PRODUCTIVITY, LIPID CONTENT AND FATTY ACID COMPOSITION OF SOME SELECTED CYANOBACTERIAL STRAINS UNDER DIFFERENT GROWTH CONDITIONS

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Abstract

The present study is a trial to cultivate three different cyanobacterial strains (*Anabaena laxa*, *Anabaena fertilissima* and *Nostoc muscorum*) under four different growth conditions using $BG11_0$ growth medium. These conditions are represented by static glucose medium with glucose (1%, w/v), aerated medium (aerated by bubbling technique depending on atmospheric CO_2 normally existed in air with a concentration of 0.3%), growth medium enriched with molasses of sugar cane (0.7%, v/v) and aerated growth medium enriched with glucose (1%, w/v). *A. laxa*, *A. fertilissima* and *N. muscorum* exhibited high biomass production under mixotrophic growth condition rather than aerated autotrophic condition. Whereas, static glucose medium enhanced the growth of *A. laxa*, *A. fertilissima and N. muscorum* significantly with dry weight yield of 3.6, 3.1 and 5.2 g L^{-1}, respectively. Moreover, glucose enhanced lipid content for both *A. laxa* and *N. muscorum* to produce 293.9 and 253.5 µg g^{-1} fresh wt., respectively. While *A. fertilissima* exhibited the highest lipid content under aerated enriched glucose medium (307.6 µg g^{-1} fresh wt.). Static glucose medium supported the lipid synthesis rate of *N. muscorum* to record 6.3 folds, as compared to the control, after 10 days of treatment. While *A. fertilissima* exhibited its highest lipid synthesis rate under aerated enriched glucose condition after 2 days. Ten fatty acids were detected for all the investigated cyanobacterial strains with different percentages, under static glucose medium (1%, w/v) during the stationary phase. Half of them were saturated fatty acids and the others were two mono-unsaturated and three poly-unsaturated fatty acids. Myristic, palmitoleic and arachidonic acids were the most abundant among all the tested isolates.

Key words: Cyanobacteria; mixotrophy; autotrophy; lipid content; fatty acids

Introduction

Commercial use of microalgae as sources of specific lipids began in the 1970s with the extraction of b-carotene from *Daunanella salina* (**Raja *et al*., 2008**).

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Interest in docosahexaenoic (DHA) has increased recently because of the recognition that ω3- polyunsaturated fatty acids are important for good health and in lowering the risk of diseases where chronic inflammation plays an important role (**Harwood and Caterson, 2006**). This includes cardiovascular disease, various cancers, arthritis and dementia. Among many types of algae, microalgae seem to be promising because they have high growth rates (**Rittmann, 2008**). Their lipid content could be adjusted through changing growth medium composition (**Naik *et al*., 2006**). Quantitatively, the total lipid content varies between species ranging from very low (4.5%) to very high (80%) (**Renaud *et al*., 1999; Hu *et al*., 2008**). Several microalgae such as *Chlorella protothecoides* (**Wu *et al*., 1992**), *Crypthecodium cohnii* (**de Swaaf *et al*., 2003 a&b**) are capable of uptaking carbohydrates (e.g., glucose) directly and transforming them to lipid (**Miao *et al*., 2006**). *Nostoc spp*. can grow mixotrophically, using glucose and sugarcane molasses as organic substrates, and greater production of biomass and phycobiliproteins can be reached when compared with the autotrophic growth (**Borsari *et al*., 2007**). Also, *Anabaena sp.* PCC 7120 was grown in the presence of exogenous glucose in light (**Guoce *et al*., 2011**). Microalgae can be cultured in heterotrophic conditions where organic carbons, such as sugars, sugarcane molasses and organic acids, serve as carbon sources. Accordingly, the lipid content for a particular species depends on growth phase with lowest yields common for logarithmic-increasing in late logarithmic- and stable or increasing in stationary phase (**Hu *et al*., 2008; Xu *et al*., 2008**). Microalgal lipids can be changed with variations in nutrients, temperature, salinity, pH, photoperiod, light intensity and light quality (**Dunstan *et al*., 1993**). During the optimal conditions for growth, microalgae synthesize glycerol-based membrane lipids that are mainly composed of various polyunsaturated fatty acids (**Hu *et al*., 2008**). During stress conditions, such as limitation in nutrients, microalgae shift their lipid biosynthetic pathways and start accumulating large quantities of neutral lipids (**Dunstan *et al*., 1993**). The neutral lipids are mostly triglycerides that serve primarily as a storage form of carbon and energy (**Hu *et al*., 2008**) and they can account for as much as 80% of the total lipid content in the cell (**Meng *et al*., 2009**). Generally, microalgal triglycerides contain saturated and monosaturated fatty acids with C_{16} and C_{I8} profile (**Bertoldi *et al*., 2006; Hu *et al*., 2008; Meng *et al*., 2009**). Microalgae with higher levels of triacylglycerol should contain higher proportion of saturated and monosaturated fatty acids and lower proportion of polyunsaturated fatty acid (**Dunstan *et al*., 1993**). In addition, it was reported that microalgae contain more variations in fatty acid composition than higher plants (**Bertoldi *et al*., 2006; Hu *et al*., 2008**). This study aimed to investigate the capability of *Anabaena laxa* (Rabenhorst) Braun A, *Anabaena fertilissima* and *Nostoc muscorum* to grow in mixotrophic culture to assay the testing glucose and sugarcane molasses as substrates. Also, to assess the potential of both *Anabaena sp and Nostoc sp*. to be used to transform carbon from flue gases or from organic sources into valuable products.

