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Growth Characteristics and Proximate Profile of Duckweed (*Lemna minor*) Cultured in Calabar – Humid Zone of Nigeria

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Abstract: A twenty-day growth trial was conducted to evaluate the growth characteristics and proximate composition of duckweed (Lemna minor) cultured in a concrete pond (33,975.43 litres) with a pond depth of 40cm and dilution of 25% piggery effluent. Observation revealed that biomass increase occurred every day. Harvesting was carried out every four days for five times successfully and total yield was 14.72 kg. The growth of duckweed harvested and that obtained from a natural pond were sun-dried and representative samples taken for proximate analysis. The proximate composition of the two samples were compared, the results obtained showed that the grown duckweed contained crude protein (42%), crude fibre (28%), ether extract (1.5%), ash (8%) and nitrogen free extract (10.5%) fractions; while the duckweed from the natural pond had crude protein (21.87%), crude fibre (20%), ether extract (1%), ash (11%) and nitrogen free extract (46.13%), respectively. The proximate composition of the cultured duckweed appeared higher in all fractions beside the nitrogen free extract. However, irrespective of the medium where the duckweed was harvested, the crude protein value obtained suggested that duckweed can be incorporated into livestock feeds as a protein supplement, particularly when grown on nutrient rich mediums.
Keywords: Duckweed, proximate, pond, biomass, livestock

Introduction

The decreased availability and high cost of conventional feed resources to support animal production is a problem. This increased demand for animal feed has necessitated the search for unexploited cheaper alternatives. Duckweed is one of such alternatives, belonging to the plant family *Lemnaceae*. The duckweed is monocotyledonous and consists of four genera: *Lemna*, *Spirodela*, *Wolffia* and *Wolffiella* (Monette *et al.*, 2006). Presently, about-forty species have been identified worldwide. However, *Lemna is* the largest genera and the most complex within the entire family. It is a small green aquatic macrophytic plant, measuring 0.3 to 2.0mm in size and floats freely as thick blanket-like mats on top of the water surface especially stagnant pools/ponds (Landolt, 1986; Skillicor *et al.*, 1993). Most species of duckweed multiply principally through vegetative propagation by the formation of daughter fronds from two pockets on each side of the narrow end of the frond (Culley *et al.*, 1981; Reddy and Debusk,1985). Although, many species can survive extremes of temperature, they generally grow faster under warm and sunny conditions (Skillicorn, *et al.*, 1993). However, most species show prolific growth in the tropics.

The nutrient uptake of this small plant gives it the necessary composition to be used as a dietary supplement for a number of animals including poultry, swine and ruminants (Russoff *et al.*, 1980; Haustein *et al.*, 1990; Leng *et al.*, 1995). Duckweed grown under ideal conditions on domestic or animal waste and harvested regularly will commonly have a crude fibre content of 5-15%, which is quite low as they do not need to support upright structures (Leng *et al.*, 1995) and a crude protein content of 35-45% (Skillicorn *et al.*, 1993; Gurtekin and Sekerdag, 2008). According to Russoff *et al.* (1980), duckweed grown on dairy waste lagoons had the potential to be an effective protein supplement to grains for both animal fodder and human consumption. Excessive discharge of nutrients to the environment leads to eutrophication with several problems. However, duckweed serve as nutrient pumps that have great capacity in absorbing nutrients and their high nutrient removal efficiency can be used to clean wastewater in an effective, cheap and simple way (Nhapi, 2004; Gurtekin and Sekerdag, 2008) while providing nutrient rich folder for animal feeding. Duckweed growth is favoured principally by organic waste (pollutants) as well as inorganic nutrients in ponds among other factors that might be variable, such as temperature, sunlight and pH. Any waste organic material that is readily biodegradable and has a sufficient high nutrient content could be used for duckweed cultivation. The most economical sources of such waste materials are all kinds of animal manure, kitchen wastes, and wastes from a wide range of food processing plants, biogas effluents and slaughter house wastes (Oron *et at.*, 1987; Nhapi, 2004). However, there is paucity of technical and agronomic information about duckweed culture and feed use, more so details of farming practices are not easily available to the public, let alone to livestock farmers in developing countries (Skillicorn *et al.*, 1993). The purpose of this study therefore was to evaluate the growth characteristics and proximate composition of duckweed on piggery effluent medium in Calabar, located in the humid high rain forest zone of Nigeria.

Materials and Methods

The experiment was conducted at the University of Calabar Teaching and Research Farm. Calabar is located on latitude $4^0$57'N and longitude $8^0$19'E of the equator. Annual temperature and rainfall ranges from 25^0 – 30^0C and from 1260 to 1280mm, respectively. The relative humidity is between 70 and 90% and Calabar is 98 metres above sea level. A concrete pond of 33,975.43 litres was used. Water was pumped into the pond from a borehole on the farm, after washing. The pond water was diluted with the piggery effluent at 25% level (Bergmann *et al.*, 2000). Duckweed (*Lemna minor*) was obtained from a natural pond in small Iwuru village, at Akamkpa Local Government Area, Cross River State. Harvesting was carried out every four (4) days based on increase in biomass in the pond, with five (5) successful harvest in all. Harvesting was facilitated with a manually constructed catch net. The weight of each harvest of duckweed was recorded and thereafter sun-dried duckweed representing, that grown in Calabar and that from the natural pond in small Iwuru were then determined for proximate composition according to methods of AOAC (2000).

