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NUTRITIVE VALUES OF SOME FOOD PLANTS, FRESH AND PROCESSED FISH SPECIES

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Abstract

The chemical composition of four edible plant foods species, three fish species and one prawn were analyzed in Food Chemistry Laboratory of Behbahan Khatam Alanbia University of Technology, Behbahan, Iran in 2014. The analysis of fatty acid and sugars composition were performed by gas liquid chromatography and high performance liquid chromatography, respectively. Protein and lipid content were founded higher in baked and fried in fish *S. commersonnianus* (74.29%), (20.20%), fish *Sphyraena helleri* (88.12%) and (17.77%), respectively. Ash content in fish *S. commersonnianus* varies from 9.80% to 15.34%, and in fish *S. helleri* from 5.83% to 7.68%. Based on the proximate analysis, it can be calculated that an edible portion of 100 g of studied edible plant foods provides, on average, around 303.9±1.04 kcal. The plant *Portulaca neglecta* is suitable for high temperature food processes. The macronutrient profile in general revealed that the wild plant foods were with rich sources of protein and carbohydrates, and had low amounts of fat. The highest protein, the lowest fat and energy contents were found in boiled in both fish species; therefore, boiling can be recommended as the best cooking method for healthy diet.

Keywords: Food Plants, Fatty Acid Composition, Sugar Composition, Proximate Composition

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Introduction

The considerable use of wild edible plant species by the local people in their diet motivated us to carry out the present nutrients analysis. In spite of their importance as a food source, to the best of our knowledge, there are no published studies on the nutritional composition of wild edible plants and information on the nutritional composition of these varieties. The present study was therefore, initiated to evaluate the nutritive value of *Alocasia lancifolia, Asparagus palaestinus*, *Portulaca neglecta* and *Solanum incanum* are consumed in India and Iran, but these food plants are novel for analysis of composition.

The food plants being the rich sources of carbohydrates, fats and proteins, which form the major portion of the human diet, are the cheaper source of energy. The importance of these biochemical compounds has been recorded by various scientists (Kalita *et al.,* 2007; Hussain *et al.,* 2009). Besides these nutrients, the moisture, fiber, and ash contents and the energy values of individual plant species have also been regarded important to the human health (Cummings *et al.,* 2004; Mcsweeney *et al.,* 2005; Hussain *et al.,* 2010).

Proximate and nutrient analyses of edible plants play an important role in assessing their nutritional significance (Pandey *et al.*, 2006). As various edible medicinal plant species are used as food along with their medicinal benefits, evaluating their nutritional significance can help to understand the worth of these plant species (Pandey *et al.,* 2006). For herbal drug's standardization is concerned, WHO also emphasize on the need and importance of determining proximate and micronutrients composition of the food plants. Such herbal formulations must pass through standardization processes (Niranjan and Kanaki, 2008).

They are also increasingly marketed for their health benefits to consumers (Schmidt *et al.,* 2006, Agusa *et al.,* 2007). Generally, marine fish can be divided into pelagic and demersal fish. Pelagic fish are those fish associated with the surface or middle depth of body water (Fisheries Research Institute, 2004). Marine pelagic fish can be divided further into coastal fish and oceanic fish depending on the continental shelf they inhabit (McLintock, 2007). Various studies have been carried out on the proximate chemical composition (Uauy and Valenzuela, 2000; Schonfeldt, 2002), and fatty acids profiles of different fish species (Adeyeye, 2000; Adeyeye, 2005). There is, however, dearth of accurate basic chemical composition data for fish species particularly from Asian sources (Adeyeye, 2002). This constitutes a barrier to development of the

use of the resources. Proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituents accounts for about 96-98% of the total tissue constituents in fish (Nowsad, 2007). The assessment of the proximate composition of the fish is not only important to know its nutritive value, but also for its better processing and preservation (Mridha *et al.*, 2005).

However, processing methods such as boiling, frying, roasting and smoking have been used to preserve and increase its availability to consumers for maximum around two years after caught fish (Olayemi *et al.*, 2011). Most processing methods often times involve removal of the wastes parts of the fish which may have negative effect on the total nutritive values of the fish (Saliu, 2008). Previous works reported the effect of processing methods on different fish types for determination of their nutritive values (Sanchez-Muniz *et al.,* 1992; Oluwaniyi and Dosumu, 2008; Osibona, 2011). Fish is rarely eaten raw and usually cooked in different ways before consumption. Heating is one of the common methods in food processing. Heat is applied for food in different ways (Boiling, baking, roasting, frying and grilling) to enhance their flavor and taste; increase shelf life (Garcia-Arias *et al.,* 2003). However, the effect of different cooking methods invariably affects the nutritive value of fish. The effects of different cooking methods on proximate and mineral composition of some fish species have been reported (Ersoy *et al.,* 2006; Gokoglu *et al.,* 2004; Kucukgulmez *et al.,* 2006; Rosa *et al.,* 2007; Weber *et al.,* 2008; Stephen *et al.*, 2010). Aim of this study was to compare the nutritive values of selected food plants and fish species.

