "Fish intake and serum fatty acid profiles from freshwater fish." The American journal of clinical nutrition 84 (6): 1299–307.

Su, K.P., S.Y. uang, C.C. Chiu and W.W. Shen. 2003. "Omega-3 fatty acids in major depressive disorder". European Neuropsychopharmacology 13 (4): 267–71.

Thurston, C.E., M.E. Stansby, N.L. Karrick, D.T. Miyauchi and W.C. Clegg. 1959. Composition of certain species of fresh water fish. Food Research, 19, 231-34.

Turkmen, A., M. Turkmen, Y. Tepe and I. Akyurt. 2005. Heavy metals in three commercially valuable fish species from Iskenderun bay, northern east. Mediterranean sea, Turkey, food Chem., 91:167-172.

United States Department of Agriculture. 2011. "Nutrient data for 15067, Fish, Pollock, walleye, cooked, dry heat". USDA National Nutrient Database for Standard Reference.

Venturi S., F.M. Donati, A. Venturi and M. Venturi. 2000. "Environmental iodine deficiency: A challenge to the evolution of terrestrial life?". Thyroid 10 (8): 727–9.

Yehuda, S., R. Sharon and D. I. Mostofsky. 2005. "Mixture of essential fatty acids lowers test anxiety". Nutritional Neuroscience 8 (4): 265–7.

Available Online at ESci Journals
Journal of Food Chemistry and Nutrition
ISSN: 2307-4124 (Online), 2308-7943 (Print)
http://www.escijournals.net/JFCN

CONCENTRATIONS OF PHENOLIC COMPONENTS IN NORTH CAROLINA WINES

[a]Sara E. Spayd*, [b]James F. Harbertson, [b]Maria S. Mireles
[a] *Department of Horticultural Science, Campus Box 7609, North Carolina State University, Raleigh, NC 27695-7609, USA.*
[b] *School of Food Science, Washington State University, IAREC, 24106 N. Bunn Road, Prosser, WA 99350, USA.*

A B S T R A C T

One hundred and seventy samples of North Carolina (NC) red wines at the State Fair Wine Competition in Oct 2012 were collected to assess the phenolic composition of NC wines. At least 75% of the grapes used for vinification were grown in NC to be included. Wines were from cultivars of *Vitis vinifera* L., French American hybrid and *Vitis rotundifolia* Mich. All wines were analyzed using the Adams-Harbertson Assay. Descriptive statistics were generated for cultivars 19years for *V. vinifera* wines that had eleven or more samples. Chambourcin and Noble wines had higher mean anthocyanin concentrations than the mean for all *V. vinifera* wines. Small polymeric pigment (SPP) concentration was lowest in Sangiovese and highest in Chambourcin and Cabernet Franc wines. Cabernet Franc wines had the highest and Noble wines the lowest large polymeric (LPP) pigment concentrations. Almost a four-fold difference in anthocyanin concentration was found due to vintage between the lowest and highest concentrations. Our data support the observation that NC *V. vinifera* wines are likely to be perceived as less astringent than wines from Washington and California based on tannin concentration and are low in anthocyanin concentration, hence relatively low in red color.

Keywords: *Vitis vinifera* L., *Vitis rotundifolia* Mich., French-American hybrids, anthocyanins, tannins, cultivar.

INTRODUCTION

North Carolina's wine industry has experienced a revival during the past twenty years. Prior to the Prohibition era North Carolina (NC) was one of the United States of America's largest wine-producing states with most of the wines made from native muscadine (*Vitis rotundifolia* Mich.) grapes. While muscadines are still a large portion of the 21st century NC wine industry, cultivars of "bunch" grapes (*Vitis vinifera* L., American hybrids and French-American hybrids) constitute roughly half of the acreage in the state. Little information is available on the composition of NC grapes and wines (Goldy *et al.,* 1989; Carroll *et al.,* 1991). Commercial winemakers have observed that wines prepared from NC wines are lighter in color and seem to be lower in astringency than commercial wines from other regions. Phenolic and tannin concentration vary with species, cultivars, and growing regions (Harbertson et al., 2002; Harbertson *et al.,* 2008; Liang *et al.,* 2012; Zhu *et al.,* 2012a; Zhu *et al.,* 2012b). Malvidin 3-glucoside is the dominant anthocyanin in *V. vinifera* grapes and young wines. *V. labruscana* and French- American hybrids contain mixtures of mono- and di-glucoside anthocyanins. Muscadine grape berry phenolics are characterized by the presence of delphinidin 3,5-diglucoside and pelargonidin-3,5-diglucosides (Goldy *et al.,* 1989; Zhu *et al.,* 2012b). Additionally, when compared with other grape species muscadines contain ellagic acid and high contents of flavan-3-ols and flavonols (Zhu *et al.,* 2012b). Phenolic compounds contribute to the texture and color of wines, particularly red wines. Type of phenolic compound plays an important role in their sensorial impact. Increased chain length and galloylation increase the interaction of skin tannins with salivary proteins, though lower molecular weight seed tannins were equally astringent (Brossaud *et al.,* 2001). Sensory evaluation is expensive and time consuming. Chemical methods for measuring phenols in wine have been evaluated with regard to their relationship to sensory properties. Using the adapted (Harbertson *et al.,* 2002) protein precipitation assay of Hagerman and Butler (1978), wine tannin highly correlated with sensory perception of astringency (Kennedy *et al.,* 2006;

* Corresponding Author:
Email ID: ananda@alcorn.edu

Mercurio and Smith 2008). Additionally, protein precipitable tannin was positively correlated with astringency, large polymeric pigments, gallic acid and a catechin derivative (Boselli *et al.,* 2004).

The purpose of this study was to determine concentrations of phenolic components in NC wines in order to provide a comparative baseline for NC winemakers and broaden the base of knowledge of phenolic constituents in wines made from grapes of *V. vinifera*, *V. rotundifolia* and grape hybrids.

MATERIALS AND METHODS

One hundred and seventy commercial red wine samples were collected in 50 mL polypropylene disposable screw cap centrifuge tubes (Cat. No. 14-375-150; Fisher Scientific, Waltham, MA) on 4 Oct 2012 during the NC State Fair Wine Competition, Raleigh, NC (Table 1). The tubes were filled to the brim to minimize headspace and the caps were securely fastened. Distribution of cultivars within vintages varied. Forty-seven (37%) wines were non-vintage. Known vintage dates across cultivars ranged from 2001 to 2011. The largest proportion (77%) of vintage dated wines was from the 2008 through 2010 vintages. After collection samples were stored at about 2°C until FedEx First Overnight® shipment to the Irrigated Agriculture Research and Extension Center, Prosser, WA. Wines were shipped overnight in an insulated container that included Blue Ice© blocks (Rubbermaid®, Atlanta, GA). The time between sampling and final analysis was ~2 months.

Table 1. Vintage distribution of cultivars and species distribution of red wines made from NC grapes sampled at the NC State Fair Wine Competition, 4 Oct 2012.

