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SEED SPROUTS, A PHARAOH'S HERITAGE TO IMPROVE FOOD QUALITY

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ABSTRACT

Three methods for growing Egyptian clover sprouts hydroponically in dark were compared. Growing sprouts using the glass jar method resulted in the largest numerical yield of sprouts per equal unit pench area (6781 g/m^2) with adequate yield per unit volume of seeds (8.7 g of sprouts/ g of seeds). The highest sprout yield per unit volume of seeds (>9 g of sprouts/ g of seeds) was obtained using covered panet method. Seeding density at 4-6 g/100 cm^2 of the panet and harvest of clover sprouts at 5 days old with soaking time is recommended to provide a product of highest possible nutritional value (3.73 g of protein and 0.93 g of fiber / 100 g clover sprouts) for human foods. Four seeding rates for growing radish and rocket sprouts in soil in natural sun light were compared. Seeding rate at 60-80 g/m^2 for radish and 30-40 g/m^2 for rocket seeds were recommended to provide a green sprouts of high yield with good sprout physical characters and good nutritional value (2.1 g of protein and 0.7 g of fiber/ 100 g fresh rocket sprouts and 1.68 g of protein and 0.54 g of fiber/ 100 g fresh radish sprouts). The lipid content of the sprouts was relatively low (0.03 – 0.16 % on a fresh weight basis). Raw clover sprouts had the lowest content of lipid and therefore, could be recommended for lowing weight. Development of food products from germinated clover, radish and rocket may be promising in Egyptian human foods for their nutritional advantageous due to low content of fats and high protein utilization.

INTRODUCTION

Seed germination and production of sprouts is an old habit that was adopted thousands of year's age by the ancient Egyptians. **Nazeer (1967)** in his book "Egyptian habits between yesterday and today" showed a photo for a necklace from barley sprouts **(Fig. 1)**. It dated back to the around (2890-3686 B.C.). The necklace referred to the "return" of life to the god "OSIRIS". The god was considered to refer to the life of spring plant and flooding of water Nile. In the current Egyptian habits, seed germination is still practiced among Egyptians families, particularly in spring festivals. Germinated seeds of faba bean, fenugreek, chickpea…..etc are present on tables in spring fests. Seed germination results in greenish and beginning "return" of life in seeds and both are indicates of hope, optimism and renewed life.

However, during the past decade consumer concern over nutritional value of food has increased dramatically. Consumers have modified traditional eating habits to include more fresh foods such as salads in their diet **(Sawyer *et al* 1985)**.

“Home – grown” products are generally considered more nutritious than comparable purchased products because they can be consumed directly after harvesting (**Cairney, 1997)**. Methods for “home – grown” clover and alfalfa sprouts have been previously reported **(Sawyer *et al* 1985)**.

Seed sprouting is the practice of soaking, draining and leaving seeds until they germinate and begin to sprout. It has been identified as an inexpensive and effective technology for improving the nutritional quality of seeds. As water is introduced, enzyme inhibitors are disabled and the seed explodes to life **(Frias *et al* 1995; Bau *et al* 1997 and Schhulze *et al* 1997)**.

Germination unfolds and enzymes trigger elaborate biochemical changes. Proteins break into amino acids-water-soluble vitamins such as B complex and vitamin C are created **(Vanderstoep, 1981; Sattar *et al* 1995; Zielinski *et al* 2005 and Khattak *et al* 2007)**. Fats and carbohydrates are converted into simple sugars. Weight increases as

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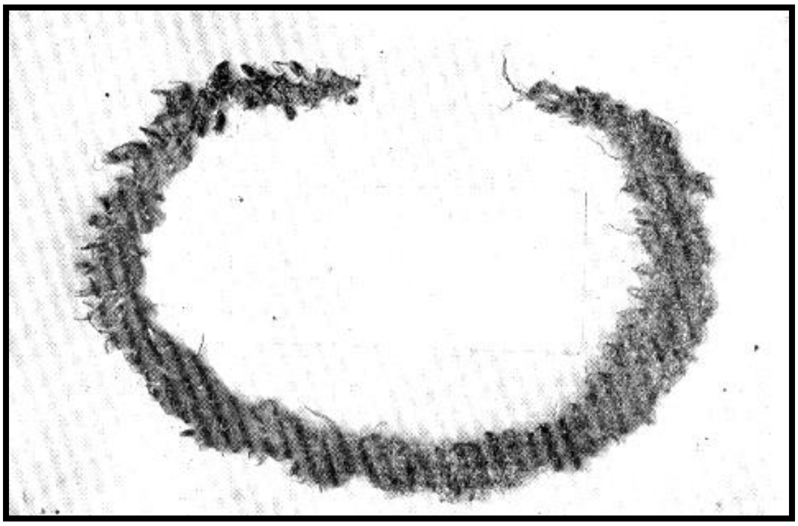

Fig. 1. Photo for a necklace from barley sprouts referred to the return of life to the god Osiris, dated back to around 2890-2686 B.C. (from Nazeer book 1967 "Egyptian habits between yesterday and today")

the seed absorbs water and minerals **(Cairney, 1997)**. Proteins from sprouts are considered to be good alternates to the costly animal proteins. In addition, consumer's acceptability (cook ability, taste and flavor) is also increased through sprouting **(Badshah *et al* 2003 and 2006)**.