Materials and Methods

Samples preparation

The *Alocasia lancifolia* was purchased from three various localities of Maharashtra, India. Three wild edible plants viz. *Asparagus palaestinus*, *Portulaca neglecta* and *Solanum incanum* were collected from three areas in around Behbahan city, Iran in April 2010. After collection, the plants were grouped by taxon; air dried in a freeze-drier (Ly-8-FM-ULE, Snijders) and were powdered before analysis (Moser, 1983; AOAC, 2000; Harada *et al.,* 2004; Flegg and Maw, 1977).

Collection of fish species

Fresh Scom beroides lysan (*Scomberoides commersonnianus*), with a length (45-53cm) and weight of (1kg) and Sphyraenidae (*Spyraena helleri*) with a length (57-63 cm) and weight of (1kg) were collected from Behbahan market of Iran. The fish samples were gutted, washed, filleted, finely minced and homogenized for chemical analyses. All samples of seafood and edible plants were analyzed in chemistry laboratory of Behbahan Khatam Alanbia University of Technology, Behbahan, Iran.

Chemical composition

Samples of edible plant foods and fish species were analyzed for chemical composition (protein, fat, carbohydrates and ash) using the AOAC procedures (AOAC, 2000). The crude protein content (N×4.38) of the samples was estimated by the Macro Kjeldahl method according to León-Guzmán *et al.* (1997); the crude fat was determined by extracting a known weight of powdered sample with petroleum ether, using a Soxhlet apparatus; the ash content was determined by incineration at 600 ± 15 ºC. Total carbohydrates were calculated by difference. Total energy was calculated according to the following equations of Manzi *et al.* (2001): Energy (kcal) = 4 ×(g protein+ g carbohydrate)+ 9×(g lipid)

Fatty acid composition

Fatty acids were determined by gas–liquid chromatography with flame ionization detection (GLC–FID)/capillary column based on the ISO 5509 (2000) trans-esterification method. The fatty acid profile was analyzed with a Chrompack CP 9001 chromatograph (Chrompack, Middelburg, Netherlands) equipped with a split–splitless injector, a FID, and a Chrompack CP-9050 autosampler. The temperatures of the injector and detector were 250 ºC. Separation was achieved on a 50 m × 0.25 mm i.d. fused silica capillary column coated with a 0.19 lm film of CP-Sil 88 (Chrompack). Helium was used as carrier gas at an internal pressure of 120 kPa. The column temperature was 140 ºC, for a 5 min hold, and then programmed to increase to 220ºC at a rate of 4 ºC/min and then held for 10 min. The split ratio was 1:50, and the injected volume was 1.2. The results are expressed in relative percentage of each fatty acid.

Sugar composition

Free sugars were determined by high performance liquid chromatography coupled to a refraction index detector (HPLC–RI) based on the method used by Harada *et al.* (2004), with minor modifications. Dried powder (1.0 g) was extracted with 40 mL of 80% aqueous ethanol at 80 ºC for 30 min. The resulting suspension was centrifuged at 15,000g for 10 min. The supernatant was concentrated at 60 ºC under reduced pressure and defatted three times with 10 mL of ethyl ether, successively. After concentration at 40 ºC, the solid residues were dissolved in water to a final volume of 5 mL. Soluble sugars were determined by using HPLC (Knauer, Smartline system) at 35 ºC. The HPLC system was equipped with a Knauer Smartline

2300 RI detector and with a Eurospher 100-5 NH2 column (4.6×250 mm, 5 mm, Knauer). The mobile phase was acetonitrile/deionized water, 7:3 (v/v) at a flow rate of 1.25 ml/min. The results are expressed in g/100 g of dried weight. The sugar standards used for identification were purchased from Sigma Chemical Co. (St. Louis, USA): D(-)-fructose, D(+) galactose, D(+)-glucose anhydrous, D(+)-sucrose, and D(+)-xylose.

Statistical analyses

Analysis of variance (ANOVA) (IBM SPSS Statistic 19) was used to compare means of the proximate composition and fatty acid data. Further analysis was carried out where there was significant difference ($P<0.05$).