Cultivar	Vintage									
	Non-	2001	2005	2006	2007	2008	2009	2010	2011	Total
French-American hybridsa										
Chambourcin	5	-	-	1	-	1	2	1	1	11
Foch	1	-	-	-	-	-	-	-	1	2
Vitis rotundifolia Mich.										
Noble	11	-	-	-	-	-	-	-	1	12
Ison	1	-	-	-	-	-	-	-	1	2
Vitis vinifera L.										
Barbera	1	-	-	-	-	-	1	1	-	3
Cabernet Franc	7	-	-	-	1	1	1	4	-	14
Cabernet Sauvignon	4	-	-	2	1	2	5	7	1	22
Lemberger	-	-	-	-	1	-	-	-	-	1
Malbec	1	-	-	-	-	1	-	-	-	2
Merlot	4	-	1	1	-	4	9	8	-	27
Montepulciano	1	-	-	-	-	-	-	-	-	1
Mourvedra	1	-	-	-	-	-	-	-	-	1
Nebbiolo	-	-	-	-	-	-	-	1	-	1
Norton	1	-	-	-	1	-	-	1	-	3
Petit Verdot	1	-	-	-	1	-	-	-	-	2
Pinot noir	1	-	-	-	-	-	-	-	-	1
Sangiovese	3	1	-	-	-	-	1	1	-	6
Syrah	2	-	1	-	-	2	3	4	-	12
Tannat	2	-	-	-	-	-	-	-	-	2
Tempranillo	-	-	-	-	-	-	-	-	1	1
Speciesb										
French American hybrids	6	-	-	1	-	1	2	1	2	13
Vitis rotundifolia	20	-	-	-	-	-	-	-	2	22
Vitis vinifera	52	1	2	3	5	15	22	32	3	135

[a]All wines within a cultivar/species were prepared from no less than 75% of grapes from that cultivar and 100% of that species.

[b]Includes wines that were < 75% of a specified cultivar, but all wines are 100% of the indicated species.

Wines were analyzed in duplicate for total anthocyanins, total tannins, total phenolics, small polymeric pigments (SPP), and large (LPP) polymeric pigments using the Adams-Harbertson assay which combines protein precipitation, bisulfite bleaching, pH shift and ferric chloride to measure the various phenolic classes (Adams and Harbertson 1999, Harbertson *et al.,* 2002). The guidelines for dilution set forward by Jensen et al., (2008) were used for the protein precipitation analysis.

At the time of entry, wineries submitted information regarding source of grapes (NC or not) and cultivar composition. Of those wines only wines produced from at least 75% NC fruit, 100% of a species and 75% of a single cultivar were included in calculation of descriptive statistics using the mean of the laboratory duplicates for a cultivar. Wines that were not captured in cultivar or yearly data were included in species as long as they contained 75% or more of the species. Descriptive statistics were generated for cultivars (Cabernet Sauvignon, Cabernet Franc, Chambourcin, Merlot, Noble, and Syrah) and *species* that had six or more samples. Although sample numbers are low, the wines sampled represent a large proportion of those commercially available at the time of collection. An insufficient number of samples of *V. labruscana* wines were received to be included in the present survey. Descriptive statistics including n, mean, median, range, and 95% confidence interval were generated using SAS® (Cary, NC) PROC MEANS.

RESULTS AND DISCUSSION

Cultivars: French-American hybrid cv. Chambourcin and *V. rotundifolia* cv. Noble wines contained the highest mean anthocyanin concentration of the eight cultivars in the present study (Table 2). However, the median anthocyanin concentration of Noble wines was much lower in anthocyanin concentration than the mean concentration of Chambourcin wines. Anthocyanin concentration of wines from these two cultivars was more than double that of wines from the six *V. vinifera* cultivars. Of the wines from *V. vinifera,* Sangiovese wines had the lowest anthocyanin concentration. Auw *et al.,* (1996) reported increasing anthocyanin concentration from Chambourcin to Noble to Cabernet Sauvignon. Lee and Talcott (2004) found that Noble juice had the highest anthocyanin concentration of five red muscadine cultivars evaluated in their study. Mean NC Cabernet Sauvignon and Syrah wine anthocyanin concentrations were about 45% lower than their Barossa Valley counterparts (Skogerson *et al.,* 2007).

With regard to polymeric pigments, mean SPP concentration was lowest in Sangiovese, Merlot and Noble wines, while mean LPP concentrations were lowest in Noble and highest in Cabernet Franc wines (Table 2). SPP concentrations of Barossa Valley Cabernet Sauvignon wines had slightly higher SPP and about 50% lower LPP (Skogerson *et al.,* 2007) than Cabernet Sauvignon wines from NC. NC Merlot wines had the highest and Noble wines had the lowest mean LPP:SPP ratio of the cultivars in the present study. Of the *V. vinifera* cultivars in the present study, Syrah had the lowest mean LPP:SPP. Auw *et al.,* (1996), using bisulfite bleaching to determine the chemical age of wines (Somers and Evans 1977), found that Noble wines had a lower degree of anthocyanin polymerization than Cabernet Sauvignon and Chambourcin wines. In the Harbertson-Adams assay, the pigments in the supernatant of BSA precipitation are bleached by bisulfite (Adams *et al.,* 2004). In the present study, lower concentrations of LPP and a lower SPP:LPP ratio parallel the differences in chemical age between Noble and Cabernet Sauvignon and Chambourcin wines reported by Auw *et al.,* (1996).

Although no sensory evaluation was performed in this work, we speculate that NC *V. vinifera* wines would be less astringent that wines from Washington and California based on the strong correlation between protein precipitable tannins from the Harbertson-Adams assay and sensory perception of astringency (Landon *et al.,* 2008). SPP and LPP concentrations were positively correlated with perceived sensorial bitterness and astringency. In their study, Washington Merlot wines with SPP = 1.17 and LPP = 1.13 AU were considered lower in perceived bitterness and astringency than Washington Merlot wines with SPP = 1.72 and LPP = 2.21 AU. In the present study, NC Merlot wines mean SPP and LPP contents were 1.35 and 1.15 AU, respectively (Table 2).

Total tannins also differed between wines from different cultivars (Table 2). Chambourcin wines had at least 50% lower mean total tannin concentrations than wines from *V. vinifera* cultivars. Noble wines were intermediate in mean total tannin concentration to Chambourcin and *V. vinifera* cultivars. Mean tannin concentration in NC Cabernet Sauvignon wines was 240 and 281 mg/L lower than WA and CA Cabernet Sauvignon wines, respectively, as reported by Harbertson *et al.,* 2008.

Table 2. Descriptive statistics for phenolic compounds as determined by the Adams-Harbertson assay in red cultivars of *Vitis vinifera* L., French-American and *Vitis rotundifolia* Mich. wines produced from North Carolina grapes.

Cultivar[a]	Descriptive statistics				
	Mean	Standard error	Median	Minimum	Maximum
	Total anthocyanins (mg/L malvidin 3-O-glucoside equivalents)				
Chambourcin (11)[b]	239	51	217	47	592
Cabernet Franc (14)	85	17	79	2	237
Cabernet Sauvignon (20)	106	18	86	0	281
Merlot (27)	86	12	73	0	220
Noble (12)	218	50	146	53	607
Sangiovese (6)	51	8	50	23	78
Syrah (12)	99	13	97	7	167
	Small polymeric pigments (Absorbance units)				
Chambourcin	1.86	0.20	1.86	0.45	2.82
Cabernet Franc	1.79	0.20	1.56	1.19	3.77
Cabernet Sauvignon	1.62	0.11	1.67	0.56	2.51
Merlot	1.35	0.10	1.43	0.21	2.39
Noble	1.36	0.16	1.28	0.63	2.29
Sangiovese	0.91	0.09	1.02	0.61	1.09
Syrah	1.79	0.08	1.77	1.27	2.27
	Large polymeric pigments (Absorbance units)				
Chambourcin	0.84	0.25	0.72	0.05	2.73
Cabernet Franc	1.30	0.22	1.09	0.52	3.70
Cabernet Sauvignon	1.02	0.13	0.92	0.09	2.78
Merlot	1.15	0.10	1.07	0.28	2.62
Noble	0.50	0.15	0.32	0.00	1.62
Sangiovese	0.171	0.09	0.66	0.44	1.02
Syrah	0.76	0.09	0.84	0.00	1.08
	LPP:SPP				
Chambourcin	0.89	0.53	0.36	0.02	6.07
Cabernet Franc	0.80	0.16	0.64	0.18	2.68
Cabernet Sauvignon	0.72	0.13	0.55	0.07	2.21
Merlot	1.32	0.44	0.82	0.17	12.5
Noble	0.35	0.09	0.36	0.00	0.89
Sangiovese	0.81	0.09	0.90	0.42	1.02
Syrah	0.43	0.06	0.48	0.00	0.67
	Total tannin (mg/L catechin equivalents)				
Chambourcin	113	23	91	0	233
Cabernet Franc	432	64	390	133	1,081
Cabernet Sauvignon	387	50	368	0	872
Merlot	397	36	399	1	780
Noble	209	68	129	0	732
Sangiovese	313	55	262	191	497
Syrah	294	41	290	87	522
	Total phenolics (mg/L catechin equivalents)				
Chambourcin	964	79	931	699	1,401
Cabernet Franc	1,383	94	1,452	691	1,892