Legumes are good and relatively inexpensive sources of protein and energy and they represent an important food component in poor country countries. However, clover and alfalfa (lucerne) are valuable sources of a high quality protein in temperate climates. The arial parts of the plant are used as forage in the form of green feed, hay or pellets. The human consumption of clover and alfalfa is generally low, but in some countries there has been an increasing interest in using alfalfa and clover sprouts in green salads on in the form of tablets or juices **(Oakenfull, 1980 and Oleszek, 1998)** for their favorable effect on blood cholesterol.

Researchers have evaluated various growing methods for clover sprouts as well as quality of the product post-harvest. **Hamilton and Vanderstoep, (1979)** analyzed nutrient content of alfalfa sprouts harvested after 84 hr. growth periods in glass jars and reported that 100g of clover sprouts contained 4 g of protein, 1.1 g of fiber and 0.1 g of fat.

On the other hand, light – grown sprouts are morphologically, ultrastrucuturally and metabolically different from those grown in the dark. Green sprouts of radish and rocket are tender baby vegetables, high in chlorophyll and may substitute lettuce.

Radish and rocket fresh green sprouts have a slightly salty taste, hot and rich in enzymes, low in fat, highly nutritious, rich in energy and essential vitamins and amino acids **(Cairney, 1997)**.

Since the quality and quantity of bioactive compounds are important when the sprouts are considered as a new functional food, the present study was undertaken to investigate the effect of sprouting techniques on sprout yield, characters and nutritional value of clover, radish and rocket sprouts.

MATERIALS AND METHODS

The experimental work was carried out in the Horticulture Department, Faculty of Agriculture. Ain Shams University. Organic seeds of radish (*Raphanus sativus*); rocket (*Eruca Sativa*) and Egyptian clover (*Trifolium alexandrium*), were obtained from private farm in Kalubia Governorate under the author supervision. The seeds were cleaned from all impurities for sprouting as per following procedure in the following studies:

Clover sprouting study

Seeds of clover "Egyptian berseem" were used in the following experiments:

1. Sprouts production methods

Three production methods for clover sprouts were developed and standardized in a laboratory based on published reports.

These methods were (a) the glass jar method (GJM), (b) the panet method (PM), using two transparent poly styrene covered panet (sandwich and strawberry shape) and (c) tray method (TM) using both foam plate and plastic tray with untreated cellulose sponge on the bottom.

1.1. The glass jar method

Clover seeds (12 g) and tap water (300 ml) was placed in a 0.7 L. capacity glass jar (household version) which was then covered with cheese cloth secured by a rubber band. The jar was stored in dark for 12 hr. to allow seeds to soak at room temperature. After which soaking water was discarded and the seeds were rinsed with water in the jar (approximately 1.0 min.). The rinse water was discarded, the jar was inverted at a 45° angle and stored at room temperature in dark for 12 hr. The rinse-store procedure was repeated 8 times until 96 hr. cumulative time had been completed (harvest time).

1.2. The panet method

The transparent polystyrene panet method was similar to the GJM except that attached panet cover (instead of cheese cloth) was used to cover clover seeds/sprouts and all panet (either sandwich (22×9.5×7.5) or strawberry (14×9.5×6) shape) were inverted horizontally in dark at room temperature.

1.3. The tray method

The tray method using sponge on the bottom was similar to the GJM with the following exceptions: (a) after the initial 12 hr. soaking period, drained (in a plastic strainer), rinsed clover seeds were placed on a foam plate (22×13×3 cm) and on plastic tray (38×17.5×4 cm) lined with wet layer of sponge (3 mm thick soaked in boiling water 5 minutes before use); (b) clover seeds were distributed to form a single layer on the sponge and (c) the tray with the seeds (covered with an empty tray) was held at room temperature in a dark area as reported by **Fordham *et al* (1975)**. Each 24 hr., the tray with the seed/sprout was sprayed with tap water through out sprouting periods to avoid microbial growth.

The experiment finally included 5 sprouting chamber i.e. 1.glass jar, 2. sandwich panet shape, 3. strawberry panet shape, 4. foam tray and 5. plastic tray.

After 96 hr. cumulative growing time, clover sprouts were collected, washed (to remove ungerminated seeds and seeds hulls), precooled in ice water for 5 minutes and air dried for data collection.

