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NUTRITIONAL VALUE OF SOME SELECTED GREEN MICROALGAE

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ABSTRACT

Extensive human food studies have demonstrated that certain microalgae maintained high nutritional quality. The aim of the present study was to investigate the potentiality of some green microalgae species as functional food. The tested microalgae include Chlamydomonas sp. (BIRD CHL-108), Chlorella protothecoides (BIRD CHL-127), Coelastrum scabrum (BIRD CHL-130), Cosmarium sp. (BIRD CHL-131), Scenedesmus obliquus (BIRD CHL-192) and Tetradesmus wisconsinensis (BIRD CHL-203). The nutritional value of the tested green microalgae was evaluated by analysis of certain cellular metabolites, including crude lipid, crude protein, carbohydrates, crude fibres, ash and moisture content. The digestibility and energy contents of these metabolites were estimated by determination of total digestible nutrients (TDN), digestible crude protein (DCP), nutritive value (NV), gross energy (GE), digestible energy (DE), metabolizable energy (ME), and net energy (NE). In general, the biomass of the microalgae exhibited wide significant ($P \leq 0.05$) varieties in protein content (16.78–63.93%), lipids (4.21–10.33%), total carbohydrates (15.97-38.6%), crude fibres (0–1%), ash (1.92-27.4%) and moisture content (6.73-9.43%). Significant variation in TDN (15.45-56.2%), DCP (13.66-62.92%), NV (0.221-3.08%), GE (352.3-547.41 Kcal $100g^{-1}$), DE (249-418 Kcal $100g^{-1}$), ME (28.43–409.2 Kcal 100g-1), and NE (-39.77- 91.95 Kcal $100g^{-1}$) were recorded. Based on these results, most of the tested microalgae maintained high nutritional value and could be as a potential renewable biosource of functional food.

Keywords: *Energy, food, feed, green algae, nutritional value, protein.*

INTRODUCTION

With the continuous increase of food prices and the predicted increase in the earth's population, it becomes necessary to seek about unconventional sources of food. It is predicted that the earth's population will double to 8 billion in the 21stcentury (Blume, 1979). The future prospects would include an even higher incidence of hunger, starvation, and malnutrition. The production of food from unconventional sources may alleviate some of these problems. The use of microalgae in biotechnology has been increased in recent years, these organisms being implicated in food, cos-

metic, aquaculture and pharmaceutical industries (Borowitzka and Borowitzka, 1988). The first use of microalgae by humans was by the Chinese Scientist, who used Nostoc to survive during famine 2000 years ago (Spolaore *et al.,* 2006). In early 1950's, the mass production of certain protein-rich microalgae was considered as a possibility to close the predicted so called "protein gap" (Becker, 2007).

Comprehensive nutritional studies have demonstrated that algae proteins are of high quality and comparable to conventional vegetable proteins. Nowadays commercial production of microalgae for human nutrition has been already a reality (Kay, 1991; Abd El Baky *et al.,* 2009). All over the world, many commercial products of microalgae or mixtures with other health foods can be found in the market in the form of tablets, powders, capsules, pastilles and liquids as nutritional supplements (Becker, 1988, Spolaore *et al.,* 2006). Microalgae can also be incorporated as functional food additives into food products (e.g. pastas, biscuits, bread, snack foods, candies, yoghurts, soft drinks), providing the health promoting effects that are associated with microalgal biomass, probably related to a general immune-modulating effect (Belay *et al.* 1993). In spite of some reluctance for novel foods in the past, nowadays there is an increasing consumer demand for more microalgae-based (e.g, Spirulina and Chlorella) natural food products presenting health benefits (Herrero *et al.,* 2006; Abd El Baky and El-Baroty, 2012; Guedes *et al.,* 2011).

Functional foods supplemented with microalgae biomass are much more convenient with potential health benefits and attractiveness to consumers (Pulz and Gross, 2004). In some countries (e.g. Germany, France, Japan, USA, China, Thailand), food production and distribution companies have already started wide-scale activities to market functional foods with microalgae and cyanobacteria (Pulz and Gross, 2004). Food safety regulations for human consumption are the main constraint for the biotechnological exploitation of microalgal resources; therefore production of algal biomass can be achieved by using clean nutrient media for growing the microalgae to avoid any bioaccumulation of herbicides and pesticides, or any other toxic substances (Li *et al.,* 2007).