Material and Methods

Isolates and growth medium

Anabaena laxa (Rabenhorst) Braun A, *Anabaena fertilissima* Rao CB and *Nostoc muscorum* Agardh C were obtained from the culture collection of soils, water and environment research institute at agriculture research center, Giza, Egypt. $B.G11_0$ (nitrogen free) medium was prepared according to **Allen's and Stanier (1968)**. The isolates were grown in 250-ml Erlenmeyer flasks at 28±2ºC with continuous illumination at intensities of 2500 Lux

Experimental Set up

Growth conditions

The investigated cyanobacterial isolates were sub-cultured, separately, in 5 L Erlenmeyer bottles, containing 3 L $B.G11_0$ (nitrogen free) medium inoculated with 30 ml of pre-cultured isolates during exponential phase. These isolates were cultured under four growth conditions (treatments). a) Autotrophic growth condition, each isolate was aerated by bubbling air at regular pressure (200 ml min^{-1} with 50 Hz frequency), and closed by rubber plug having a narrow glass tube as an air outlet. This condition was depending on CO_2 (0.3%) which exist normally in air, b and c) Mixotrophic growth conditions, were created by adding glucose (1%, w/v) and molasses of sugar cane (0.7%, v/v) separately, respectively, to the growth media under static condition (without aeration), and d) the last one Mixotrophic growth condition was created by adding glucose (1%, w/v) to the growth medium under aerated condition. Before bubbling into the cultures, the air was allowed to pass through a series of "wolf" bottles containing disinfecting solution of copper sulfate, mercuric chloride and sterilized water at the same time. All bottles were kept under the same conditions of temperature and light intensity.

Growth parameters

Dry weight

A definite volume of algal suspension (50ml) was centrifuged at 4000 rpm for 10 min. The cell pellets were washed twice with distilled sterilized water and dried over night in an oven at 80ºC for constant weight (g l^{-1}) (**Leganse *et al*., 1987**).

Chlorophyll (*a*) content

The spectrophotometeric method recommended by **Arnon (1949)** was used for the estimation of chlorophyll *a* pigment. A definite volume of well shaked algal suspension sample was homogenized in 80% acetone and kept in a freezer for about 24h, to ensure complete extraction. The extract was measured against

blank of 80% acetone at 645 and 663 nm. Chlorophyll *a* fraction (mgg^{-1} fresh weight) was determined by using the following equation: Chlorophyll *a* content=$12.7\ E^{663}$-$2.69\ E^{645}$

Total lipids determination

Lipids were extracted from the algal isolates with chloroform/methanol (1:1, v/v) by the method of **Barnes and Blackstock (1973)**. The extracted lipids were determined by the phosphovaniline method. Briefly, 0.5 ml of concentrated sulfuric acid was added to the extracted lipids and heated for 5 min. in a boiling water bath and left to cool at room temperature. The phosphovaniline reagent (2.5ml) was added to the unknown and the blank tubes (0.5 ml sulfuric acid) with vigorous shaking, and then left at room temperature for 10 min. The developed color was measured at 520 nm by using spectrophotometer. The total lipids were determined against the standard calibration cholesterol curve.

Lipid content percentage (%)

The percentage of isolate's lipid production at different growth media conditions were calculated from the following equation:

Lipid content % = $100\times (t_n - t_0) / t_0$. Where, t_n and t_0 represented lipid content at times t_n, and t_0 within the experiment period.

Fatty acids analysis

An extra amount of the extracted lipid was taken for fatty acids analysis. The fatty acid composition was determined by gas chromatography system according to the method of **Ronald and Ronald (1991)**. The carrier gas was Helium with flow rate of 1.9 ml/min and injector temperature was 250°C. The column used was ZB-wax 30m×0.25mm×0.25µm with an oven initial temperature of 50°C. Initial time was 2min with rate of 10°C min^{-1} and the final temperature was 250°C with FID detector, 300°C.

