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Identification and chemical studies of pelagic masses of *Sargassum natans* (Linnaeus) Gaillon and *S. fluitans* (Borgessen) Borgesen (brown algae), found offshore in Ondo State, Nigeria

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The pelagic seaweed found offshore and negatively impacting fishing activity in Ondo State Nigeria, has been identified to be a mixture of *Sargassum natans* and *Sargassum fluitans* which presumably floated from the Sagasso Sea of North Atlantic. In a bid to harness the potential uses of the seaweed biomass, the mixed *Sargassum* species were analyzed for the proximate composition, some minerals and phytochemical constituents using standard methods. The mixed *Sargassum* species contained 154 mg/100 g% protein, 86.5 mg/100 g ash content, 25.5 mg/100 g fat, 71.5 mg/100 g fibre and 573 mg/100 g carbohydrate. Thus it could be consumed by humans if cleaned. Owing to the small concentration of Nitrogen (6.3 mg/100 g), phosphorus (96.5 mg/100 g) potassium (28 mg/100 g), the percentage ratio of N-P-K (1-10-3) of *Sargassum* spp. was recommended as fertilizer. The presence of flavonoids, tannins, terpenoids and saponins show that the species can be harnessed for their medicinal potentials.

Key words: *Sargassum natans, Sargassum fluitans,* brown algae, proximate analysis, phytochemical, fertilizer, Nigeria.

INTRODUCTION

In July 2012, the Nigerian media reported the occurrence of an unknown seaweed floating massively off the coast of Ajegunle-Erun-Ama (Lat. 06^o 19′ 32″, Long. 04^o 30′ 32″E, alt 5 m) in Ondo State, Southwestern Nigeria. The fishermen in the area observed that between April and July during the wet season, their nets were often filled with the seaweed mass instead of fishes. Consequently, their fishing occupation was adversely affected. Additionally, handling the seaweed biomass resulted in skin and eye irritation. Owing to these reports, two field trips were made to the locality with a view to collecting the seaweed and getting any useful information from the fishermen. The seaweed was instantly identified by the second author as *Sargassum*, a brown alga.

On a global scale, *Sargassum* (*Sargassum natans* and *Sargassum fluitans*) has broad distribution offshore of the North Atlantic (Schneider and Searles, 1991) and outside the Sargasso Sea there are more *Sargassum* floating in the Gulf of Mexico than anywhere else in the world (Conver and Sieburth, 1964; Gower and King, 2008). *S. fluitans* has recently been added to the Global database of Invasive Species Specialist Group (ISSG) (2011). The floating *S. natans* and *S. fluitans* are taxonomically valid speciesthat dominate the algal communities of the

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Figure 1. Sargassum mass (*Sargassum natans* and *S. fluitans*) found at Ajegunle Erun-Ama beach, Ondo State, Nigeria. Part of the lateral branches (A), gas bladders (B).

Sargasso Sea and both occur in the western Atlantic Ocean (Guiry and Guiry 2011; Wynne 2011). Based on six years record of satellites imagery tracking of movement and distribution of floating *Sargassum* spp. in the Gulf of Mexico and West Atlantic, Gower and King (2008) reports that floating *Sargassum* species originate from Gulf of Mexico and have a life span nearly always one year.

Five *Sargassum* species, *Sargassum acinarium*, *Sargassum cyniaun Sargassum filipendula, Sargassum ramifolum* and *Sargassum vulgare* were described and reportedly found in some West African countries (John et al., 2003). Of all these species, only *S. vulgare* and its variety (var. *foliosissimum* are distributed in 12 West African countries including Nigeria. It was thought desirable to ascertain whether the features of *Sargassum* from Ondo State, Nigeria, resemble any of the species recorded for West Africa.