Out of about 17,000 algal species that have been described since the turn of the last century, only a few have been investigated and described as excellent for possible sources of functional food. The important microglia includes species of *Chlorella, Scenedesmus*, (Rodulfo, 1990; Herrero *et al.,* 2006) *Prophyridum and Dunaliella* (Xu *et al.,* 2001), Spirulina platensis (Abd El Baky and El-Baroty, 2012; Guedes *et al.,* 2011). The primary aim of this study was to evaluate the potentiality of some Egyptian green microalgae as potential unconventional sources of functional food. Special attention was given to evaluate the nutritional value of some unexplored microalgae as *Coelastrum, Cosmarium and Tetradesmus.*

MATERIALS AND METHODS

1. Test isolates and growth medium.

Six different microalgae species belonging to the class Chlorophyceae were selected for this study. The isolates were obtained from the culture collection of the Biotech Interna-

tional R&D (BIRD) Centre, Mansoura, Egypt. These isolates are Chlamydomonas sp. (BIRD CHL-108), Chlorella protothecoides Krüger (BIRD CHL-127), Coelastrum scabrum Reinsch (BIRD CHL-130), Cosmarium sp. (BIRD CHL-131), Scenedesmus obliquus (Turpin) Kützing (BIRD CHL-192) and Tetradesmus wisconsinensis G. M. Smith (BIRD CHL-203). Identification of these microalgae followed Komark and Fott (1983) and Bourrelly (1990). The tested isolates were cultivated on *Navicula* nutrient medium (Starr, 1978). The composition of *Navicula medium* (gl^{-1}) is 0.1 g $Ca(NO_3)_2.4H_2O$, 0.14 g $K_2HPO_4.3H_2O$, 0.025 g $MgSO_4.7H_2O$, 0.1 g $NaSiO_3.9H_2O$, 0.02 g $NaCO_3$, 1.0 ml Iron stock solution (one liter Iron solution contains 5.0 g $FeCl_3.6H_2O$ and 30 g $Na_2.EDTA.2H_2O$), and 1.0 ml trace element solution (one litre trace element solution contains 2.8 g H_3BO_3, 0.9 g $MnCl_2.4H_2O$, 0.125 g $ZnCl_2$, 0.08 g $CuSO_4.5H_2O$, 0.9 g $Na_2MoO_4.2H_2O$, and 0.014 g $CoCl_2.6H_2O$).

2. Biomass collection.

The four test isolates were cultured on Navicula nutrient medium (Starr, 1978), in 2.0 litre Erlenmeyer flasks containing 900 ml culture. Three replicate flasks were used for each isolate. Culture flasks contain nutrient media were autoclaved and then inoculated by 10% (v/v) 2 week old culture (about 0.05 gl-1 dry biomass; dried at 60ºC). Culture flasks were incubated for 20 day at 25 ± 2o C and continuous light of 2.789 w/m2. At the end of incubation period, the algal biomass was harvested by filtration through a membrane filter (Nylon Lab Pak mesh opening 1 micron 121n*121N PK/6). The algal cells were washed twice with distilled water and dried at 60°C to a constant weight. The dry weight of algal biomass was determined gravimetrically and expressed as gl^{-1} (Dayananda *et al.,* 2005). The dried algal biomass was kept frozen for further analysis. Before use, the frozen algal biomass was kept in a desiccator to cool down to room temperature.

3. Estimation of the nutritional value of algae test isolates.

3.1.Determination of moisture and ash.

Moisture and ash content were determined according to the methods described in AOAC (1990). One gram of algae biomass (w1) of previously dried at 60°C was dried again in an oven with air circulation at 105 °C till constant weight (w2) is achieved. The samples were then ignited for 2h at 600 ±15oC, cooled in a desiccator and weighed (w3). For statistical analyses, each test isolate was determined in triplicates. The following equations were used for determination of moisture and ash content in the test algae.

$$Moisture\ \% = \frac{W1 - W2}{W1} \times 100$$

$$Ash\ \% = \frac{W3}{W2} \times 100$$

3.2. Determination of lipid content.

The lipid content of algal biomass, dried at 60°C , was estimated according to soxhlet solvent extraction method (Sadasivam and Manickam, 1996) using petroleum ether as an extraction solvent. The extraction process continued for at least 18 h. Vacuum rotary evaporator was used to remove the excess solvent. The residue (petroleum ether extract) was weighed using a sensitive balance and expressed as % gg^{-1} of dry weight biomass.