Cabernet Sauvignon	1,481	84	1,488	748	2,256
Merlot	1,363	99	1,522	1	2,251
Noble	1,408	176	1,304	175	2,645
Sangiovese	1,158	73	1,218	834	1,344
Syrah	1,200	95	1,204	615	1,675
`Non-tannin phenolics (mg/L catechin equivalents)					
Chambourcin	851	63	858	578	1,167
Cabernet Franc	951	66	944	539	1,372
Cabernet Sauvignon	1,094	72	1,060	485	1,784
Merlot	967	72	1,042	0	1,552
Noble	1,200	152	1,059	108	1,913
Sangiovese	846	58	864	622	1,054
Syrah	906	69	900	529	1,274

[a]All wines within a cultivar were prepared from no less than 75% of grapes from that cultivar. Data were pooled across all years sampled.
[b]Number of estimates of the mean.

Concentrations of tannin in Syrah wines from California, Washington and Australia were also greater than tannin concentrations in the present study (Harbertson *et al.,* 2008). In Washington Cabernet Sauvignon wines were grouped by tannin into low medium and high concentrations, 250, 631, 1071 mg/L CE, respectively (Landon *et al.,* 2008). Sensory attributes of astringency and bitterness correlated with tannins, SPP and LPP concentrations in wine. In the present study, *V. vinifera* wines averaged tannin concentrations intermediate to the low and medium concentrations based on the Landon *et al.,* study (2008). Of the NC wines sampled, tannin concentrations of 72% of *V. vinifera* wines were $\leq$ 450 mg/L CE; 71% of the French-American hybrid wines were $\leq$ 300 mg/L CE; and, only one muscadine wine had a concentration $\geq$ 250 mg/L CE (data not shown). A possible explanation for lower concentrations of anthocyanins and tannins in NC wines is berry weight. Typically Cabernet Sauvignon berries in NC weighed from 1.25 to 2 g/berry (S. Spayd, unpublished data, 2014) compared with the 0.8 to 1.0 g/berry reported for Washington (Keller *et al.,* 2005). Differences in berry weight are probably due to higher precipitation resulting in higher available moisture content in NC vineyard soils compared with the lower precipitation, deficit irrigated vineyard soils of eastern WA (Keller et al., 2005). North Carolina typically has not only warm to hot days during much of the growing season, but also warm night temperatures. Elevated temperatures also probably played a role in lower anthocyanin concentration since temperatures are detrimental to anthocyanin accumulation in grapes (Spayd *et al.,* 2002).

Wine total and non-tannin phenolic concentrations also differed by cultivar (Table 2). Cabernet Sauvignon and Noble wines had the highest and Chambourcin wines had the lowest mean concentrations of the six cultivars evaluated. Auw *et al.,* (1996) reported that Noble wines were highest and Cabernet Sauvignon wines were the lowest in total phenols with Chambourcin wines intermediate in total phenol concentration. Mean total phenolic concentration of NC Noble wines were similar to concentrations of wines made from Florida Noble grapes (Auw *et al.,* 1996) that were fermented on the skins for three days. Mean total phenolic concentration of NC Chambourcin wines were intermediate in total phenolic concentration to wines from Georgia Chambourcin grapes (Auw *et al.,* 1996) that were fermented on the skins for seven days and wine made by hot pressing the fruit prior to fermentation. Total phenols in Auw's study (1996) were determined by the Folin-Ciocalteau method (Singleton and Rossi 1965). The Folin-Ciocalteu assay is useful for determining approximate total phenolic concentration, but it may not be related to sensorial astringency (De Beer *et al.,* 2004). In the case of Cabernet Sauvignon, wines were 50% higher in total phenolics than those made from Cabernet Sauvignon grapes from Georgia (Auw *et al.,* 1996) using any skin contact/juice extraction method. Of the 214 samples analyzed, a NC Noble wine tied with a Zinfandel wine, made from fruit sourced in California, for the highest concentration of both total and non-tannin phenols (data not shown).

Species: When pooled across all cultivars, French-American hybrid wines had the highest and *V. vinifera* wines had the lowest mean anthocyanin concentration of the three species (Table 3).

Table 3. Descriptive statistics for phenolic compounds as determined by the Adams-Harbertson assay in red *Vitis vinifera* L., French-American and *Vitis rotundifolia* Mich. wines produced from North Carolina grapes.

Species[a]	Descriptive statistics				
	Mean	Standard error	Median	Minimum	Maximum
Anthocyanins (mg/L malvidin 3-O-glucoside equivalents)					
Vitis vinifera (135)[b]	93	5	83	0	281
French-American hybrid (13)	219	49	200	47	592
Vitis rotundifolia (22)	174	31	108	42	607
Small polymeric pigments (Absorbance units)					
Vitis vinifera	1.52	0.05	1.46	0.21	3.77
French-American hybrid	1.93	0.22	1.86	0.45	3.50
Vitis rotundifolia	1.22	0.10	1.20	0.61	2.29
Large polymeric pigments (Absorbance units)					
Vitis vinifera	1.04	0.05	0.94	0.00	3.70
French-American hybrid	0.82	0.22	0.72	0.05	2.73
Vitis rotundifolia	0.48	0.10	0.45	0.00	1.62
LPP:SPP					
Vitis vinifera	0.83	0.10	0.63	0.00	12.5
French-American hybrid	0.84	0.45	0.36	0.02	6.07
Vitis rotundifolia	0.43	0.08	0.37	0.00	1.14
Total tannin (mg/L catechin equivalents)					
Vitis vinifera	399	21	358	0	1,187
French-American hybrid	134	37	91	0	500
Vitis rotundifolia	259	57	177	0	833
Total phenolics (mg/L catechin equivalents)					
Vitis vinifera	1384	36	1383	1	2,465
French-American hybrid	1016	79	1078	699	1,520
Vitis rotundifolia	1260	123	1214	175	2,645
Non-tannin phenolics (mg/L catechin equivalents)					
Vitis vinifera	986	24	1,019	0	1,784
French-American hybrid	886	58	946	578	1,167
Vitis rotundifolia	1,004	112	970	77	1,913

[a]All wines within a species were prepared from no less than 100% of grapes from that species. Means were pooled across all years and all cultivars within the species sampled.
[b]Number of estimates of the mean.

The inclusion of two Foch wines with very high anthocyanin concentrations (434 and 711 mg malvidin 3-glucoside equivalents/L) was the reason that the French-American hybrid wines as a group were so much higher in mean anthocyanin concentration than the *V. rotundifolia* wines despite the similarity in Chambourcin and Noble wine anthocyanin concentrations. *V. rotundifolia* wines had the lowest polymeric pigment concentrations of the three species. Large polymeric pigment concentration of *V. rotundifolia* averaged roughly half that of the concentration in French-American hybrid wines. Though concentrations of SPP and LPP differed between *V. vinifera* and French American wines, mean proportion of the polymeric pigments (LPP:SPP ratio) were similar between the two groups of wines. *V. vinifera* wines contained almost thrice and *V. rotundifolia* wines contained almost twice the concentration of total tannin as French-American hybrid wines. Mean total phenols and non-tannin phenols were relatively similar between wines from the *V. vinifera* and *V. rotundifolia* and lowest in French American hybrid wines. The range in total tannin and non-tannin phenolic concentration for the three species was widest for *V. vinifera* wines.

