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Potential use of seaweeds in Nile tilapia (*Oreochromis niloticus)* diets

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SUMMARY – In our search for natural marine resources likely to be used in animal nutrition, to partially replace imported ingredients, five seaweeds were selected. The seaweeds studied were three phanerogams (*Ruppia maritima*, *Posidonia oceanica* and *Cymodocea nodosa)* and two green algae (*Ulva rigida* and *Chaetomorpha linum)*. The chemical analysis shows that dry matter (DM), ash, crude protein (CP) and crude fibre (CF) contents vary in the five seaweeds according to the species and the season of collection. When considering the nutritional needs of Nile tilapia, *Ulva rigida* seems to be the best option to be included in diets for this fish. Then, we formulated four diets containing different levels of *Ulva rigida*: A (0% Ulva), B (9% Ulva), C (18% Ulva) and D (27% Ulva).

Keywords: Nutrition, Nile tilapia, algae, phanerogam, *Ulva rigida.*

RESUME *– "Potential d'utilisation de ressources marines végétales en l'alimentation du Tilapia du Nil (*Oreochromis niloticus*)". Au cours de notre prospection de ressources marines naturelles susceptibles d'être utilisées en nutrition animale, en substitution partielle aux ingrédients importés, cinq espèces de végétaux marins ont été sélectionnées. Il s'agit des trois phanérogames* (Ruppia maritima*,* Posidonia oceanica *et* Cymodocea nodosa) *ainsi que des deux algues vertes* (Ulva rigida *et* Chaetomorpha linum). *L'analyse chimique montre que les teneurs en matière sèche, matière minérale, matière azotée totale et cellulose brute pour les cinq espèces sont variables selon l'espèce et la saison de collecte. En tenant compte des besoins nutritionnels du Tilapia du Nil, il s'avère que l'espèce* Ulva rigida *est la mieux indiquée pour être incorporée dans l'aliment de ce dernier. C'est ainsi que nous avons formulé quatre aliments, contenant différents niveaux d'*Ulva rigida *: A (0% Ulva), B (9 % Ulva), C (18% Ulva) et D (27 % Ulva).*

Mots-clés : *Nutrition, tilapia du Nil, algues, phanérogame,* Ulva rigida*.*

Introduction

Maize and soybean are traditionally used in animal feeds as a source of dietary energy and proteins. However, the price of the two ingredients represents a constraint to their incorporation in Tilapia diets. The use of industrial and agricultural by-products, as well as of seaweeds, some of them abundant on the Tunisian coast (lagoons and shore), offers the possibility of reducing the cost of diets. Seaweeds are interesting ingredients for their high protein value and essential amino acid content and could be used in animal nutrition. Nutritional value of *Ulva lactuca* was tested for goats, however Ventura and Castañon (1998) concluded that this algae could be considered as a medium-quality forage for goats, with a high protein content. According to Ventura *et al.* (1994) feed intake and growth rate of chickens fed on diets containing 0, 100, 200 and 300 g/kg of *Ulva rigida*, decreased ($p<0.05$). The results of this study showed that crude *Ulva rigida* is not a suitable ingredient for poultry diets, at least inclusion rates of 100g/kg or higher. Fresh water algae and aquatic macrophytes were tested in Tilapia diets. Appler and Jauncey, (1983) supplied 5% of *Clodophora glomerata* in a fingerling *Oreochromis niloticus* diet*,* which indicated a better growth performance than the control group. Appler (1985) reported that *Hydrodictyon reticulatum* meal incorporated in *Oreochromis niloticus* diets at a level of 10% produced 63.9% of the growth of the fish fed on the full fishmeal diet. Concerning the aquatic macrophytes, El-Sayed (1992) recommended lower levels of inclusion (25%), to obtain good growth of Tilapia.

Our study started by studying different bibliography concerning the ecology of seaweeds found in Tunisia, and the possibility of their exploitation in animal nutrition. The species retained were three phanerogams (*Ruppia maritima*, *Posidonia oceanica* and *Cymodocea nodosa*) and two green algae

(*Ulva rigida* and *Chaetomorpha linum)*. Among these five species, our objective was to select those that can be introduced into the dietary formula of Nile tilapia, *Oreochromis niloticus*.

Materials and methods

To examine the seaweeds' chemical composition variability, 100 kg fresh weight of each plant species were taken from selected sites around three lagoons in the north of Tunisia during an annual cycle (summer, autumn, winter and spring 1999-2000). In the following year, 2001, seaweeds were collected in spring. This choice was based on the fact that during this period of the year, the studied species are in great quantities, contrary to the other seasons where the quantities were lower. *Chaetomorpha linum* was collected from the north lake of Tunis, *Ulva rigida* and *Cymodocea nodosa* from the lagoon of Bizerte, *Ruppia maritima* from the lagoon of Ghar El Meleh and the *Posidonia oceanica* was collected from the shore near Ghar El Meleh lagoon.