3.3. Determination of crude protein.

The Crude protein was determined by the method of Bradford (1976) and modified by Stoscheck (1990). The algal protein was extracted by 1.0 M NaOH. The samples were then incubated for 2h in a refrigerator, and then centrifuged at 4000rpm for 10 minutes. For 0.1 ml aliquots of the extract, 5 ml of Bradford reagent (Comassie brilliant blue G 250) was added and the intensity of the developed blue colors was determined at 595 nm using a spectrophotometer after 5 min but no longer than 30 minutes. A standard curve was made using bovine serum albumin (BSA). The protein concentration of algae biomass was calculated from the standard curve. For statistical analyses, protein content for each isolate was determined in triplicates.

3.4. Determination of total carbohydrates.

Total carbohydrate content in algae biomass (0.1 g) was analyzed by the anthrone method of (Hedge and Hofreiter, 1962). The algae biomass was hydrolyzed with 5 ml 2.5 N HCl and incubated in boiling water bath for 2 hours, then cooled to room temperature and neutralized with Na_2CO_3 powder until effervescence ceases, All volumes of sugar tubes were equalized using distilled water, centrifuged at 4000 rpm and the supernatant was collected. For 0.1 ml aliquots of the supernatants, 4.0 ml of anthrone reagent was added, heated for 8 minutes in boiling water bath, then cooled rapidly and the intensity of the developed green to dark green colour was measured at 630 nm. A standard curve was made using glucose. The concentration of carbohydrates in algae test isolates was calculated from the standard curve. For statistical analyses, carbohydrate content for each isolate was determined in triplicates.

3.5. Determination of crude fibres

Crude fibre content in algae biomass was analyzed by the method of Maynard (1970). To 1.0 g dried defeated algae (lacking petroleum ether extract) sample, 100 ml of sulphuric acid (0.255 ± 0.005N) was added and allowed to boil for 30 minutes with bumping chips. The residue of samples was filtrated through muslin and washed with boiling water until the washings are no longer acidic. To the residue, 100 ml of sodium hydroxide (0.313± 0.005N) was added and allowed to boil for 30 minutes. The residue was filtrated through muslin and washed with boiling 1.25%H_2SO_4, then water and finally with alcohol. The residue was then removed and transferred to a pre-weighted crucible (w1), dried at 130 ± 2 °C for 2 hrs, cooled in a desiccator and weighed (w2). Then ignited for 30 minutes at 600°C, cooled in a desiccator and weighed (w3). For statistical analyses, crude fibre content of each test isolate was determined in triplicates. The % crude fibre was calculated from the following equation.

$$\% \text{ crude fibre} = \frac{(W2-W1)-(W3-W1)}{\text{Wt. of sample}} \times 100$$

4.Calculated parameters

4.1.Total Digestible Nutrients (TDN): It is a rough estimate of the available energy of food and feed. The total digestible nutrients (TDN) were estimated according to the equation applied by Abu El- Naga and El-Shazly (1971).

% TDN = 0.623 (100 + 1.25 lipids %) – 0.72 crude protein (CP %)

4.2. Digestible Crude Protein (DCP): It is the amount of crude protein actually absorbed by the animal. Digestible crude protein (DCP) was calculated according to the equation of Demarquilly and Weiss (1970):

DCP = 0.929 CP (%) – 3.52.

4.3. Nutritive value (NV): It was calculated according to Abu-El-Naga and El- Shazly (1971) as:

% NV = TDN/CP.

4.4.Gross Energy (GE): It is the total energy in a food or feed. It is determined by measuring the amount of heat produced when a feed is completely oxidized in a bomb calorimeter. The gross energy (GE) was calculated following this equation of NRC, (1984) as:

GE (Kcal 100 g^{-1}) = 5.72 crude protein + 9.5 lipids + 4.79 crude fibre + 4.03 carbohydrates.

4.5.Digestible Energy (DE): Digestible energy gives an indication of the actual amount of bioavailable energy of food or feed. The digestible energy (DE) was estimated according to NRC, (1984) equation as:

DE (Mcal kg^{-1}) =0.0504 CP (%) + 0.077 lipids (%) +0.02 CF (%) +0.000377 (carbohydrates) 2 (%) + 0.011 (carbohydrates) (%) - 0.152.