Seaweeds are of economic importance. *Sargassum* species are used as fodder and fertilizer in China and many parts of Asia (Round, 1973). *Sargassum* forms about 10% of the average diet in Japan where tender parts of the plant are eaten raw as salad or cooked with coconut milk. Also in Bermuda, indigenes spread out salt free *Sargassum* clumps as fertilizer around the base of banana. Algin, a carbohydrate found in *Sargassum* is extracted for use in textile, paper and pharmaceutical industries (Chennubhotla et al., 1981). *Sargassum* biomass is used as a potential renewable energy resource such as biogas (Wang et al., 2009, Yokoyama et al., 2007). Despite the annual invasion of *Sargassum* biomass and its attendant negative impact on the traditional fisheries in Ondo State, the plant material caught in the nets could be useful to humans. In view of this, the present study was undertaken to identify the invading *Sargassum* species and carry out chemical studies using the biomass. This is with a view to harnessing the potential uses of the seaweed.

MATERIALS AND METHODS

Collection and Identification of Plant materials

Plant materials were collected into glass jar containing sea water during the two visits made to Ajegunle-Erun-Ama beach, Ondo State Nigeria Figure 1. Detailed identification of the plant material was done in the laboratory with the aid of dissecting microscope and verified with illustrations by Széchy et al. (2012), Dawes and Mathieson (2008), John et al. (2003) Littler and Littler (2000) and Schneider and Searles (1991).

Proximate analysis

The powdered *Sargassum* sample was analyzed for crude protein, crude fat, fibre, moisture, ash using the methods described in AOAC (2005). The carbohydrate content was calculated by using the formula below. The analyses were duplicated.