Results and Discussion

The results of the chemical composition and estimated energetic value obtained for the four plant foods species are shown in Table 1. Protein was found in high levels and varied between 5.7± 0.18 g/100 g in *Alocasia lancifolia* and 32.69± 0.03 g/100 g in *Asparagus palaestinus*. However, it is known that the protein contents of plant foods are affected by a number of factors, namely the type of plant foods, the stage of development, the part sampled, level of nitrogen available and the location (Die´z and Alvarez, 2001). Fat ranged from 3.29± 0.01 g/100 g in *Alocasia lancifolia* and 13.76± 0.01 g/100 g in *Solanum incanum*. The wild plant foods were rich sources of protein and had moderate amounts of fat making it an ideal snack material (Die´z and Alvarez, 2001). Carbohydrates calculated by difference, were also an abundant macronutrient and ranged from 34.67± 0.17 g/100 g in *Asparagus palaestinus* and 72.66± 0.22 g/100 g in *Alocasia lancifolia*.

The moisture content of plants was found to range from 8.00± 0.06 g/100g for *P. neglecta* to 23.90± 0.03g/100g for *S. indicum,* which makes them more stable during storage and packaging. Similar low moisture contents (8-24 g/100g) have been reported on some of these spices (Tchiegang and Mbougueng, 2005). The ash content found between 7.3± 0.02g/100g and 22.6± 0.03 g/100g—a range that is much higher than that reported earlier (Tchiegang and Mbougueng, 2005). These differences may probably reflect the difference in the origin and varieties of samples.

The ash content varied between 7.3± 0.02 g/100 g in *Alocasia lancifolia* and 22.6± 0.03 g/100 g in *Portulaca neglecta*. All the species seem to have a normal chemical composition compared with other edible plant foods (Manzi *et al.,* 2001; Manzi *et al.,* 2004; Agahar-Murugkar and Subbulakshmi, 2005). On the basis of the proximate analysis, it can be calculated that an edible portion of 100 g of these plant foods provides, on average, 300 kcal. The highest values were guaranteed by *Alocasia lancifolia*, while *Asparagus palaestinus* give the lowest energy contribution (Table 1). The results for fatty acid composition, total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) of the studied plant foods are shown in Table 2. In general, the major fatty acids found in the studied samples were linoleic acid (C18:2 n -6) and oleic acid (C18:1 n -9), followed by palmitic acid (C16:0). This is in agreement with the results reported in other plant foods (Die´z and Alvarez, 2001). It is known that linoleic acid is the precursor of 1-octen-3-ol, known as the alcohol of fungi, which is the principal aromatic compound in most fungi and might contribute to plant foods flavor. This is consistent with the observations that, in plant foods, unsaturated fatty acids predominate over the saturated in the total fatty acid content (Mauger *et al.,* 2003). Considering total MUFA content, *Solanum incanum* had the lowest value but contained the highest PUFA content, also being the plant food with the highest value of linoleic acid. *Asparagus palaestinus* found the lowest SFA value, and the highest value of oleic acid presenting value was for *Alocasia lancifolia* in agreement with those published previously (Die´z and Alvarez, 2001). A rapidly expanding literature documents the importance of trans fatty acids (TFAs) in human health due to the increased risk of cardiovascular disease where they are negatively correlated with plasma HDL-cholesterol concentration and positively correlated with plasma LDL-cholesterol level. It is also important to point out that, in contrast to other fungi (Die´z and Alvarez, 2001); no other fatty acids with an odd number of carbon atoms have been detected in considerable amounts. Concerning sugar composition (Table 3), the four plant foods showed some homogeneity. All of them presented glucose and fructose as main sugars. In *Alocasia lancifolia*, *Solanum incanum* and *Asparagus palaestinus,* fructose was the most abundant sugar ranging from 5.21± 0.03 to 8.06± 0.18 g/100 g of dried weight.

Proximate composition of raw, fried, boiled and baked of *Scomberoides commersonnianus* and *S. helleri* are shown in Tables 4 and 5. Fat minimum content was found to be 5.50% in raw *S. helleri* and highest content in the fried *Scomberoides commersonnianus* (20.20%). The ash content was highest in boiled fish *Scomberoides commersonnianus* (15.34%). Protein content was recorded highest in the baked *S. helleri* (88.12%).