4.6.Metabolizable Energy (ME): It is the digestible energy intake minus the energy in the urine minus the energy in the gaseous product of digestion. The metabolizable Energy (ME) was calculated according to Pantha (1982) as:

ME (Kcal 100 g^{-1}) = 3.4 carbohydrates + 8.1 lipids +4.2 CP.

4.7.Net Energy (NE): It is metabolizable energy minus the heat increment of feeding. The NE system is more accurate than other energy systems because it gives the net value of each feed after accounting for all the energy losses in the process of feed and nutrient utilization. Net energy (NE) was estimated according to (Rivière, 1977) as:

NE (MJ kg^{-1}) = [(TDN (%) X 3.65 – 100)/ 188.3] x 6.9.

5. Statistical analysis.

Values of each measurement represent three replicates ±SD. Values of standard deviation (SD) were calculated using Microsoft Office Excel 2013.

RESULTS

The experimental results presented in Figure (1) showed distinct, highly significant ($P \leq 0.05$) variations in biomass contents of crude protein, total carbohydrates, crude lipids, crude fibre, ash content and moisture of different tested algae. The wt. % (the gravimetric weight of a component /dry weight biomass dried at 60°c) of crude protein varied widely between 16.78% (*Chlamydomonas* sp., isolate BIRD CHL-108) and 63.93% (*Cosmarium* sp., isolate BIRD CHL-131). The total carbohydrates ranged between 14.12% (*Coelastrum scabrum*, isolate BIRD CHL-130) and 38.6% (*Chlamydomonas* sp., isolate BIRD CHL-108) (Figure 1). The lipid content varied within a narrow range between 4.21 % (*Cosmarium* sp., isolate BIRD CHL-131) and 10.33% (Chlorella protothecoides, isolate BIRD CHL-127). The wt. % of crude fiber was undetectable for some isolates (*Cosmarium* sp., isolate BIRD CHL-131) and fluctuated around 1% for other test algae. The ash content varied significantly

between 1.92% (*Cosmarium* sp., isolate BIRD CHL-131) and 27.4% (*Chlamydomonas* sp., isolate BIRD CHL-108). The % moisture of biomass dried at 60°c varied between 6.7% (*Tetradesmus wisconsinensis*, isolate BIRD CHL-203) and 9.4% (*Coelastrum scabrum*, isolate BIRD CHL-130).

As seen from (Table 1), distinct wide and highly significant ($P \leq 0.01$) variations did exist in wt. % of total digestible nutrients (TDN), digestible crude protein (DCP), nutritive value (NV), gross energy (GE), metabolizable energy (ME), digestible energy (DE), and net energy (NE) in biomass of different test microalgae. The % TDN fluctuated between and a maximum value of 56.2 % (*Chlamydomonas* sp., isolate BIRD CHL-108) and a minimum value of 15.45% (*Cosmarium* sp., isolate BIRD CHL-131). The % DCP fluctuated between 62.9% (*Cosmarium* sp., isolate BIRD CHL-131) and 13.66% (*Chlamydomonas* sp., isolate BIRD CHL-108). The % NV ranged between 3.08% (*Chlamydomonas* sp., isolate BIRD CHL-108) and a 0.22% (*Cosmarium* sp., isolate BIRD CHL-131).

The gross energy (GE) fluctuated between 547.4 Kcal 100 g^{-1} (*Cosmarium* sp., isolate BIRD CHL-131) and 352.3 Kcal 100 g^{-1} (*Chlamydomonas* sp., isolate BIRD CHL-108), metabolizable energy (ME) between 409.2 Kcal 100 g-1 (*Cosmarium* sp., isolate BIRD CHL-131) and 284.3 Kcal 100 g^{-1} (*Chlamydomonas* sp., isolate BIRD CHL-108), digestible energy (DE) between 418 Kcal 100 g^{-1} (*Cosmarium* sp., isolate BIRD CHL-131) and 249 Kcal 100 g^{-1} (*Chlamydomonas* sp., isolate BIRD CHL-108) and the net energy (NE) between 91.95 Kcal 100 g^{-1} (*Chlamydomonas* sp., isolate BIRD CHL-108) and 14.04 Kcal 0 g^{-1} (Scenedesmus obliquus, isolate BIRD CHL-192).