Statistical analysis

Differences between treatments were assessed by one-way analysis of variance (ANOVA) by using Statistical Package for the Social Sciences (SPSS) software for Windows, version 11; SPSS Inc, Chicago, using the least significance difference test (LSD) at probability (p) values ≤ 0.05. The values were expressed as mean ± standard deviation (SD, n=3).

Results

Significant biomass production and increased dry weight of the investigated algal isolates was observed by adding glucose to the growth medium (Fig. 1). The highest dry weight was obtained at 12^{th} day for *N. muscorum* (5.2 g l^{-1}) followed by 3.6 g l^{-1} and 3.1 for *A. laxa* and *A. fertilissima* at 10^{th} and 12^{th} day respectively. Aerated enriched glucose medium also enhanced biomass production for both *A.*

laxa and *A. fertilissima* where they exhibited 3.4 g l^{-1} at 6^{th} and 2.9 g l^{-1} at 8^{th} compared to 1.6 g l^{-1} at 12^{th} and 2.1 g l^{-1} at 18^{th} under aerated medium and 1.1 g l^{-1} at 4^{th} and 1.7 at 8^{th} under molasses (0.7%, v/v) medium. *N. muscorum* exhibited no growth on molasses (0.7%, v/v) medium. But it showed high dry weight on aerated medium (1.4 g l^{-1} at 8^{th} day) compared to aerated enriched glucose medium (1.2 g l^{-1} at 6^{th} day). It seems from this data that addition of organic carbon sources is not favorable for biomass production for this organism.

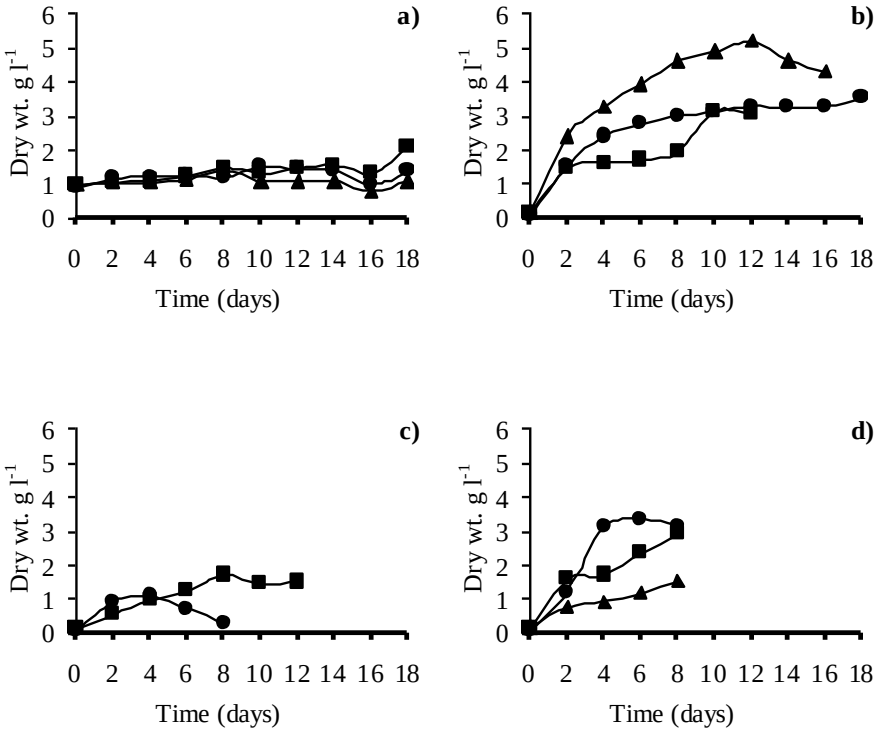

Figure 1. Dry weight content (g L^{-1}) of *Anabaena laxa* (○), *Anabaena fertilissima* (■) and *Nostoc muscorum* (▲) at different growth media conditions a) aerated (0.3% CO_2), b) static glucose (1%, w/v), c) molasses (0.7%, v/v) and d) aerated enriched glucose (1%, w/v) medium. Values are the mean of three replicates.

The highest chlorophyll *a* values were obtained under aerated conditions i.e. absence of organic carbon sources and under continuous light illumination (Fig. 2). Where *A. laxa* exhibited the highest chlorophyll content (99.3 mg l^{-1} after 18 days) followed by *N. muscorum (*42.4 mg l^{-1} for after 14 days. Whereas, *A. fertilissima* exhibited its highest chlorophyll content under mixotrophic conditions to record 121.8 mg l^{-1} at 12^{th} day under static glucose medium compared to 69.1

mg l^{-1} at 26th day under aerated medium. It seems that presence of organic carbon source enhanced chlorophyll productivity for this organism in a short period of time. It was obvious that molasses medium inhibited *N. muscorum* growth completely over all the experiment period.