Samples collected during the annual cycle of 1999-2000 and in spring 2001 were washed with tap water, dried under the sun and then crushed. Samples from each species were weighed initially and placed in a freeze-drier until they reached a constant weight and were reweighed to assess water content, then analysed for contents of crude protein (CP), crude fibre (CF), ether extract, and minerals according to standard methodology (AOAC, 1990). Digested energy and proteins were calculated. The chemical composition, digested energy and proteins were introduced into a linear programme. The programme was then constrained to include algae meal in diets at increasing concentrations. Diet formulae were designed according to the recommendation of Guillaume *et al.* (1999).

Results and discussion

The results of the chemical analysis are shown in Table 1. In spring 2001, *Posidonia occinica* contained the lowest amount of total nitrogen and *Cynodocea nodosa* had the highest. The other species contained between 11% and 15% CP. The CP levels in all studied species are lower than levels found in micro algae used in animal nutrition (Lipstein and Hurwitz, 1980; Toyomizu *et al.,* 2001). *Ulva rigida* CP level is lower than levels reported by Mathers and Montgomery (1997).

Table 1. Chemical composition of seaweeds (spring 2001)

Species	DM†	CP†† (%DM)	CF††† (%DM)	Fat (%DM)	Ash (%DM)	Calcium (g/kg)	Phosphorus (g/kg)
Chaetomorpha linum	83.8	13.6	24	2	31.8	1.07	0.23
Ruppia maritima	85.3	11.8	14	2.4	37	4.5	0.24
Posidonia oceanica	77.7	5.2	28	2.4	26.8	1.8	0.12
Ulva rigida	80.7	11.3	5	2	45.2	2.5	0.23
Cymodocea nodosa	84.5	15.13	19	2.2	21.4	1	0.35

†DM: Dry matter.
††CP: Crude protein.
†††CF: Crude fibre.

As for CF levels, in this season, *Ulva rigida* contained the lowest levels, *Ruppia maritima* had a medium content, and *Cymodocea nodosa*, *Chaetomorpha linum* and *Posidonia oceanica* had the highest. Ash content varied between species. *Ulva rigida*, *Ruppia maritima* and *Chaetomorpha linum* contained higher concentration than *Posidonia oceanica* and *Cymodocea nodosa*. *Ruppia maritima* contained the highest levels of calcium, while all the seaweeds had approximately similar levels of phosphorus, not exceeding 0.5 g/kg.

The final aim of this work was to study the possibility of incorporating seaweeds as alternative ingredients in Tilapia diets. According to the chemical composition of the five studied species, only Ulva rigida could be incorporated. It has a total fibre level lower than 5 g/kg, and also has an acceptable total proteins level compared to others. According to Leary and Lovell (1975) high levels of fibre in the diets of many finfish species, have been shown to reduce growth. For tilapia, Anderson *et al.* (1984), concluded that dietary fibre levels above 5% reduce food utilisation and digestibility and protein utilisation were reduced with excess fibre levels in the diets.

The composition of the diet formulated by linear programming is shown in Table 2. Decreases in maize and soybean meal were compensated with increases of *Ulva rigida* meal. However, it is possible to completely substitute maize meal for algae meal at the level of 27% in a diet with about 50% of soybean meal, and obtain similar values for digested energy (DE) and digested proteins (DP), when approaching this level, total mineral values become a limiting factor. Up to a level of 27%, protein/energy (P/E) ratios decrease; Wang *et al*. (1985) reported that the optimum P/E ratio was 20 mg/kJ. In addition, the fat level of the diet decreases. De Silva *et al*. (1991) indicated that an 18% lipid content in a diet spared protein and a 30% protein, 18% lipid diet was recommended.

Table 2. Ingredient, nutritive value and chemical composition of feeds

	A†	B†	C†	D†
Ingredients (%)				
Maize	27	19	10	0
Soybean meal	56	55	50	46
Fish meal	14	14	16	17
Soybean oil	0	0	3	7
Ulva rigida	0	9	18	27
VMM††	3	3	3	3
Nutritive values				
DE (MJ/kg dry matter) †††	12.96	12.14	12.10	12.13
DP (g/kg dry matter) ††††	281.2	282.1	283.9	281.3
Chemical composition				
Essential amino acids (%)†††††				
Arginine	2.44	2.59	2.74	2.85
Lysine	2.38	2.38	2.43	2.42
Histidine	0.82	0.79	0.76	0.72
Threonine	1.27	1.63	1.98	2.32
Tryptophane	0.40	0.59	0.77	0.95
Isoleucine	1.70	1.90	2.10	2.27
Leucine	2.80	3.34	3.88	4.37
Valine	1.42	1.69	1.91	2.12
Phenylalanine	2.83	3.23	3.62	3.98
Fat (%)	18.6	17.6	15.6	13.4
Ash (%)	4.97	9.44	13.92	18.33
Calcium	0.61	0.86	1.17	1.44
Phosphorus	0.31	0.54	0.78	1.01

†A: Control: 0% Ulva; B: 9 % Ulva; C: 18% Ulva; D: 27% Ulva.
††VMM: Vitamin and mineral mixture.
†††DE: Digested energy.
††††DP: Digested proteins.
†††††All values as % of dietary protein.

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