CONCLUSION

North Carolina Noble and Chambourcin wines had higher total anthocyanin concentration than all NC wines made from *V. vinifera* cultivars. Noble wines were low in SPP and LPP concentration. Merlot and Cabernet Franc wines were also low in SPP and LPP concentration, respectively. Our data support the observation that NC *V. vinifera* wines are likely to be perceived as less astringent than wines from Washington and California based on tannin concentration and are low in anthocyanin concentration, hence relatively low in red color.

ACKNOWLEDGEMENTS

This research was supported in part by USDA-NIFA-SCRI grant VA-422179. The authors thank the North Carolina Department of Agriculture for assistance in collection of wine samples.

REFERENCES

Adams, D.O. and J.F. Harbertson. 1999. Use of alkaline phosphatase for the analysis of tannins in grapes and red wines. Am. J. Enol. Vitic. 50:247-252.

Adams, D.O., J.F. Harbertson, and E.A. Picciotto. 2004. Fractionation of red wine polymeric pigments by protein precipitation and bilsulfite bleaching. In *Red Wine Color: Revealing the Mysteries*. Waterhouse, A.L. and J.A. Kennedy., Eds.; Vol. 88 pp. 275-288. Am. Chem. Soc., Washington, DC.

Alongi, K.S., O.I. Padilla-Zakour, and G.L. Sacks. 2010. Effects of concentration prior to cold-stabilization on anthocyanin stability in Concord grape juice. J. Agr. Food Chem. 58:11325-11332.

Auw, J.M., V. Blanco, S.F. O'Keefe, and C.A. Sims. 1996. Effect of processing on the phenolics and color of Cabernet Sauvignon, Chambourcin, and Noble wines and juices. Am. J. Enol. Vitic. 47:279-286.

Bosselli, E., R. Boulton, J. Thorngate, and N. Frega. 2004. Chemical and sensory characterization of DOC red wines from Marche (Italy) related to vintage and grape cultivars. J. Agric. Food Chem. 52:3843-3854.

Brossaud, F., V. Cheynier, and A.C. Noble. 2001. Bitterness and astringency of grape and wine polyphenols. Aust. J. Grape Wine Res. 7:33-39.

Carroll, D.E., E.B. Poling, and R.G. Goldy. 1991. Wine-grape Reference for North Carolina. NC Agric. Res. Ser. Bull. 480, pp. 31. http://content.ces.ncsu.edu/21480.pdf

De Beer, D., J.F. Harbertson, P.A. Kilmartin, V. Roginsky, T. Barsukova, D.O. Adams, and A.L. Waterhouse. 2004. Phenolics: A comparison of diverse analytical methods. Am. J. Enol. Vitic. 55:389-400.

Gawel, R. 1998. Red wine astringency: A review. Aust. J. Grape Wine Res. 4:74-95.

Goldy, R.G., E.P. Maness, H.D. Stiles, J.R. Clark, and M.A. Wilson. 1989. Pigment quantity and quality characteristics of some native *Vitis rotundifolia* Michx. Am. J. Enol. Vitic. 40:253-258.

Hagerman, A.E. and L.G. Butler. 1978. Protein precipitation method for quantitative determination of tannins. J. Agric. Food Chem. 26:809-812.

Harbertson, J.F., R.E. Hodgins, L.N. Thurston, L.J. Schaffer, M.S. Reid, J.L. Landon, C.F. Ross, and D.O. Adams. 2008. Variability of tannin concentration in red wines. Am. J. Enol. Vitic. 59:210-214.

Harbertson, J.F., J.A. Kennedy, and D.O. Adams. 2002. Tannin in skins and seeds of Cabernet Sauvignon, Syrah, and Pinot noir berries during ripening. Am. J. Enol. Vitic. 53:54-59.

Jensen, J.S., H.H. Malmborg Werge, M. Egebo, and A.S. Meyer. 2008. Effect of wine dilution on the reliability of tannin analysis by protein precipitation. Am. J. Enol. Vitic. 59:103-105.

Keller, M., L.J. Mills, R.L. Wample, and S.E. Spayd. 2005. Cluster thinning effects on three deficit-irrigated *Vitis vinifera* cultivars. Am. J. Enol. Vitic. 56:91-103.

Kennedy, J.A., J. Ferrier, J.F. Harbertson, and C.P. des Gachons. 2006. Analysis of tannins in red wine using multiple methods: Correlation with perceived astringency. Am. J. Enol. Vitic. 57:481-485.

Landon, J.L., K. Weller, J.F. Harbertson, and C.F. Ross. 2008. Chemical and sensory evaluation of astringency in Washington state red wines. Am. J. Enol. Vitic. 59:153-158.

Lee, J.H. and S.T. Talcott. 2004. Fruit maturity and juice extraction influences ellagic acid derivatives and other antioxidant polyphenolics in muscadine grapes. J. Agric. Food Chem. 52:361-366.

Liang, Z., Y. Yingzhen, L. Cheng, and G.-Y. Zhong. 2012. Polyphenolic composition and content in the ripe berries of wild *Vitis* species. Food Chem. 132:730-738.

Mercurio, M.D. and P.A. Smith. 2008. Tannin quantification in red grapes and wine: comparison of polysaccharide- and protein-based tannin precipitation techniques and their ability to model wine astringency. J. Agric. Food Chem. 56:5528-5537.

Singleton, V.L. and J.A. Rossi.1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am. J. Enol. Vitic. 16:144-158.

Skogerson, K., M. Downey, M. Mazza, and R. Boulton. 2007. Rapid determination of phenolic components in red wines from UV-visible spectra and the method of partial least squares. Am. J. Enol. Vitic. 58:318-325.

Somers, T.C. 1971. The polymeric nature of wine pigments. Phytochemistry 10:2175-2186.

Talcott, S.T. and J.H. Lee. 2002. Ellagic acid and flavonoid antioxidant content of muscadine wine and juice. J. Agric. Food Chem. 50:3186-3192.

Spayd, S.E., J.M. Tarara, D.L. Mee, and J.C.Ferguson. 2002. Separation of sunlight and temperature effects on composition of *Vitis vinifera* cv. Merlot berries. Am. J. Enol. Vitic. 53:171-182.

Zhu, L., Y. Zhang, J. Deng, H. Li, and J. Lu. 2012. Phenolic concentrations and antioxidant properties of wines made from North American grapes grown in China. Molecules 17:3304-3323. http://www.mdpi.com/1420-3049/17/3/3304

Zhu, L., Y. Zhang, and J. Lu. 2012. Phenolic contents and compositions in skins of red wine grape cultivars among various genetic backgrounds and originations. Int. J. Mol. Sci. 13:3492-3510. http://www.mdpi.com/1422-0067/13/3/3492/htm

Available Online at ESci Journals
Journal of Food Chemistry and Nutrition
ISSN: 2307-4124 (Online), 2308-7943 (Print)
http://www.escijournals.net/JFCN

PROXIMATE AND MINERAL COMPOSITION OF INDIGENOUS QATARI DISHES: COMPARATIVE STUDY WITH SIMILAR MIDDLE EASTERN DISHES

[a]Tahra ElObeid*, [b]Susanna Phoboo, [a]Zainab Magdad
[a] Human Nutrition Program, Department of Health Sciences, Qatar University, Doha, Qatar.
[b] Dhulikhel hospital, Kathmandu University Hospital, Dhulikhel, Nepal.