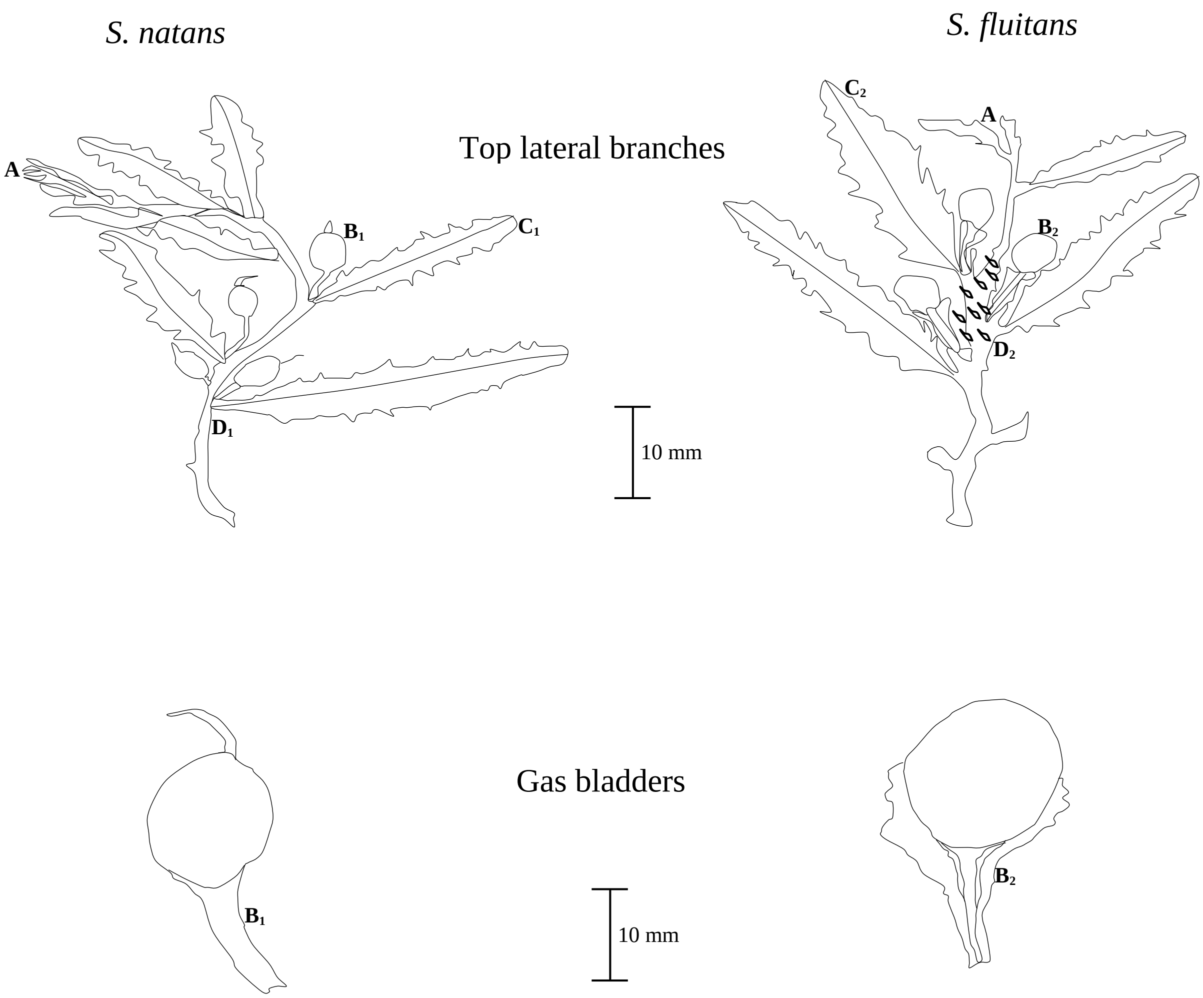

Figure 2. *Sargassum* (*S. natans* and *S. fluitans*. Receptacle (A), gas bladder with spine, stalk without wing (B_1), gas bladder without spine, stalk with wing (B_2), linear leaf with seriated margin (C_1), lanceolate leaf with seriated margin(C_2), lateral branch without spines (D_1), lateral branch with spines (D_2).

$$\%CHO = 100 - \%\text{moisture} + \%\text{ash} + \%\text{fat} + \%\text{protein} + \%\text{fibre}$$

Mineral analysis

The method of Walsh (1971) was used for the digestion of dried *Sargassum* material. After digestion, percentage of potassium, magnesium, zinc, iron, iodine were analyzed using atomic absorption spectrophotometer (FC 210/211, VGP Bausch Scientific AAS). Nitrogen content was determined by Kjeldahl method. Phosphorus was determined using Vanadomolybdate yellow method (AOAC, 2005). Percentage transmittance was determined at 400nm using Spectronic 20 (Bausch and Lomb) Colorimeter. Analyses were duplicated.

Phytochemical analysis

Phytochemical qualitative analysis of the plant sample was carried out using standard procedures described by Sofowora (1993) and Evans (2002).

RESULTS AND DISCUSSION

The *Sargassum* mass is shown in Figure 1. Based on light microscopical studies, the *Sargassum* 'wracks' was identified as a mixture of *S. natans* (Linnaeus), Gaillon and *S. fluitans* (Borgesen) Borgesen (Figure 2). The two species were differentiated as outlined in Table 1. Of all the morphological differences, two are particularly remarkable - the usual occurrence of spines on the air bladder of *S. natans* and their absence in *S. fluitans.* The other distinguishing character is that while *S. natans* had long stalk bladder, the *S. fluitans* had short stalk with wing tissue around it (Figure 2).

Several workers (Schnieder and Searles, 1991; Littler and Littler, 2000; Dawes and Mathieson, 2008; Conti, 2008; Shapiro, 2004) observed that *S. fluitans* is separated from *S. natans* by the lack of spines on the gas (H_2S) bladder (pneumatocysts) and the presence of

Table 1. Morphological comparison of *Sargassum natans* and *S. fluitans* collected from Ajegunle - Erun-Ama beach in Ondo State, Nigeria.

Species	Stem	Leaf shape	Leaf size (mm)	Leaf apex	Leaf margin	Vesicle	Vesicle stalk
S. natans	Flat on one side and slender tapering on other side, branchlet smooth	Narrow, linear-oblong	$1\text{-}3^{a}$ x $15\text{-}20^{b}$	obtuse	shallowly toothed	Pea-shaped with spine tip (ca. $1\text{-}2^{a}$ x $0.5\text{-}3^{b}$ mm)	Long and slender (ca.1-3 mm
S. fluitans	Flat on one side and slender tapering on other side, branchlet spiny	Broad, lanceolate-elliptical	$3\text{-}5^{a}$ x $15\text{-}21^{b}$	acute	deeply toothed	Pea-shaped without spine tip (ca. $1\text{-}3^{a}$ x $1\text{-}3^{b}$ mm)	Long and winged (ca.1-3 mm)

A, Width range; b, length range.