Total lipid content

An obvious significant variation in lipid content was observed between species under different culture conditions (Table 1). The lipid content of *A. laxa* showed gradual increase during exponential phase for all the treatments but with different pattern of amount produced.

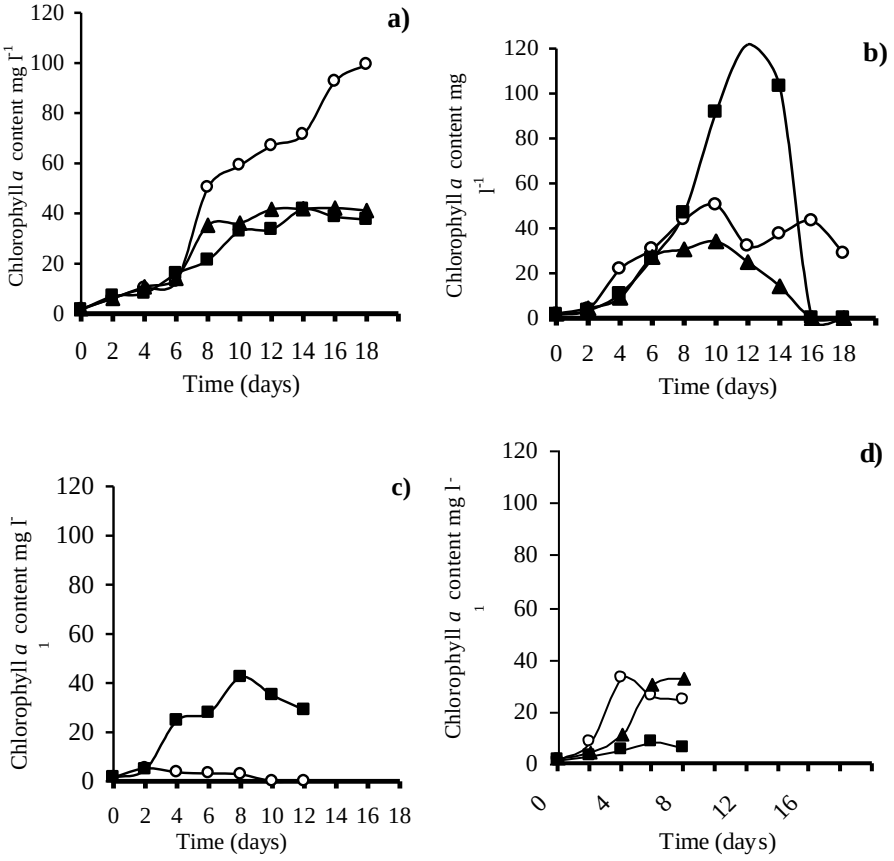

Figure 2. Chlorophyll *a* content mg L^{-1} of *Anabaena laxa* (○), *Anabaena fertilissima* (■) and *Nostoc muscorum* (▲) at different growth media conditions a) aerated (0.3% CO_2), b) static glucose (1%, w/v), c) molasses (0.7%, v/v) and d) aerated enriched glucose (1%, w/v) medium. Values are the mean of three replicates.

Glucose enriched medium recorded the highest significant lipid content, about 6.5 folds of zero time extent, compared with the other treatments. Meanwhile, aerated treatment produced about 3.6 folds of zero time after 12 days. A close value was achieved under 0.7% (v/v) molasses medium to reach 3.6 folds of starting point but in a shorter time period after only two days of incubation period.
A. fertilissima recorded high lipid content (307.6 µg g^{-1}fresh wt.) after two days when incubated under aerated enriched glucose medium. This amount was the highest lipid content compared with the other treatments. Molasses treatment exceeded lipid content by about 5 folds of zero time value. The lipid content in aerated medium fluctuated from high to low but still lower than the start point. With respect to incubation periods it seems that aerated enriched glucose medium is the most promised treatment for the rate of lipid synthesis for *A. fertilissima*, as it showed high significant differences at 2^{nd} ,4^{th} , 6^{th} and 8^{th} days compared to the other treatments at the same time intervals.