A B S T R A C T

Proximate composition and mineral content analysis of 10 traditional Qatari dishes revealed that protein contents ranged from 1.7 to 12.4%, while the fat content ranged from 0.13 to 1.0 %. The meat dishes contained higher levels of sodium ranging from 1276 to 1989 mg/100g while iron and zinc content varied from 0.3 to 7.4 and 0.03 to 4.5 mg/100g respectively. The level of potassium and calcium was found to be highest in Aseeda (sweet dish) with 375.7 and 403.6 mg/100g respectively. There is considerable difference in the nutrient composition of the Qatari dishes from that of the similar dishes from the Gulf States possibly due to variations in the raw materials and preparation processes. Data from this study will be helpful in calculating nutrient content of traditional dishes of Qatar for planning diet charts and also for developing a Qatar Food Database in the future.

Keywords: Food composition, Proximate analysis, Qatar; Traditional dishes; Mineral content.

INTRODUCTION

In Qatar, the nutrition and lifestyle changes have played a major role in the occurrence of diet-related chronic non-communicable diseases. It was reported that non-communicable diseases are predicted to account for 69% of all deaths in Qatar (WHO, 2011). Recent statistics show that diet related diseases like Type 2 diabetes and hypertension are on the rise. The prevalence of type 2 diabetes among Qatari population will escalate by 130% in the next three decades (Mushlin *et al*., 2012; WHO, 2011). The results from the Qatar STEP wise report for 2012 showed that 70.1% of the respondents were overweight, the prevalence of high blood sugar among the respondents was 16.7%; (Supreme Council of Health, 2013).

The nutritional paradox of the Arab countries is reflected in the two types of nutritional challenges that is currently being faced by these countries; problems related to deficiency in nutrients such as anemia and growth retardation and, problems that have resulted due to rapid changes in lifestyle and diet such as type 2 diabetes and hypertension (Musaiger, 2012). According to WHO (2013), 'Qatar is among the GCC countries in advanced nutritional transition stage**,** with large number of overweight and obese population as well as some population sub-group suffering from under-nutrition and micronutrient deficiencies. Nutrition transition is malnutrition, not from a need for food, but the need for high quality nourishment'. Qatar imports 90% of its food; the total food import is expected to rise 153% in the coming decade due to population growth (QNFSP, 2013). Both raw and processed food are imported in the country. Despite the rising popularity of fast food, traditional dishes that are either cooked at home or bought from restaurants and stores still form a large of the diet among the Qatari population.

In order to understand the effect of food on health, food composition chart is necessary. Food composition tables have been established in many countries around the world. The information provided in them is used by health professionals in creating diets for individuals with specific dietary requirements such as for those with diabetes, obesity, high blood pressure and high cholesterol. The key principle for food composition table is the description of foods and their components. Food

* Corresponding Author:
Email ID: tahra.e@qu.edu.qa

composition table can also assist in the formulation of nutrition interventions to meet regulatory standards as well as in accurate food labeling, product formulation, studying food consumption pattern and in research related to diet and health (Dashti *et al*., 2001; Lewis & Lupien, 1996).

There is minimum data on the composition of traditional dishes that are consumed in Qatar. Most of the data is compiled from published articles on the Gulf Region with minimum reference to change of ingredients and recipes that are specific to the Qatari dishes. The framework of the food composition data should initially be data generation. In Qatar, this data is the compilation of all the foods that are consumed in the country which includes traditional composite dishes, adapted composite dishes and newly introduced foods. Raw materials and processed food may be extracted from existing data as most of these foods are imported to the country. The next steps would be analytical data generation, data compilation (in food composition database) and data dissemination (to users through internet or printed material).

Analysis of traditional dishes of Qatar is not well established. Only one study has been conducted so far. Al Nagdy *et al*. (1994) analyzed the chemical composition of 17 Qatari dishes. Qatar has more than 50 traditional dishes therefore the nutrient composition of a large number of Qatari dishes still need to be carried out. Although these dishes share same names in all the Gulf countries, there are variation in the nutrient composition due to differences in recipes. In this study, 10 traditional Qatari dishes were analyzed for their proximate composition and mineral content.

MATERIALS AND METHODS

Selection of Qatari Traditional Foods: Ten food (dishes) were carefully chosen from a list of 50 regularly consumed foods in Qatar. These composite dishes represent different food groups prepared from different vegetables, meats, fish, cereals and sweets. The recipes of these composite dishes were evaluated and revised by three different Qatari women to validate the accuracy of the ingredients and recipes. The selected dishes includes; ThareedLaham - Bedouin recipe, HareesDagag, MakboosDagag- Hamsa method, MashkoolRubian, MadrobatDagag, MargoogLaham, Barinoish, KobozRugag, Sago and Asseda. For each composite food three analytical samples were drawn. The ingredients of the 10 composite foods are illustrated in Table 1.

Table 1. Ingredients of traditional Qatari dishes.

Dishes	Ingredients (W/W %)
Sago	Sago 50, sugar 33, hot water 10, rose water with saffron 2, powdered cardamom 2, Margarine 1, and Nuts 2.
Asseda	Wheat flour 70 , sugar 10, hot water 10, powdered cardamom 2, oil 2, powdered cinnamon 2, saffron with rose water 2, margarine 2
HareesDagag	Harees (crushed wheat) 30 , chicken 27, hot water 39 , salt 2, margarine 2
MakboosDagag	Hot water 25, onions 3, rice 36, chicken 15, tomato 3, garlic 1, ginger 1, cinnamon 1, salt 2, turmeric 1, cardamom 1, black pepper 1, spicy green pepper 1, sunflower oil 3, margarine1.
MadrobatDagag	Chicken 10, rice 30, water, 38, parsley 5, dill 5, coriander 4, onions 2, garlic 2, tomatoes 2, tomato paste 2, turmeric 1, powder cardamom 1, cinnamon 1, salt 2, sunflower oil 2.
Barinoish	Rice 60, sugar 20, water 20
KobozRugag	Wheat flour 69 , water 20, salt 1, dates with water (supernatant only) 10
MashkoolRubian	Shrimp 47, rice 20, water 21, onions 2, garlic 1, tomatoes 1, turmeric 1, powdered cardamom 1, cinnamon 1, salt 2, sunflower oil 2, capsicum 1
ThareedLaham	Meat with bone and fat (lamb) 20, water 35, squash 5, carrots 5, onions 3, potato 5, spicy green pepper 3, garlic 5, tomatoes 3, tomato paste 3, turmeric 2, cardamom 2, salt 3, capsicum 2, KobozRugag 10
MargoogLahem	Meat with bone and fat (lamb) 25, water 35, potato 4, onions 3, capsicum 3, squash 3, parsley 3, coriander 2, tomato paste 2, Iranian bread 14, salt 2, spice 1

Preparation of the composite dishes for nutrient analysis: All the raw materials used in the preparation of the samples were purchased on the same day of preparation from the retail stores. Fresh produce was stored in the refrigerator for a few hours prior to cooking. Dishes were then cooked according to the

recipes provided and reviewed by three Qatari women. Final dishes were then stored at a temperature of 2°C for 12 hours prior to analysis and raw ingredients for recipes with their amounts were recorded (Table 1).