Table (1): Variation in total digestible nutrients (% TDN), digestible crude protein (% DCP), nutritive value (% NV), gross energy (GE Kcal 100 g^{-1}), metabolized energy (ME Kcal 100 g^{-1}), digestible energy (DE Kcal 100 g^{-1}), and net energy (NE Kcal 100 g^{-1}) of the studied microalgae.

Test isolates	% TDN	% DCP	% NV	GE (Kcal 100 g^{-1})	ME (Kcal 100 g^{-1})	DE (Kcal 100 g^{-1})	NE (Kcal 100 g^{-1})
BIRD CHL-108	56.2 ± 2.03	13.66 ± 1.24	3.08 ± 0.42	352.3 ± 2.25	284.3 ± 1.2	249 ± 1.5	91.95 ± 3.1
BIRD CHL-127	36.05 ± 2.2	42.57 ± 2.06	0.74 ± 0.1	489.3 ± 14.88	373.7 ± 2.5	364 ± 2.4	17.67 ± 2.2
BIRD CHL-130	34.25 ± 0.48	41.98 ± 0.38	0.699 ± 0.002	422.65 ± 8.73	323.5 ± 5.3	327 ± 4.2	21.87 ± 1.2
BIRD CHL-131	15.45 ± 0.95	62.92 ± 1.35	0.221 ± 0.09	547.41 ± 12.65	409.2 ± 5.1	418 ± 4.9	-39.77
BIRD CHL-192	31.79 ± 1.8	46.53 ± 0.64	0.591 ± 0.2	484.57 ± 11.10	365.6 ± 3.5	368 ± 2.4	14.04 ± 1.6
BIRD CHL-203	38.74 ± 1.3	36.45 ± 0.61	0.899 ± 0.07	438.37 ± 8.75	334.5 ± 4.5	325 ± 4.9	36.30 ± 2.3