The highest lipid content for *N. muscorum* was recorded at 10^{th} day under glucose medium which was about 7.2 folds of zero time, and for aerated enriched glucose medium the highest value was obtained at 8^{th} day was 182.5 µg g^{-1}fresh wt. In contrast, *N. muscorum* growth was inhibited completely under 0.7% (v/v) molasses medium.
It seems that after reaching the maximum value, the lipid content declined for all the treatments specially glucose and aerated glucose medium where after 8^{th} day the death of the organism clearly appeared in the flasks.
Lipid content percentage of *A. laxa*, *A. fertilissima* and *N. muscorum* when compared with the initial lipid content at different growth media conditions was represented in Fig. 3. Aerated $BG11_0$ growth medium for both *A. laxa and N. muscorum* enlarged the lipid content production gradually during exponential phase till they reached their maximum values during stationary phase. On the contrary, *A. fertilissima* showed a marked reduction of lipid production during the incubation period; moreover, enriched glucose medium exhibited the highest rates. *N. muscorum* recorded the maximum yield (628.4 %) followed by *A. laxa* (552.3%) and *A. fertilissima* (220.1%) after 10, 8 and 4 days, respectively. While for molasses medium *A. fertilissima* exhibited the highest rate (342.4%) at 6^{th} day followed by *A. laxa* (255.7%) at 2^{nd} day. Whereas, *N. muscorum* was inhibited completely and couldn't recover again. Aerated enriched glucose medium improved the lipid rate content in case of *A. fertilissima* (512.4%) at 2^{nd} day followed by *N. muscorum* (424.3%) at 8^{th} day, while, *A. laxa* recorded the lowest rate (225.1%) at 8^{th} day.

Table 1. Total lipid content (µg g^{-1}fresh wt.) of *Anabaena laxa*, *Anabaena fertilissima* and *Nostoc muscorum* at different growth media conditions a) aerated (0.3% CO_2), b) static glucose (1%, w/v), c) molasses (0.7%, v/v) and d) aerated enriched glucose (1%, w/v) medium.

Media condition / Time (days)	Aerated	Static glucose	Molasses	aerated enriched glucose	LSD
Anabaena laxa					
0	45.0±0.7	45.0±0.7	45.0±0.7	45.0±0.7	0.6
2	97.9±8.5	187.3±20.5	160.3±5.2	110.±3.7	8.6
4	102.4±6.4	247.7±11.7	158.7±4.2	148.8±4.7	6.7
6	111.3±1.1	237.0±11.3	133.2±4.2	150.6±12.4	6.4
8	110.2±3.2	293.9±12.4	101.1±3.3	146.5±1.9	4.9
10	130.3±6.9	181.7±9.5	0	0	5.6
12	162.4±5.1	122.3±8.2	0	0	4.4
14	139.4±5.4	0	0	0	2.0
16	137.4±3.0	0	0	0	2.4
18	136.2±1.9	0	0	0	2.6
LSD	4.0	8.2	2.2	3.6	
Anabaena fertilissima					
0	50.2±2.8	50.2±2.8	50.2±2.8	50.2±2.8	2.3
2	41.2±1.9	74.4±1.5	127.5±8.3	307.6±17.3	7.1
4	38.4±2.3	160.8±3	156.9±9.9	303.8±22.5	9.1
6	30±1.4	156.03±3	222.2±9.8	258.6±14.8	7.0
8	32.3±3.1	108.7±1.5	185.2±21.4	207.7±18.4	10.4
10	20.7±2.2	0	292.5±19.4	0	7.2
12	27.7±3.9	0	138.9±9.5	0	3.9
14	45±1.2	0	0	0	1.3
16	36.2±3.2	0	0	0	1.6
18	45.1±0.1	0	0	0	1.0
LSD	2.0	1.4	8.9	9.6	
Nostoc muscorum					
0	34.8±0.1	34.8±1	34.8±0.1	34.8±0.1	0.8
2	38.5±0.5	22.9±2.8	0	119.8±2.8	1.7
4	71.5±0.99	53.8±1.6	0	170.3±5.2	2.1
6	72.2±9.2	81.9±3.4	0	168.1±21.2	8.6
8	72.1±3.1	130.6±4.0	0	182.46±4.7	3.7
10	77. 8±7.0	253.5±16.9	0	0	6.8
12	66.2±7.5	220.9±12.9	0	0	5.7
14	73.3±0.9	0	0	0	0.8
16	85.6±9.5	0	0	0	4.3
18	43.1±1.9	0	0	0	0.7
LSD	4.4	5.8	0.2	5.8	

Where: **LSD**, least significance difference; Data are expressed as mean ± SD (n= 3).