Fried fish had a higher level of fat than raw or other cooked fish. The increase in fat content of the fried fish fillets is also related to oil absorption during the cooking process. Fat increase can be due to the oil penetration into the food after water is partially lost by evaporation (Saguy and Dana, 2003). Similar results have

been reported for African Catfish fried in sunflower oil (Rosa *et al.,* 2007). The lower fat content in the boiled and baked *S. helleri* is mainly due to absorption of water used in the curry preparation. The protein content was generally high which an expected outcome is since fishes are good sources of protein (Tidwell and Allan, 2001). The higher protein content in the fried fish is due to meat because of moisture loss. Further evidence of this is seen in the fact that *S. helleri* cooked in curry and steamed had lower protein content but had higher moisture contents. This can be attributed to absorption of water from the cooking medium thereby causing dilution of the muscle tissue analyzed. This higher protein content in fish is important from a dietary point of view since; the quality of fish protein is very high because of its essential amino acid composition (Beklevik *et al.,* 2005). Fish proteins are especially labile and easily denatured than those of meats and the molecules are already stretched to the disruptive action of enzymes that increased in digestion. Adiachi *et al.* (1958) stated that application of heat result in some increase in digestibility that effect on the 10-20 percent of globular proteins in fish muscles. Further, reports also indicate that fish muscle is more digestible than other animal protein due to lower level of connective tissue (Al- Jehah *et al.,* 1999). The increase in dry matter content was observed in fried fish. The highest moisture content was recorded in fresh and decrease moisture content was noticed in all method of cooked fish when compare to fresh fish. These changes were similar to those reported by Gokoglu *et al.* (2004) in rainbow trout and in sardines by (Garcia-Arias *et al.,* 2003). Water losses, occurring during frying resulted in higher protein content in fried fish as compared to the fresh fish (Garcia-Arias *et al.,* 2003). Accordingly, the increase in ash, protein and fat content found in cooked silver catfish fillets is explained by the reduction in moisture. Differences in water contents between fresh smoked rainbow trout were found to be significant (Unlusayin *et al.,* 2001). These findings also supported by Gall *et al.* (1983), that deep fried fish fillet. The higher ash content in the cooked fish might be due to its higher bony consistency and high scaly nature. Such fish offer minerals in their edible forms more abundantly than large-sized fish do (Higashi, 1962).

The proximate composition of raw fillets both fish species is similar to earlier reports in tested fish (Zuraini *et al*., 2006). Proximate composition of protein, fat and ash of fishes *S. commersonnianus* and *S. helleri* was varied in all the cooking methods. There was no significant difference observed in fat content among boiled, baked and raw fish fillets (P>0.05). Similar results were reported for sardine and African catfish fried in vegetable oil (Candela *et al.,* 1996). Increased ash content was noticed in all the cooked *S. commersonnianus* fillets when compared to raw fish fillets. Accordingly, the increase in ash, protein and fat content found in cooked silver catfish fillets is explained by the reduction in moisture. This was because their content of protein, fat and carbohydrate did not differ much. Comparison of all food based plants and seafood exanimated showed that *Asparagus palaestinus* contains the highest amount of protein (32.69%), while *Solanum incanum* and *Alocasia lancifolia* contains the highest values of fat (13.76%) and energetic (329.2 kcal/100g) respectively. *Portulaca neglecta* contains the highest amount of ash (22.6%). There was also certain information in previous studies that was insufficient to be used for comparison with the current study. Thus, it is hopeful that details on the sampling procedures and methods of analysis used in this study will be able to provide sufficient information for any comparative purposes in the future. The proximate values obtained from this study would be useful to help the consumers in choosing fish based on their nutritional values besides providing an update to food composition database.

Several factors influence the nutritional content of the processed fishes and the type and level of losses due to processing. The heat and flow of gases cause drying of the seafood item. This decreases the water content thereby causing the changes associated with dehydration such as increasing the protein and fat concentration of processed fillets. The nutrient changes that occur during concentration will depend on the contents of the mixture and the temperature at which the process takes place. Generally, there is a decrease in water content and corresponding increase in other nutrients.

Table 1**.** Proximate chemical composition (g/100 g of dried weight) and energetic value of four wild edible food plants

Composition	*Alocasia lancifolia*	*Asparagus palaestinus*	*Portulaca neglecta*	*Solanum incanum*
Total fat	3.29 ± 0.01^{a}	3.44 ± 0.02^{a}	5.26 ± 0.02^{b}	13.76 ± 0.01^{c}
Crude protein	5.70 ± 0.18^{a}	32.69 ± 0.03^{b}	23.47 ± 0.02^{c}	12.85 ± 0.03^{d}
Ash	7.30 ± 0.02^{a}	10.70 ± 0.01^{b}	22.60 ± 0.03^{c}	11.00 ± 0.07^{d}
Carbohydrates	72.66 ± 0.22^{a}	34.67 ± 0.17^{b}	40.67 ± 0.23^{c}	38.49 ± 0.04^{d}
Energy (kcal)	343.05 ± 1.74^{a}	300.40 ± 0.73^{b}	303.90 ± 1.04^{b}	329.2 ± 0.26^{c}