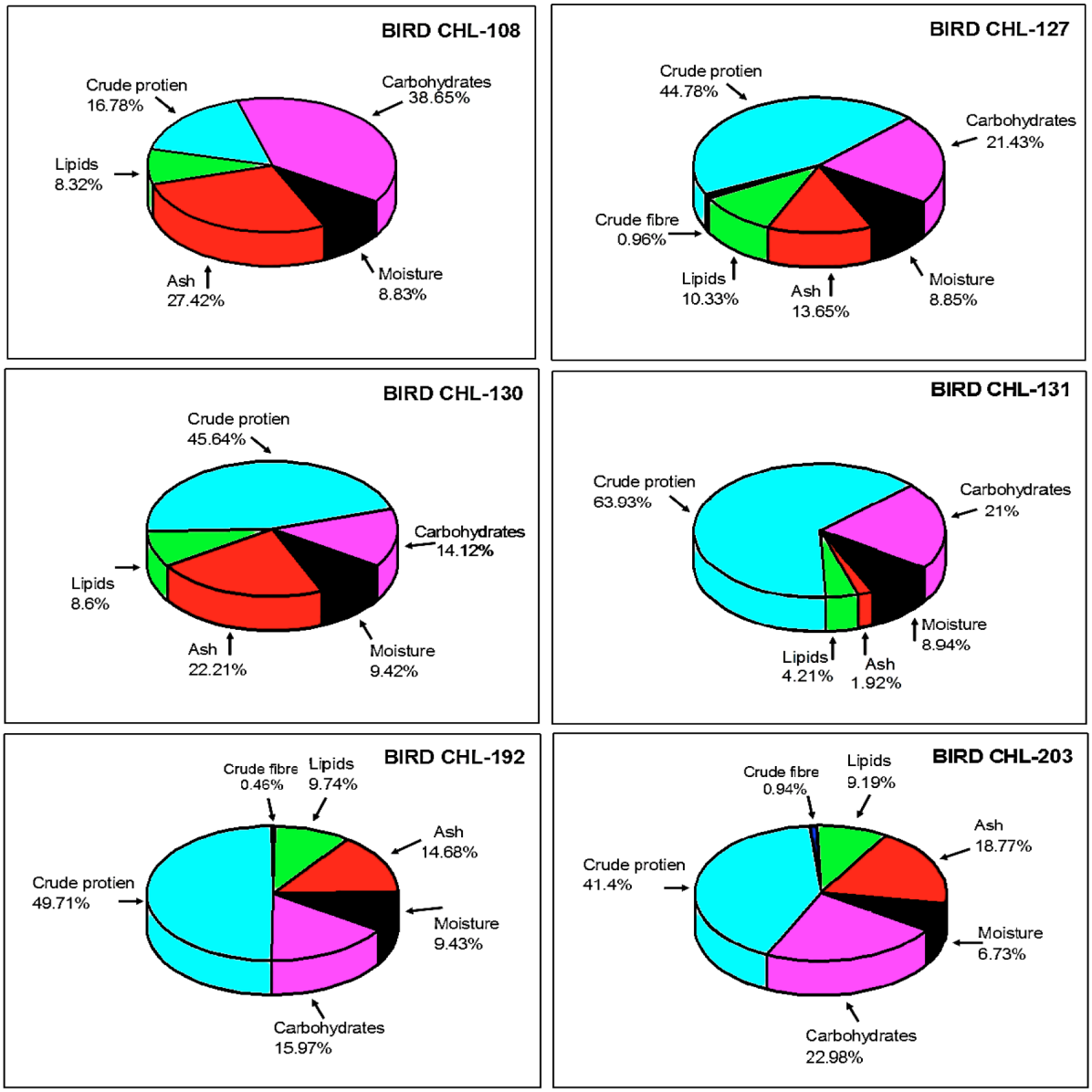

Figure (1) : Nutritional analysis (moisture, ash, crude fibre, lipids, protein and carbohydrates) in the tested microalgae. Each value represents a mean of three measurements and was calculated as wt. % (weight percent of the algal biomass dried at 60°c).

DISCUSSION

Many nutritional studies have confirmed the capacities of microalgae as a novel source of protein and the average food grade quality of most of the algae examined is equal or even superior to that of other conventional high-quality plant proteins (Becker, 2004). Crude protein (CP) and crude fibers (CF) are viewed classically as an indicator of the nutritional value of the food materials (Bryant and Kuropat, 1983; Heneidy, 2002). The high protein content of various microalgae species is one of the main reasons to consider them as a potential unconventional source of protein (So-

letto *et al.,* 2005). Several studies have indicated that in the late-logarithmic growth phase, microalgae contain typically 30-60% protein, 10-20% lipids and 5-20% carbohydrates (Brown *et al.,* 1989; Brown *et al.,* 1997; Renaud *et al.,* 1999; Becker 2007; Eladl 2008).

The results of the present study agreed well with previous similar researches as the biomass contents of crude protein varied between 16.78% and 63.93%, carbohydrates between 14.12 and 38.65%, lipids between 4.21% and 10.33% (Figure 1). The biomass of certain tested microalgae species, namely *Cosmarium* sp., *Scenedesmus obliquus*, *Coelastrum scabrum*, *Chlorella protothecoides,* and *Tetradesmus wisconsinensis*, contain considerably high levels of crude protein with all of 63.93%, 49.71%, 45.64%, 44.78%, and 41.4%, respectively. These results agree with Garcia-Garibay *et al.* (1999) who reported that crude protein content of *Chlorella* sp., *Scenedesmus obliques* and *Scenedesmus acutus* ranged between 40 and 64% of dry weight. In this study, the tested isolates with relatively high protein levels may represent a potential feedstock of food with high nutritional value. It has been reported that high biomass content of ash decreases the amount of organic constituents per unit food weight and lowers food value (Polisini and Boyed, 1972). In this study, the ash contents of biomass of different tested isolates were relatively low (1.9–27.4%), indicating the high nutritional value of the biomass of the tested algal species as food and feed. The crude fibre is an inseparable part of food and feed of plant origin (Pisarikova et al, 2007). Crude fibre is composed of various components such as cellulose, hemicellulose, pectic substances in addition to indigestible oligosaccharides (VanSoet and McQueen, 1975; Trowell, 1974). In general, digestibility of food or feed deteriorates with the increasing of crude fibre (Pisarikova *et al.,* 2007). It has been reported that crude fibre is not digested by the enzymes in the gastrointestinal tract of mammals, but it is digested by enzymes of the microflora of the gastrointestinal tract (Stratil, 1993). Accordingly, it is evident that high crude fibre decreases the nutritional value of a food or feed raw materials including algal biomass. The extremely low content of crude fibre of biomass of all tested microalgae that never exceed 1% may indicate their superior nutritional value.