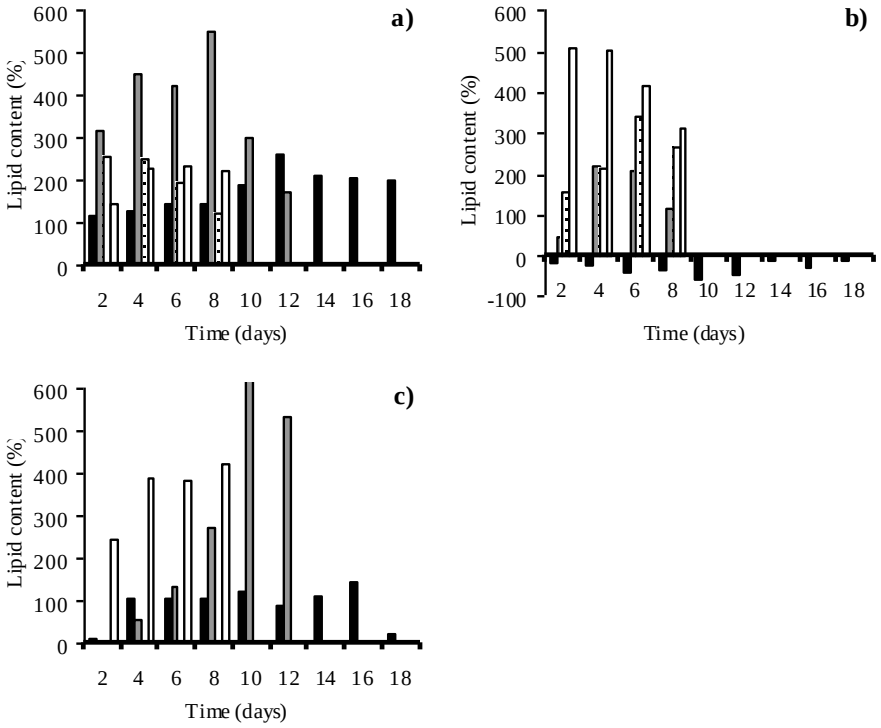

Figure 3. Lipid content percentage of a) *Anabaena laxa*, b) *Anabaena fertilissima* and c) *Nostoc muscorum* when compared with the initial lipid content at different growth media conditions; aerated (0.3% CO_2) (■), static glucose (1%, w/v) (▩), molasses (0.7%, v/v) (⊡) and aerated enriched glucose (1%, w/v) medium (□). Values are the mean of three replicates.

Table 2 shows, analyses of all selected species have the same types of fatty acids but with considerable differences in quantities. Generally saturated fatty acids is the most abundant of total fatty acids composition compared with both mono and poly-unsaturated fatty acids for the three cyanbacterial spp. *A. fertilissima* exhibited. the highest values for saturated fatty acids (83.3%) followed by *N. muscorum* (80%) then *A. laxa* (71.2%). Accordingly, *A. laxa* has the highest values for both mono and polyunsaturated fatty acids composition among the investigated spp. (23.3 and 5.6%, respectively) followed by *N. muscorum* and *A. fertilissima*. With regard to *A. laxa*, stearic acid was the most abundant saturated fatty acid (25.2%), palmitoleic acid was the dominant mono-unsaturated fatty acid (13.2%), and arachidonic represented the most abundant poly-unsaturated fatty acids acid (3.4%). Myristic acid was detected in high levels for *N. muscorum*

followed by *A. fertilissima*, also, palmitoleic acid recorded the highest percentage of mono-unsaturated fatty acids for both *N. muscorum* and *A. fertilissima*.

Table 2. Fatty acids composition in dry weight (%) of *Anabaena laxa*, *Anabaena fertilissima* and *Nostoc muscorum* grown under static glucose medium (1%, w/v) during the stationary phase.

Fatty acid		Common name	*A. laxa*	*A. fertilissima*	*N. muscorum*
Saturated	C12:0	Lauric acid	4.6	11.18	20.35
	C14:0	Myristic acid	17.97	37.5	20.69
	C16:0	Palmitic acid	17.6	13.8	15.04
	C18:0	Stearic acid	25.2	17.6	19.78
	C20:0	Arachidic acid	5.8	3.25	4.13
Total saturated acids			71.17	83.3	79.99
Mono unsaturated	C16:1	Palmitoleic acid	13.2	8.6	10.17
	C18:1	Oleic acid	10.1	5.27	6.64
Total			23.3	13.87	16.81
Poly-unsaturated	C18:2	Linoleic acid	1.01	0.77	0.44
	C18:3	Lenolenic acid	1.2	0.43	0.29
	C20:4	Arachidonic acid	3.4	1.67	2.47
Total			5.61	2.87	3.2
Total unsaturated acids			28.91	16.74	20.01

Discussion

The present study revealed that the maximum growth rate and the highest dry weight were achieved under 1% (w/v) glucose static medium. In this context **Yamane *et al*. (2001)** reported that about 15–19% higher growth was obtained in the mixotrophic culture. Furthermore, **Guoce *et al*. (2011)** reported that glucose improved the cell growth evidently, the maximal specific growth rate under mixotrophic condition (0.38 d^{-1}) being 1.6-fold of that of photoautotrophic growth. Moreover, fructose was taken up and utilized in *Anabaena variabilis* for mixotrophic growth (**Haury and Spiller 1981; Valiente *et al*., 1992**) and was able to enhance the development and growth of *Anabaena azollae* in mixotrophic culture. **Rozen *et al*. (1986)** and **Rozen *et al*. (1988)** demonstrated the potential of mixotrophy growth condition. **Guoce *et al*. (2011)** reported that *Anabaena sp.*

PCC7120 did not grow on glucose in darkness. Our experiment implied that the utilization of glucose requires the participation of light, and the weak light due to the shading effect at high cell density may also impede mixotrophic growth.