Table 2. Proximate analysis of mixture of *Sargassum natans* and *S, fluitans* powder.

[a]Content	Percentage (%)
Carbohydrates (by difference)	57.3 ± 0.21
Protein	15.4 ± 0.0
Moisture content	9.0 ± 0.14
Ash	8.65 ± 0.07
Crude Fibre	7.15 ± 0.21
Ether Extract (Fat)	2.5 ± 0.07

a, Mean of two readings ± SD.

winged tissue around the bladder stalk. However the two species are difficult to differentiate from one another once they have reached the shoreline (Shapiro, 2004). The present study also confirms this observation. That both *S. natans* and *S. fluitans* were mixed together in the present study, is highly suggestive of the fact that the invading seaweed must have originated from the Sargasso sea in the North Atlantic Ocean where according to Stoner and Greening (1984), both species co-exist. *S. natans* and *S. fluitans* are two most similar and common holo-pelagic brown algae (Conover and Sieburth, 1964), reproducing vegetatively by fragmentation (Awasthi, 2005; Rogers, 2011). They remain completely pelagic during their lifecycle and are never attached to the sea floor during their life cycle (Hemphill, 2005; Round, 1981). However, strong currents occasioned by several storms in May or June bump into the edges of the Sargasso Sea breaking off segments of the ecosystem (Grower and King, 2008). In the process, the sea currents and winds carry the *Sargassum* fragments along, eventually sweeping it into West African coastal regions of countries like Nigeria and Gabon (Colombini and Chelazzi, 2003). *Sargassum,* being highly tolerant of variations in environmental parameters like desiccation, sunlight, salinity and temperature occupies a broad range of habitats (Abbott and Dawson, 1978, Fritsch, 1965).

The proximate analysis of mixed *Sargassum* sample is shown in Table 2. Crude protein (154 mg/100 g) was relatively higher when compared with the crude protein of two commonly consumed Nigerian vegetables. Idris (2011) reported that *Telfairia occidentale* had 87.3 mg/100 g protein and Adeboye (2004) obtained 116-123 mg/100 g protein for two varieties of *Senecio biafrae.* Proteins are required for growth and body building. In this study, ash content in *Sargassum* sample was 86.5 mg/100 g but Gbadamosi et al. (2012) reported 87.2 mg/100 g for *S. biafrae*. The crude fat (25.5 mg/100 g) of the seaweed is lower than that of *T. occidentale* (35.7 mg/100 g) obtained by Gbadamosi et al. (2012). All these show that *S. natans* and *S. fluitans* have nutritional potentials.

Seaweeds and their products are used in coastal Asia to enhance growth and productivity, however, horticultural uses of *Sargassum* are limited (Eyras et al., 2008; Klock-Moore, 2000; Win and Saing, 2008). Although using *Sargassum* biomass as fertilizer is another way of harnessing its potentials, *Sargassum* is natural fertilizer for *Panicum amarum*, a saline habitat grass (Williams, 2008). Ocean algae consistently have lower nitrogen content when compared to compost from traditional feed stocks (Eyras et al., 1998; Maze et al., 1993). As shown in Table 3, the percentage ratio of N-P-

Table 3. Mineral analysis of mixture of *Sargassum natans* and *S. fluitans* powder.

Mineral	[b]mg/100 g
Phosphorus	96.5 ± 2.12
Magnesium	42.75 ± 0.35
Potassium	28.0 ± 0.74
Iron	8.7 ± 0.28
[a]Nitrogen (Kjeldahl)	6.360. ± 0.2
Zinc	0.05 ± 0.0
Iodine	0.04 ± 0.0

a, Converted from % to mg/100 g by multiplying

Table 4. Quantitative phytochemical analysis of mixture of *Sargassum natans and S. fluitans* powder.