Energy is not a nutrient, but it is a property of nutrients that are released during the metabolic oxidation of proteins, carbohydrates and lipids. The quality of forage can be expressed in several parameters, such as total digestible nutrients, digestible crude protein and caloric value (Duivenbooden, 1985). The total digestible nutrients (TDN) is an appropriate measure of bioavailable food energy (Lofgreen 1951) and it is regarded as a areliable measure of energy requirement of human food or animal feed (Heneidy, 2002). In general, the biomass of all tested green microalgae exhibited high values of crude protein (CP%), Total Digestible Nutrients (TDN), Digestible Crude Protein (DCP), Gross Energy (GE), Metabolizable Energy (ME), Digestible Energy (DE). These results may highlight the potential value of the biomass of all the tested algae as renewable biosource of food and feed with reasonable energy contents. It must be highlighted that the net energy is more accurate than other energy systems because it

gives the net value of each feed after accounting for all the energy losses in the process of feed and nutrient utilization. Based on the experimental results (Table 1), the relatively high NE of *Chlamydomonas* sp. (91.95 Kcal $100g^{-1}$), *Tetradesmus wisconsinensis* (36.30 Kcal $100g^{-1}$) and *Coelastrum scabrum*, (21.87 Kcal $100g^{-1}$), indicate their energetic value as feedstock of food and feed. However, more researches involving trails with animal feeding experiments are required to affirm the high nutritional value of the investigated green microalgae.

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الملخص العربى

القيمه الغذائيه لبعض الطحالب الخضراء الدقيقه

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مع التزايد المستمر لأسعار الغذاء والزياده المتوقعه للسكان ،أصبح من الضرورى البحث عن مصادر مختلفه للغذاء. أوضحت الدراسات المتعلقه بغذاء الانسان أن بعض أنواع الطحالب الدقيقه تمتلك قيمه غذائيه عاليه.فى هذاالبحث تم دراسه القيمه الغذائيه لبعض أنواع الطحالب الخضراء الدقيقه وهى: *Chlamydomonas sp. (BIRD CHL-108), Chlorella protothecoides (BIRD CHL-127), Coelastrum scabrum (BIRD CHL-130), Cosmarium sp. (BIRD CHL-131), Scenedesmus obliquus (BIRD CHL-192) and tetradesmus wisconsinensis (BIRD Chl 203).*

تم تقييم القيمه الغذائيه للعزلات المختبره عن طريق تحليل نواتج الايض الخلويه ممثله فى محتوى الدهون ، البروتين، الكربوهيدرات، الالياف، الرماد ونسبه الرطوبه. تم تقيم قابليه الهضم ومحتوى الطاقه لهذه النواتج الأيضيه عن طريق : حساب النسبه المئويه للمغذيات القابله للهضم، البروتين الخام القابل للهضم,القيمه الغذائيه لنواتج الأيض للمغذيات ,طاقه الأيض و صافى الطاقه المكتسبه .

أظهرت النتايج تباين واضح وعالى الدلاله الإحصائيه *(P≤0.05)* فى محتوى البروتين *(16,78- 63,93%)* و الدهون *(4,21- 10,33%)* و الكربوهيدرات *(15,97 – 38,6%)* والالياف *(0- 1%)* والرماد *(1,92- 27,4%)* ومحتوى الرطوبه *(6,73 -9,43%)* للكتله الحيويه لطحالب الاختبار المختلفه .

أظهرت النتايج أيضا تباينا واضحا فى محتوى الكتله الحيويه للطحالب القابله للهضم *(15,45 -.56,2%)* والبروتين الخام القابل للهضم *(13,66 -62,92%)*و القيمه الغذائيه الكليه (*0,22 – 3,08%)* والطاقه الكليه (*352,3 – 547,4*) كيلو كالورى / *100* جرام) والطاقه الناتجه عن الأيض(*284,3 – 409,2*) كيلو كالورى / *100*جرام)وطاقه الأيض (*249 - 418*) كيلو كالورى / *100* جرام) وصافى الطاقه المكتسبه (- *39,77 – 91,95* كيلو كالورى / *100*جرام).

إعتمادا على هذه النتايج فإن غالبيه الطحالب المختبره تمتلك قيمه غذائيه عاليه ويمكن إستخدامها كغذاء أو مكملات غذائيه عاليه الفائده والطاقه.

JOESE 5

NUTRITIONAL VALUE OF SOME SELECTED GREEN MICROALGAE

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