Proximate composition: Cooked samples were prepared and homogenized, the samples were then coded, and stored in zip-lock plastic bags at - 20°C. Analyses commenced within two days after every sampling for the proximate composition. For the mineral analysis, samples were analysed after 1 week during which they were stored at - 20°C. The analysis was carried out at the Central Laboratory Unit at Qatar University. All analyses for macro-nutrients (moisture, crude protein, crude fat, ash) and micro-nutrients were performed in triplicates. Fat, ash and moisture content were determined at the Human Nutrition Program at the College of Arts and Sciences, Qatar University. Moisture content of all the foods, was determined in triplicates within two days of food preparation according to the AOAC Official Method 931.15 (2011). Crude fat was determined in duplicate by extracting 5 g samples in a Soxhlet apparatus using petroleum ether with a boiling point range of 40–60 °C. Protein analysis was performed in triplicate by the Kjeldahl method AOAC Official Method 960.52 (2011) and a conversion factor of 6.25 was used.

Mineral Analysis: Inductively coupled plasma mass spectrometer (Agilent, 7500Ce) was used for trace element measurements. Clean Nickel cones were used for sample analysis to avoid memory effects. A microconcentric nebulizer with a desolvation introduction system (ARDIUS, CETAC, USA) was used in the measurements. The instrument was first optimized for a maximum ion intensity with a 10 pg mL^{-1} standard solution of ^{89}Y. After optimization of all the instrumental conditions, a multielement standard solution composed of W, Bi, Pb, Sr, La, Ce, and Ba was aspirated as a blank to estimate the background. Detection limit was then calculated from the calibration curve using multi-element standard solution.

RESULTS AND DISCUSSION

Proximate compositions: Proximate compositions of all dishes analysed are given in Table 2. The table also compares the moisture content of the same dishes reported in other gulf countries. Moisture content was moderately high (63.6 ± 0.3 to 83.6 ± 0.5%) in all the meat dishes analyzed in this study. Highest moisture content was found in MadrobatDagag (83.6 ±0.5%). Similar high moisture values in meat dishes have been reported by earlier studies (Table3). KobozRugag, the traditional bread from the Arabian gulf region had the lowest moisture content (29.1 ± 0.9%). However, moisture content of KobozRugag from Bahrain was reported to be lower (6.5%; Musaiger, 2011). For Sago the moisture content was 39.8 ± 0.4%. Previous studies reported higher levels of moisture content in sago (59.4% and 70.7% moisture content; Al-Nagdy *et al*., 1994 and Musaiger, 2011 respectively). The moisture is directly related to the water content in the dish and the cooking time.= therefore, the recipe and cooking method may have resulted in such differences. For Asseda, the moisture content was 69.44 ± 0.1%. This value is higher than that reported by Al-Nagdy *et al*. (1994); Musaiger *et al*. (1998) and Musaiger (2011), who found that the moisture content of Asseda was 50.1, 65.3 and 29.7% respectively.

Table 2. Moisture content (%) of ten traditional Qatari dishes analyzed in this study along with the result from other studies done in the Gulf region.

Dishes	Result of present study	Musaiger, 2011 (Bahrain)	Habib *et al*., 2011 (UAE)	Al-Amiri *et al*., 2009	Musaiger & D'Souza., 2008 (Arabian gulf)	Musaiger *et al*., 1998 (Oman)	Al-Nagdy *et al*., 1994
HareesDagag	82.2 ± 0.1	81	79.91±2.05	NA	NA	80.2	NA
MakboosDagag	68.9 ± 0.9	72.6	65.91±4.8	NA	NA	72.6	64.4
MadrobatDagag	83.6 ± 0.5	NA	NA	NA	NA	NA	NA
ThareedLaham	82.2 ± 0.2	75	NA	NA	NA	NA	NA
MargoogLaham	81.9 ± 0.8	65.6	NA	NA	NA	NA	72
MashkoolRubian	63.6 ± 0.3	NA	NA	NA	62.7	NA	NA
Barinoish	61 ± 0.2	42.9	NA	NA	NA	59.7	50.7
KobozRugag	29.1 ± 0.9	6.5	8.63±4.68	NA	NA	NA	NA
Sago	39.8 ± 0.4	70.7	NA	NA	NA	NA	59.4
Asseda	69.4 ± 0.1	29.7	NA	52.80±0.36	NA	65.3	50.1

NA= Not analyzed.

Protein content varied from 1.7 ± 0.06 % in Asseda to 12.5 ± 0.04 % in MashkoolRubian (Table 3). Protein content is generally high in shrimp. Musaiger and D'Souza (2008) reported higher protein content in tiger shrimp cooked in rice (29.2%) over curried variety (24.6%) due to loss of water. Shrimps are a good source of protein, beneficial minerals and vitamins. Due their nutritional value and taste, they are in high demand and are cooked in a variety of ways. In Qatar, the shrimps are often cooked with rice. In our study the protein content of KobozRugag was 5.3 ± 0.07%. However, protein content in KobozRugag from Bahrain was reported to be 12.5% (Musaiger, 2011). Additionally, Habib *et al*. (2011) reported that protein content in Ragag from UAE was 10.89 ± 1.18%. Asseda, a sweet dish also made of wheat flour, contained the least protein content (1.7 ± 0.06%). However Al-Nagdy *et al*. (1994) found that the protein content of Asseda was much higher (3.1%). Similarly it was reported to be 3.9% in Oman (Musaiger *et al*.,1998) and 3.5% in Bahrain (Musaiger, 2011). The difference in protein content may be due to the difference in the wheat flour used. Whole grain wheat flour contains more protein than processed wheat flour. Fat content in the dishes analyzed in this study ranged from 0.08 ± 0.004% in Asseda to 0.96 ± 0.02 % in MakbousDagag (Table 4). The fat content in our study was lower than those reported by earlier studies. Al-Nagdy *et al*. (1994) and Musaiger (2011) reported 14.4 and 6.0 % of fat content in MakbousDagag respectively. Very high fat content was reported in Barinoish (33.1%) by Al-Nagdy *et al*. (1994) whereas Musaiger (2011) reported comparatively lower fat content (4.0 %). Barinoish is a sweet rice also known as Muhammer. Oil was not used in our recipe, whereas in the study conducted by Al-Nagdy *et al*. (1994), corn oil was used for making the sweet rice. The presence of oil and the quantity used may have changed the fat content of the dish. Al-Nagdy *et al*. (1994) who reported ghee as one of the ingredients used for making Asseda showed very high fat content (29.2%). Ghee contains around 60% saturated fat and is commonly used in many Asian and Arab traditional food. It is now a known fact that high consumption of saturated fat increases the risk of cardiovascular disease, obesity and diabetes. Manickavasagan and Al-Sabahi (2013) studied possible differences in textural and sensorial attributes in halwa made with ghee and vegetable oils. They reported that the majority of their panelists accepted the non-ghee halwa over halwa made with ghee. They also reported that the modified halwa had acceptable sensory qualities. Substitution of ghee with vegetable oil would be a healthy choice for prevention of diet related diseases in the long run.

Table 3. Protein content (%) of ten traditional Qatari dishes analyzed in this study along with the result from other studies done in the Gulf region.

Dishes	Result of present study	Musaiger, 2011 (Bahrain)	Habib *et al*., 2011 (UAE)	Al-Amiri *et al*., 2009	Musaiger & D'Souza., 2008 (Arabian gulf)	Musaiger *et al*., 1998 (Oman)	Al-Nagdy *et al*., 1994
HareesDagag	4.8 ± 0.05	5.1	3.33±0.15	NA	NA	5.4	NA
MakboosDagag	4.1 ± 0.1	5.0	6.14±1.28	NA	NA	4.8	11
MadrobatDagag	2.8 ± 0.7	NA	NA	NA	NA	NA	NA
ThareedLaham	1.8 ± 0.05	6.8	NA	NA	NA	NA	NA
MargoogLaham	4.9 ± 0.92	5.6	NA	NA	NA	NA	2.7
MashkoolRubian	12.5 ± 0.04	NA	NA	NA	29.2	NA	NA
Barinoish	2 ± 0.28	2.9	NA	NA	NA	5.2	1.8
KobozRugag	5.3 ± 0.07	12.5	10.89±1.18	NA	NA	NA	NA
Sago	1.9 ± 0.06	1.0	NA	NA	NA	Na	0.1
Asseda	1.7±0.06	3.5	NA	1.39±0.21	NA	3.9	3.1

NA= Not analyzed.