The present investigation indicated that aerated enriched glucose medium exhibited a promised result of dry weight for both *A. laxa and A. fertilissima* due to presence of glucose besides bubbling air. Similar observation was obtained by **Liang *et al*. (2009)** who reported that bubbling air into *Chlorella vulgaris* culture exerted a positive effect on cell growth. *N.muscorum* exhibited no growth on 0.7% (v/v) molasses medium due to the highly osmotic pressure caused by sugars present in it. This finding is in accordance with **Liang *et al*. (2009)**, who mentioned that both glucose and glycerol had inhibitory effects at high concentrations. *C. protothecoides* could not directly use molasses as organic carbon source because raw waste molasses contains 36.24% of sucrose; in addition, raw waste molasses contains colloidal and other impurities which might inhibit algal cell growth (**Yan *et al*., 2011; Lee *et al*., 1999**). Moreover inhibitory effect of molasses at reducing sugar concentrations above or below the range negatively influenced algal growth. Which might be due to higher osmotic pressure in media caused by higher reducing sugar concentration of molasses. (**Yan *et al*., 2011**).

With respect to chlorophyll content it was clearly observed that enriched glucose medium caused a reduction of chlorophyll content for *A. laxa and N. muscorum* than aerated medium. This was attributed to the glucose feeding resulted in massive intracellular accumulation of carbohydrates (glucose, fructose, sucrose and starch) and a delayed but pronounced reduction of the chlorophyll content. Thus, the presence of D-glucose caused a reduction of pigment content in the cell, due to the inhibition of chlorophyll *a* and phycocyanobilin biosynthesis at the stage of the transformation of their universal precursor. The assumption was made that D-glucose activates a certain macromolecular intracellular regulator, which, in turn, represses the activity of some of the key chloroplast genes (**Zvereva *et al*., 1980**).

In contrast *A. fertilissima* exhibited the highest chlorophyll (*a*) content under mixotrophic condition (1% glucose, w/v) was 121.4 mg l^{-1} after 12 days as compared to 33.4 mg l^{-1} under autotrophic aerated medium at the same day. High cellular density of the culture produced shade which reduced the irradiance into the culture, increasing the chlorophyll content per cell (**Saoudi-Helis *et al*., 1994**), this observation agreed with **Borsari *et al*. (2007)**. It seemed that biosynthesis of chlorophyll in the cyanobacterial cells as a response of addition of carbon sources, D-glucose or molasses to the growth medium had variable effect. It may cause a pronounced increase in total chlorophyll content as in case of *A. fertilissima* or cause an obvious inhibition as in case of *A. laxa and N. muscorum*, these actions were strongly related to the genetic criteria of each isolates.

The highest lipid content of *A. laxa and N. muscorum* were 293.9 and 253.5 µg g^{-1} fresh wt., respectively, that were achieved by the addition of 1% (w/v) glucose

to the culture media. **Matsuka *et al*. (1969)** reported that glucose is mainly incorporated into lipids (particularly fatty acids) to optimize growth and production of desired chemicals from microalgae, it is essential to supply the accurate carbon source. Enriched glucose medium gave the highest lipid content rather the other media; so, it clarified why carbon sources assimilated through different metabolic pathways influenced the biochemical composition of microalgae. **Liang *et al*. (2009)** reported that maximum lipid productivity (54 mg $l^{-1}day^{-1}$) was obtained when cells were grown with glucose (1%, w/v) within 6 days. However the highest lipid content of *A. fertilissima* (292.5 µg g^{-1} fresh wt.) was achieved by utilizing molasses medium (0.7%, v/v). This was due to the fact that sugarcane molasses is rich in nutrients. Besides the great concentration of carbohydrates, it had nitrogenous substances, vitamins, trace elements and many other kinds of ingredients that consist mainly of 48% sugars. Its composition varies depending on the sugarcane used for the production of sugar (**Crueger and Crueger, 1989**). This finding was in accordance with **Yan *et al*. (2011)**, who reported that increasing molasses the content lipid increased. Waste molasses was confirmed as a sole source of full nutrients to totally replace glucose-based medium in support of rapid growth and high oil yield from algae (**Yan *et al*., 2011**). This investigation recorded that, saturated fatty acids were the most abundant of total fatty acids composition compared with both mono and poly unsaturated fatty acids for our examined cyanbacterial spp. under 1% (w/v) static glucose medium. In accordance with **Chu *et al*. (1995)**, the relative amounts of C16:0, C18:0, C18:1 and C18:2 increased at the expense of C18:3 in the carbon supplemented culture and at glucose concentrations higher than 0.1% (w/v). Generally, microalgal triglycerides contain saturated and monosaturated fatty acids with C_{16} and C_{I8} profile (**Bertoldi *et al*., 2006; Hu *et al*., 2008; Meng *et al*., 2009**). Microalgae with higher levels of triacylglycerol should contain higher proportions of saturated and mono-unsaturated fatty acids and lower proportion of poly-unsaturated fatty acid (**Dunstan *et al*., 1993**).