[a]Bioactive compound	mg/100 g
Flavonoids	775.0 ± 7.07
Saponins	525.01 ± 0.0
Tannins	122.5 ± 3.53
Phenolics	80.0 ± 0.0
Alkaloids	77.5 ± 3.50
Terpenoids	66.5 ± 2.12
Cardiac glycosides	16.5 ± 2.12

a, Mean of two readings ± SD.

K (1-10-3) was relatively small. However, high N-P-K percentage does not necessarily mean a better fertilizer. Besides, N-P-K percentage ratios of organic fertilizers are typically smaller compared to inorganic ones. Organic fertilizers are not water soluble and thus release nutrients slowly over time, especially when enhanced by a soil pH 6.5-6.8, thus increasing soil fertility capacity (Granstedt and Kjellenberg, 1997). Since nitrogen generally promotes foliage growth, phosphorus promotes root growth and fruit production and potassium promotes overall health of the plant, the percentage ratio (1-10-3) of *Sargassum* in the present study is recommended as fertilizer for a new lawn and for seedling establishment. The low concentration of iodine (0.04 mg/100 g) in this study agrees with the view of Liu et al. (2012) that the contribution of iodine in *Sargassum* for treating thyroid and related diseases seems to have been over estimated.

The quantitative phytochemical analysis of the mixed *Sargassum* species is shown in Table 4. *Sargassum* seaweeds have been used in more than 226 prescriptions to treat various diseases in China (Liu et al., 2012). The uses in traditional Chinese medicine presumably depend on the phytochemical compounds in the seaweed. Although Liu et al., (2012) listed 80 *Sargassum* species that have been analyzed for their phytochemical constituents, *S. natans* and *S. fluitans* are not included. Liu et al. (2009) isolated two flavonoids from *Sargassum pallidum,* but in low concentrations. The occurrence of relatively high flavonoid constituents (750 mg/100 g) in the mixed *Sargassum* (*S. natans* and *S. fluitans*) shows that the biomass is a rich source of flavonoids hence useful medicinally. Flavonoids are known to have antiviral, antineoplastic, antithrombotic and vasodilatory activities (Alan and Miller, 1996). The occurrence of tannins in appreciable amount (122.5 mg/100 g) is significant. According to Okwu and Okwu (2004), tannins hasten the healing of wounds and inflamed mucous membrane. Phlorotannin fractions from mixed *Sargassum* species showed anticoagulant and antioxidant activities (Wei et al., 2007).

The mixed *Sargassum* sample had 66.5 mg/100 g of terpenoids. Terpenoids have antimicrobial and antiamoebic activities (Amaral et al., 1998). The present study supports the report of Liu et al. (2012) that meroterpenoids (class of compounds containing terpenoid elements) are particularly abundant in *Sargassum*. Meroterpenoids are antioxidant, anticancer, antimalarial, and antiviral and neuroprotective agents (Tsang and Kamei, 2004). Saponin constituent (525 mg/100 g) was relatively high in the mixed *Sargassum* sample. Saponins are used in manufacturing insecticides, shampoos and in the synthesis of steroid hormones (Okwu, 2003). That alkaloid (77.5 mg/100 g) occur in the *Sargassum* sample may explain the usefulness of the seaweed in the management of high blood pressure. Harborne (2000) reported that alkaloids such as rynchosphylline help in improving cardiac conditions by reducing blood pressure, increasing circulation and inhibiting deposition of arteriosclerosis plaque and blood clots.

The Nigerian traditional fishermen reported that the invading *Sargassum* mass caused skin and eye irritation when handled. This effect might be due to the production of some chemical substances as the seaweed decomposed. As observed by the present study, *Sargassum* was harmless when dry but decomposed very fast in wet conditions on the beaches, emitting foul odor (poisonous hydrogen sulphide). The inhalation of the gas could trigger irritation of the eyes and the respiratory system.

Conclusion

It was evident that the features of *Sargassum* from Ondo State, Nigeria, did not resemble any of the species recorded for West Africa. In consideration of seasonal appearance on coastal beaches, *Sargassum* constitutes a nuisance to both the fishermen and the beach lovers. Since biological, chemical and mechanical removal approaches may not be effective, attention should be focused on how the pelagic masses can be economically useful.

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