Mineral content: Analysis of selected dishes for twenty five mineral contents revealed that there was marked variation in the overall composition of minerals (Table 5). Highest amount of total mineral content was found in MashkoolRubian (2626.45 mg/100g) and the lowest total mineral content was found in Sago (50.08 mg/100g). HareesDagag, a chicken and rice dish, had the highest sodium content (1989 mg/100 g) while the lowest sodium content was found in Asseda (1.24 mg/100g). Asseda is a sweet dish in which no salt is added. The sodium content of Sago, also a sweet dish, was 6.07 mg/100g. Although Sago contains no added

salt, the sodium content of sago starch itself is around 7 mg/100 g. The results of this study were not in agreement with Al-Nagdy *et al*. (1994) who reported the sodium content of Aseeda, MargoogDagag, Mashkool, MakboosDagag, Barinoish, and Sago to be 13, 300, 155, 16 and 28 mg/100g respectively. Musaiger *et al*. (2008) also reported lower sodium content in MakboosDagag, (190 mg/100 g) and higher sodium content in Barinoish and Aseeda (381, 324 mg/100g respectively). Additionally in Bahrain, Musaiger (2011) showed that the sodium content of Aseeda, MargoogDagag, Mashkool,MakboosDagag, Harees, Barinoish, Thareed and Sago were 170, 231, 672, 285, 390, 17, 422, and 5 mg/100g respectively. According to USDA (2013), the estimated daily dietary intake for sodium should be less than 2300 mg (for males and females between the age of 14-50). One of the side effects of high sodium diet is the risk of developing cardiovascular diseases. Sodium increases blood pressure since it retains excess fluid in the body, creating an added burden on the heart. Too much sodium in the diet may also have other harmful health effects, including increased risk for stroke, heart failure, osteoporosis, stomach cancer and kidney disease (American Heart Association, 2013). The prevalence of cardiovascular diseases is increasing in the Middle east. According to the 2006 Qatar World Health Survey, 28% of individuals in the Qatari population were found to be hypertensive (Chanpong, 2008). In our study, most of the meat dishes contained very high levels of sodium and it is necessary that steps should be taken to reduce the sodium intake in diets to prevent the risk of developing hypertension and related complications.

Table 4. Fat content (%) of ten traditional Qatari dishes analyzed in this study along with the result from other studies done in the Gulf region.

Dishes	Result of present study	Musaiger, 2011 (Bahrain)	Habib *et al*., 2011 (UAE)	Al-Amiri *et al*., 2009	Musaiger & D'Souza., 2008 (Arabian gulf)	Musaiger *et al*., 1998 (Oman)	Al-Nagdy *et al*., 1994
HareesDagag	0.26 ± 0.05	1.5	1.43 ±1.6	NA	NA	1.4	NA
MakboosDagag	0.96 ± 0.02	6.0	2.64 ±0.54	NA	NA	2.0	14.4
MadrobatDagag	0.13 ± 0.001	NA	NA	NA	NA	NA	NA
ThareedLaham	0.32 ± 0.01	3.5	NA	NA	NA	NA	NA
MargoogLaham	0.08 ± 0.006	4.1	NA	NA	NA	NA	6.2
MashkoolRubian	0.34 ± 0.009	NA	NA	NA	5.6	NA	NA
Barinoish	0.09 ± 0.002	4.0	NA	NA	NA	NA	33.1
KobozRugag	0.03 ± 0.001	0.4	1.19 ±0.8	NA	NA	NA	NA
Sago	0.17 ± 0.006	2.2	NA	NA	NA	NA	4.8
Asseda	0.08 ± 0.004	6.3	NA	3.44 ±0.38	NA	4.7	29.2

NA= Not analyzed.

The deficiency of iron is another major health problem in the middle east. According to Musaiger (2002) the prevalence of iron deficiency (anemia) among preschool children of the Arab gulf countries ranged from 20% to 67%, while that among school children ranged from 12.6% to 50%. The percentage of pregnant women who suffered from anemia ranged from 22.7% to 54%. The result from our study showed that the highest iron content was found in KobozRugag (7.36 mg/100g) and the lowest in Barinoish (0.30 mg/100g). This is probably due to date extracts used in the production of KobozRugag and the fortified wheat flour. The high content of iron in KobozRugag is therefore beneficial to health if incorporated as part of a daily diet. The result of the calcium content analysis showed that the highest calcium content was found in Asseda (375.7 mg/100g) and the lowest in Barinoish (13. 6 mg/100g). The high level of calcium in Asseda may be due to the wheat flour which contains 40 mg of calcium per cup. Numerous studies have clearly revealed the association between a decreased risk of osteoporosis and adequate intakes of calcium and vitamin D (Musaiger *et al*., 2011). Food high in calcium like Asseda would be beneficial especially to children and women. Zinc is also an important micronutrient for health, the deficiency of which causes developmental abnormalities. From our results, the highest Zinc content was found in MargoogLaham (4.52 mg/100g) and the lowest in Sago (0.03 mg/100g). The highest magnesium content was found in Asseda (71.67 mg per 100g) and the lowest magnesium content found in Sago (2.42 mg/100g). Al-Nagdy (1994), found that the magnesium content in Asseda was 44 mg/100 g whereas, Musaiger (2011) found that the magnesium content of Asseda was 32 mg/100 g. However, in Oman, Musaiger *et al*. (1998) found that the magnesium content of Asseda was only 5.9 mg/100g.

Table. 5. Means for the total mineral content of selected traditional Qatari dishes (mg/100g).

Element	Reference material (Tomato leaves)	Aseeda	Margoog Laham	Mashkool Rubian	Koboz Rugag	Makboos Dagag	Harees Dagag	Barinoish	Madrobat Dagag	Thareed Laham	Sago
B (Boron)	3.33	0.66	0.33	0.25	0.21	0.21	0.11	0.05	0.15	0.21	
Na (Sodium)	13.63	1.28	1751.00	1929.00	707.40	1810.00	1989	4.12	1276	1602	6.07
Mg (Magnesium)	1196.00	71.67	55.40	69.16	57.08	31.60	59.63	7.23	32.51	57.97	2.42
Al (Aluminum)	59.64	6.95	3.37	3.30	4.14	2.18	4.53	0.26	4.16	2.00	2.63
K (Potassium)	2697.00	403.60	662.20	454.80	287.90	363.40	265.60	27.40	370.90	652.30	18.03
Ca (Calcium)	5054	375.70	80.10	160.30	52.77	37.97	52.85	13.58	59.21	54.87	13.91
Ti (Titanium)	1.67	0.25	0.63	1.01	0.57	0.39	0.51	0.07	0.01	0.18	ND
Cr (Chromium)	0.21	ND	0.0005	0.01	0.01	ND	ND	ND	ND	ND	ND
Mn (Manganese)	24.56	1.26	0.71	0.77	1.74	0.63	1.67	0.27	0.50	0.87	0.04
Fe (Iron)	36.85	1.67	6.57	2.62	7.36	1.65	2.49	0.30	3.02	4.97	6.54
Ni (Nickel)	0.16	0.003	0.008	0.003	0.015	0.004	ND	ND	ND	ND	ND
Cu (Copper)	0.47	0.12	0.41	0.58	0.32	0.20	0.36	0.09	0.03	0.14	ND
Zn (Zinc)	3.08	0.43	4.52	2.80	1.83	1.14	1.82	0.77	1.21	1.71	0.03
Rb (Rubidium)	1.49	0.23	0.34	0.15	0.50	0.38	0.29	0.02	0.22	0.49	ND
Sr (Strontium)	8.49	0.62	0.43	1.52	0.35	0.23	0.40	0.02	0.34	0.29	ND
Mo (Molybdenum)	0.04	ND	0.02	0.02	0.01	0.06	0.01	0.04	ND	ND	ND
Sn (Tin)	0.00	ND	0.01	0.01	0.01	0.02	ND	ND	ND	ND	ND
Ba (Barium)	6.29	1.31	0.16	0.06	0.21	0.07	0.11	0.01	ND	0.05	ND
Hf (Hafnium)	0.002	0.002	0.0015	0.0014	0.001	0.0012	0.0013	0.0012	0.01	0.01	0.01
Ta (Tantalum)	0.01	0.01	0.01	0.01	0.01	0.005	0.01	0.01	0.05	0.06	0.05
W(Tungsten)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.04
Au (Gold)	0.05	0.04	0.06	0.06	0.06	0.05	0.06	0.04	0.42	0.39	0.30
Hg (Mercury)	0.004	0.001	0.01	0.01	0.003	0.003	0.003	0.001	0.03	0.02	ND
Tl (Thallium)	0.01	0.004	0.003	0.0027	0.003	0.002	0.002	0.002	0.03	0.02	0.02
Pb (Lead)		0.012	0.0101	0.0083	0.013	0.0063	0.0052	0.0040	0.003	0.0026	ND