A. laxa, *A. fertilissima* and *N.muscorum* recorded high percentage of palmitoleic fatty acid (C16:1). This finding is in accordance with **Sallal *et al*. (1990)** who reported that, in lipids of *A. cylindrical*, palmitic, linoleic and linolenic acids were predominant. *N. canina* lipids contained palmitic, palmitoleic, oleic and linoleic acids as major acyl moieties, whereas in *N. muscorum* palmitic, palmitoleic, hexadecadienoic, oleic and linoleic acids were predominant. With regard to poly-unsaturated fatty acids, arachidonic acid exhibited the greatest value for the treated cyanobacterial spp.

Conclusion

This work reported the first results of a large study of the biological removal of CO_2 from flue gases using microalgae and using glucose sugar as organic carbon source.

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الأنتاجية و المحتوى الدهنى وتركيب الحمض الدهني لبعض السلالات المختارة من السيانوبكتريا تحت ظروف النمو المختلفة

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هذه الدراسة هي محاولة لزراعة ثلاث سلالات مختلفة من السيانوبكتيريا (*Anabaena laxa* ، *Anabaena fertilissima* و *Nostoc muscorum*) تحت أربعة ظروف مختلفة للنمو باستخدام وسط نمو($BG11_0$) .
وتتمثل هذه الظروف باستخدام وسط نمو من الجلوكوز بتركيز (1%, w/v) ، وسط نمو به تهوية (التهوية عن طريق تقنية الفقاقيع و تعتمد على ثانى أكسيد الكربون الجوى الموجود فى الهواء بنسبة 0.3%)، وسط نمو غني بالمولاس المستخرج من قصب السكر بتركيز (0.7%, v/v) و وسط نمو به تهوية غني بالجلوكوز بتركيز (1%, w/v). كان أعلى انتاج من الكتلة الحيوية للطحالب *A. laxa* ، *A. fertilissima* و *N. muscorum* تحت الظروف مختلطة التغذية من النمو بدلا من الظروف الهوائية ذاتية التغذية.و باستخدام وسط النمو المكون من الجلوكوز انتجت أكبر كمية للوزن الجاف للطحالب *A. laxa*، *A. fertilissima* و *N. muscorum* بمقدار 3.6 ، 3.1 و 5.2 جم/لتر على التوالى. وعلاوة على ذلك، الجلوكوز حسن من المحتوى الدهني لكل من *A. laxa* و *N. muscorum* لانتاج 293.9 و 253.5 ميكروجرام /لتر من الكتلة النضرة على التوالى. بينما كان أعلى محتوى دهنى لطحلب *A. fertilissima* فى وسط النمو ذو التهوية الغني بالجلوكوز. (307ميكروجرام /لتر). دعم الوسط الأول للنمو المحتوى على الجلوكوز انتاج الدهون فى طحلب *N. muscorum* 6.3 أضعاف الكمية مقارنة بالعينة الغير معاملة خلال 10 أيام من المعاملة. و لكن اعلى معدل لانتاج الدهون فى طحلب*A. fertilissima* كان فى الوسط ذو التهوية الغني بالجلوكوز بعد يومين. تم تحديد عشر أحماض دهنية لجميع سلالات السيانوبكتيريا بنسب مختلفة فى وسط نمو المكون من الجلوكوز بتركيز (1%, w/v) خلال مرحلة الثبات فى النمو. كان نصف تلك الأحماض من الأحماض الدهنية المشبعة و الأخرين كانوا اثنين من الأحماض الأحادية غير المشبعة و الثلاث أحماض الأخرى كانت من الأحماض الدهنية العديدة غير المشبعة. كانت اثنين آخرين أحادية غير مشبعة وثلاثة الأحماض الدهنية غير المشبعة المتعددة. أحماض الميريستيك، البالمتيوليك والأراكيدونيك كانت الأكثر وفرة بين جميع العزلات المختبرة.