Results and Discussion

The results of the yield of duckweed harvested at four days interval from the concrete pond is presented in Table 1. The initial weight of duckweed cultured was 4.5kg. The yields of the five (5) consecutive harvests were 1.34, 3.41, 2.82, 3.91, and 3.24 kg respectively. The total yield realized from the 20 day growth trial was 14.72 kg with a mean value of 2.94 kg per harvest. The yield of the duckweed was low compared to 10 - 20 metric tons/ha/year of dry matter reported by Ann and Preston (1997) and that of 10 – 40 metric tons/ha/year of dry matter reported by Leng *et al.* (1995) and Skillicorn *et al.* (1993). Duckweed can double their biomass in between sixteen hours to two days which results in an exponential growth under optimal nutrient availability, sunlight and water temperature (Ann and Preston, 1997). According to FAO (1989), the growth rate of duckweed under ideal light, temperature and pH would be exponential if there were no limitations in terms of mineral (including ammonia) deficiencies or excesses. It is probable that the poor yields recorded in this study may have been due to a poor nutrient mix. This may also have been caused by the low volume of water, high temperatures and the hotness of the concrete pond which actually increased the temperature of the water surface more than the optimum requirement of 17°C or 62°F (Skillicorn *et al.*, 1993) for duckweed under natural conditions.

Table 1: Yields of duckweed harvested at four days interval from a concrete pond

Number of times harvested	Yield (Kg)
1	1.34
2	3.41
3	2.82
4	3.91
5	3.24
Total	14.72
Mean	2.94

The proximate composition of the cultured duckweed and that harvested from the natural pond are presented in Table 2. The crude fibre, ether extract and ash values respectively, for the duckweed from the concrete pond were higher than those of the natural pond. The crude fibre for duckweed obtained in this study for both cultured or grown and natural pond was 28.00 and 20.00%, respectively. These values were higher than 7 – 10% for duckweed grown in nutrient-rich pond as opposed to 11 – 17% for duckweed in nutrient poor water (Leng *et al.*, 1995). This observed difference may be due to species cultivated in this study as *Lemna* is known to be complex within the family. However, the ash values obtained in this study (18 and 11%) for the concrete cultured and natural pond respectively were in line with the ash value of 12 – 18% reported by Leng *et al.* (1995). Generally, fibre and ash values reported in this study were higher than reported values. This observation is in line with the reports of Landolt and Kandeler (1987) and Skillicorn *et al.* (1993) that fibre and ash contents are usually higher and protein content lower in duckweed colonies with slow growth, starvation (nutrient deficient ponds) and ageing which corroborates the findings in this study. The ether extract content of both the cultured and natural pond (1.5 and 1%) respectively, fell below 1.8 – 2.5% in duckweed species grown in nutrient – poor water and 3 – 7% for duckweed grown in nutrient – rich water as reported by Leng *et al.* (1995).

However, the species cultured and the respective or varied culture mediums might be responsible for the observed differences.

Although, the nitrogen free extract value was higher for the duckweed from the natural than concrete cultured pond, results of other proximate fractions suggest lower nutrient levels of the natural pond which further shows that the nutrient composition of duckweed will vary depending on the nutrient content of the growth medium. The crude protein for the cultured duckweed was 42%. This value was higher than 15-35% range reported for CP by Leng *et al.* (1994) while that of the natural pond (21.87%) was within the range. However, the crude protein of both the cultured and natural pond duckweed were lower than 45% CP reported by Mibagwu and Adeniji (1988), but higher than 20.9% CP reported by Leng *et al.* (1995) and 18.3% CP reported by Ahammad *et al.* (2003). However, the crude protein of 42% fell within the range of 7 – 45% (Culley *et al.*, 1981) and 43% as reported by Leng *et al.* (1995). The result of crude protein obtained in this study agrees with the report of Hillman and Culley (1978), Russoff *et al.* (1978), Russoff *et al.* (1980), Leng *et al.* (1995), Huque *et al.* (1997) and Kusina *et al.* (1999) that duckweed indeed has quality protein with better amino acid profile than most plant proteins and more closely resembles animal protein than any other plant protein source. Thus, it can be effectively used as a protein supplement in livestock and poultry diets. However, its content of calcium oxalate at high doses may be toxic (Franceschi, 1989) or limit calcium availability. Hence, more research is needed for safety levels to be determined to make duckweed more nutritious and digestible.

Table 2: Proximate composition of duckweed (% DM)

Fraction	Concrete Pond	Natural Pond
Crude protein (CP)	42.00	21.87
Crude fibre (CF)	28.00	20.00
Ether extract (EE)	1.50	1.00
Ash	18.00	11.00
Nitrogen free extract (NFE)	10.50	46.13

Conclusion

Cultivation of duckweed is a continuous process that requires intensive management for optimum production. Frequent harvesting and high fertility are needed to ensure optimum productivity. The high level of fertility required to obtain this massive growth might seem to be an obstacle but is very feasible with the use of numerous wastes from varied sources. This study has shown that duckweed *(Lemna minor)*, though small in size and status, possesses a high potential as a feed resource hence could be incorporated into livestock diets at low cost.

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