ND = Not detected.

The differences maybe because of different recipes (in Oman they do not add sugar) or the quality of wheat flour in each country. Copper content was found to be the highest found in MashkoolRubian (0.58 mg/100g) and the lowest in MadrobatDagag (0.03 mg/100 g). In the study done by Musaiger and D'Souza (2008), it was found that the copper content in shrimp cooked in rice was 0.6 mg/100g. Musaiger and D'Souza (2008) also found higher content of magnesium and calcium in shrimp cooked in rice and attributed it to the high content of these minerals found in shrimps with marginal contribution from the rice itself.

CONCLUSION

In recent years, due to changes in socio-economic conditions and subsequent changes in the diet habit of the people, health problems related to excessive consumption of calories and deficiency

of vital minerals are emerging as major problems. Preparation of traditional foods has also changed with an increased addition of fats, salt and white flour. The different methods of food preparation employed in Qatar have a marked influence on the nutrient and mineral composition of traditional dishes. A natural consequence of rise in food consumption and increase in the caloric density of Qatari foods has led to the increase of non-communicable diseases in Qatar and these include obesity, cardiovascular diseases, diabetes and micronutrient deficiencies. Data on the nutrient content of Qatar foods provided to health care workers, nutritionists and dietitians will assist them in addressing the major nutritional problems that are all associated with the diet of the community.

With reference to the food composition data in the Gulf, comprehensive analysis of foods is needed since most of the data compiled is based on calculations and not from direct analysis of foods. Most countries allow the use of compositional data taken from a regulatory compilation databases, such as a national food composition database as a substitute for direct analysis. This has added a quasi-regulatory role to food composition databases and strengthens the need for maintenance of data quality in terms of both the representativeness of the samples and the quality of the analytical data.

ACKNOWLEDGEMENT

The authors would like to acknowledge Qatar University Research Office for their financial support of the study. Thanks is also extended to Mr. Jaafar Pakari, Laboratory Technician at the Human Nutrition Program, Qatar University for his assistance. The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

AUTHORS CONTRIBUTIONS

Tahra ElObeid designed the research plan and worked with Ms. Zainb Megdad in the lab and in analysis of the results and discussion. Susanna Phoboo reviewed the paper and assisted in preparation of the manuscript.

REFERENCES

Al-Jedah J.H. and R.K. Robinson. 2000. Chemical composition of some ready-to-eat meals consumed in Qatar. Nutr Food Sci 30:300-303.

Al-Nagdy S.A., A. Sawsan, A. Abdel-Ghani and M.O. Abdel-Rahman. 1994. Chemical assessment of some traditional Qatari dishes. Food Chem 49:261-264.

AOAC. 2011. *Official methods of Analysis of Association of Official Analytical Chemists,* 18th edition.

Chanpong G.F. 2008. Qatar World Health Survey overview. Department of Public Health National Health Authority. Doha, Qatar.

Dashti B.H., F. Al-Awadi, M.S. Khalafawi, S. Al-Zenki and W. Sawaya. 2001. Nutrient contents of some traditional Kuwaiti dishes: proximate composition and phytate content. Food Chem 74:169-175.

Habib H.M., H.I. Ali, W.H. Ibrahim and H.S. Afifi. 2011. Nutritional value of 10 traditional dishes of the United Arab Emirates. Ecol Food Nutr 50:526-538.

Lewis C. and J. Lupien. 1996. FAO perspectives on international food composition activities. In: Musaiger, A.O., S. Miladi, eds. Proceedings of workshop on establishing food composition data for the Arab countries of the Gulf. FAO/RNE, Cairo, Egypt.

Manickavasagan A and J.N. Al-Sabahai. 2013. Reduction of saturated fat in traditional food by substitution of ghee with olive oil and sunflower oil - A case study of halwa. J Assoc Arab Uni Basic Appl Sci: http://dx.doi.org/10.1016/j.jaubas.2013.06.003.

Musaiger A.O. 2012. The food dome: dietary guidelines for Arab countries. Nutricion Hospitalaria. 27:109-115.

Musaiger A.O. 2011. Food composition tables for the Kingdom of Bahrain. Arab Center for Nutrition. Manama, Bahrain.

Musaiger A.O., A.S. Hassan and O. Obeid. 2011. The paradox of nutrition related disease in the Arab countries- the need for action. Int J Environ Res Publ Health. 8:3637–3671.

Musaiger A.O. and R. D'Souza. 2008. The effects of different methods of cooking on proximate, mineral and heavy metal composition of fish and shrimps consumed in the Arabian Gulf. Archivos Latinoamercanos de Nutricion. 58:103-109.

Musaiger A.O. 2002. Iron deficiency anemia among children and pregnant women in the Arab gulf countries: the need for action. Nutr Health. 16:161-171.

Musaiger A.O., A.A. Mousa and V.R. Madduri. 1998. Chemical composition of some traditional dishes of Oman. Food Chem. 61:17-22.

Mushlin A.I., P.J. Christos, L. Abu-Raddad, H. Chemailtelly, D. Deleu and A.R. Gehani. 2012. The importance of diabetes mellitus in the global epidemic of cardiovascular disease: The case of the state of

Qatar. Trans Am Clin Climatol Assoc. 123:193-208.

Qatar National Food Security Program (QNFSP). 2013. Available at: http://www.qnfsp.gov.qa/issue/economics-brief-en/issue1-en. Accessed on 30 December 2013.

Supreme Council of Health. 2013. Qatar STEPwise report 2012. Chronic Disease Risk Factor Surveillance. Supreme Council of Health, Doha.

USDA, National Agriculture Library. 2013. Dietary Reference Intakes: Recommended Intakes for Individuals. Available at: http://fnic.nal.usda.gov/dietary-guidance/dietary-reference-intakes/dri-tables.

World Health Organization. 2011. Non-communicable disease profile country profile 2011- Qatar. Available at: http://www.who.int/nmh/countries/qat_en.pdf.

World Health Organization 2013. Diabetes Program - country and regional data on diabetes. Available at: http://www.who.int/diabetes/facts/world_figures/en/index2.html