Same letters in each row show no significance different (p<0.05). Data has been presented as mean ± SD; n = 3

Table 2. Fatty acids composition (%) of four edible food plants

Composition	*Alocasia lancifolia*	*Asparagus palaestinus*	*Portulaca neglecta*	*Solanum incanum*
C16:0	9.24 ± 0.27[a]	15.95 ± 0.06[b]	34.48 ± 0.05[c]	10.26 ± 0.05[d]
C18:0	17.97 ± 0.23[a]	ND	21.78 ± 0.02[b]	18.83 ± 0.11[c]
C18:1c	68.16 ± 1.67[a]	66.12 ± 0.02[b]	ND	8.60 ± 0.20[c]
C18:2c	ND	9.60 ± 0.23[a]	ND	62.29 ± 0.38[b]
C18:3c	ND	ND	ND	ND

ND means not detected. Same letters in each row shows no significance different (p<0.05). Data has been presented as mean ± SD; n =3

T able 3. Sugars composition (g/100 g of dried weight) of four wild edible food plants

Composition	*Alocasia lancifolia*	*Asparagus palaestinus*	*Portulaca neglecta*	*Solanum incanum*
Glucose	2.10 ± 0.01[a]	1.53 ± 0.02[b]	0.01 ± 0.02[c]	3.19 ± 0.01[d]
Fructose	8.06 ± 0.18[a]	6.86 ± 0.03[b]	0.86 ± 0.02[c]	5.21 ± 0.03[d]
Sucrose	2.09 ± 0.02[a]	ND	ND	0.59 ± 0.07[b]
Total sugars	12.25 ± 0.22[a]	8.39 ± 0.17[b]	0.87 ± 0.23[c]	8.99 ± 0.04[b]

ND means not detected. Means within the row with different letters are significantly different (p<0.05). Data has been presented as mean ± SD; n =3

Table 4. Proximate composition (DM powder %) of raw and cooked fillets samples of *S. commersonnianus*

Composition	Raw	Boiled	Baked	Fried
Protein	78.78 ± 0.78[a]	67.36 ± 0.98[b]	74.29 ± 0.33[c]	68.56 ± 0.41[b]
Lipid	8.46 ± 1.78[a]	12.86 ± 0.22[b]	11.74 ± 0.69[b]	20.20 ± 0.45[c]
Ash	9.49 ± 0.57[a]	15.34 ± 0.75[b]	13.63 ± 0.37[c]	9. 80 ± 0.79[a]
Carbohydrate	3.27±0.27	4.44±0.38	0.34±0.11	1.44±0.29
Energetic value (Kcal/100g)	405.12 ± 1.28[a]	402.94 ± 1.22[a]	404.18 ± 1.56[a]	461.80 ± 1.78[b]

Values are shown as mean ±standard deviation of triplicates. Values within the same row have different superscripts are significantly different (p < 0.05)

Table 5. Proximate composition (DM powder%) of raw and cooked fillets samples of *S. heller*

Composition	Raw	Boiled	Baked	Fried
Protein	86.75 ± 1.68[a]	87.16 ± 0.98[a]	88.12 ± 0.47[a]	74.11 ± 0.36[b]
Lipid	6.52 ± 0.24[a]	5.50 ± 0.68[a]	5.71 ± 0.58[a]	17.77 ± 0.34[b]
Ash	9. 50 ± 0.58[a]	7.06 ± 0.57[b]	5.83 ± 0.22[c]	7. 68 ± 0.55[b]
Carbohydrate	0.50±0.21	0.28±0.11	0.34±0.24	0.44±0.23
Energetic value (Kcal/100g)	407.68 ± 0.68[a]	399.26 ± 0.48[b]	405.23 ± 0.38[a]	458.13 ± 0.29[c]

Values are shown as mean± standard deviation of triplicates. Values within the same row have different superscripts are significantly different (p < 0.05)

Conclusions

Plant *Portulaca neglecta,* is suitable for high temperature food processes. In conclusion, the chemical composition and energy values of the wild edible plant foods clearly indicate that they provide key nutrients such as protein, unsaturated fatty acids, and carbohydrates. Therefore, it is now imperative that a nutritional database of these plant foods is set up to retain the information on these unique species and for a better management and conservation of this natural resource and habitats related to them. There were many possible factors such as size, sex, maturity of samples that can affect the differences in proximate composition of marine fish. In this research, the highest protein, the lowest fat content and calorie value were found in boiled fish; therefore, boiling can be recommended as the best cooking method for healthy diet.

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