1. Clover seeding density

Using panet method (strawberry shape), seeds of clover were used at four densities (treatments) as follows:

a. 100% seed density (the soaked seeds covered all the sponge surface in the panet, 8 g dry seeds per panet).
b. 75% seed density (the soaked seeds covered 75% of the sponge surface in the panet, 6 g dry seeds).
c. 50% seed density (the soaked seeds covered 50% of the sponge surface in the panet, 4 g dry seeds).
d. 25% seed density (the soaked seeds covered 25% of the sponge surface in the panet, 2 g dry seeds).

After 96 hr. cumulative growing time, clover sprouts were collected, washed, hulled precooled in ice water for 3 minutes and air dried for data collection.

2. Sprouting time

Clover sprouts were collected daily started from the 3^{rd} day (72 hr. after seeding) up to 7 days. Sprouts yield and length were measured daily for observing the best length of sprouting time (sprouting age) using panet method (strawberry shape) for sprouting.

Mean yield per unit volume of seed (1.0 g) was calculated, total yield and sprout length (cm) were also recorded.

Green sprouts of radish and rocket

Four producing green sprouts of radish and rocket $1m^2$ cement plot filled with clay soil was used. The cement plot dimensions were 1.0 × 1.0 × 0.5 m (L × W × H) located in the Vegetable Experimental Farm of the Faculty of Agriculture, Ain Shams University.

To study the effect of seeding rates per unit area on the green sprouts of radish and rocket vegetables, separate experiments with four seeding rates (treatments) were adopted: 120, 100, 80 and 60 g/m^2 of dry radish seeds and 60, 50, 40 and 30

g/m^2 of dry rocket seeds. Each treatment (seeding rate) was repeated four times in a completely randomized design. Irrigation was applied as needed.

Data recorded for green radish and rocket sprouts

Radish and rocket sprouts were harvested at fully expanded green cotyledons stage which was after about 8 days for radish and 11 days for rocket from seed sowing. The harvested sprouts were washed, precooled in ice water for 3 minutes and air dried for about 1.0 hr. Mean yield per unit area (1.0 m^2) and per unit volume of seeds (1.0 g) was calculated. Ten sprouts were randomizly chosen from each plot for sprouts length and cotyledon dimensions measurements.

Nutrient composition of sprouts

Fresh clover, radish and rocket sprouts were dried in oven at 60°c for 48 hr. (to constant weight). For the determination of ash, ground samples were heated at 600°c overnight. Total protein content (N × 6.25), fiber, ash and lipids were determined according to **A.O.A.C. (1990)**.

Statistical analysis

Statistical analysis was employed for each measured trait by analysis of variance (ANOVA – using completely randomized design) and the means were differentiated by LSD 0.05.

RESULTS AND DISCUSSION

1. Effect of production methods on clover sprout's characters

Mean yield and length of clover sprouts using different production methods are reported in **Table (1)** although differences in sprout length were not statistically significant, but clover sprouts produced by panet methods had the longest length. On the other hand, that sprouts yield/growth chamber recorded the higher yield with plastic tray method followed by glass jar method while the lowest yield was obtained by pannet (strawberry shape). The increment yield with plastic tray method may be due to the larger tray dimensions.

Yield of clover sprouts (g of sprouts /g of seeds) was significantly reduced by using plastic tray production methods as compared with other methods. Using panet sandwich method, for sprouts production recorded the higher yield per one g seeds (9.37 g).

However, clover sprouts producers will expect a range from 1: 5 to 1: 9 sprouts per equal weight of seeds. The higher range will obtained by using panet production method followed by glass jar method. Less range (1: 5) was obtained before by **Sawyer *et al* (1985)** in alfalfa sprouts.

Concerning total yield per unit pench area (m) or unit space volume (liter) of clover sprouts, data in **Table (1)** indicated that clover sprouts produced by the glass jar method had the highest yield per equal unit pench area (6781 g/m^2) and unit space volume (120.7 g/L.). The remaining methods produced mean yields of clover sprouts that ranged from 1902- 2322 g $sprouts/m^2$ of pench and (34.5-51.5) g sprouts/liter of space volume.

The glass jar method also produced adequate yield per unit volume of seeds. Moreover the total direct labor time necessary to produce sprouts was less by glass jar than tray method as reported before by **Sawyer *et al* (1985)**.

It has to be kept in mind also that the glass jar and panet used for sprouts production can also be used as a consumer package directly in the market for their easier and safety handling than tray used for sprouts production.

2. Effect of clover seeding density on yield and sprouts length

Data in **Table (2)** showed that the sprouts yield per unit area (panet) decreased as the seeding density decreased while sprouts yield per unit volume of seeds (g) and sprout length (cm) increased as the seeding density decreased. The 75% and 50% seeding density could be recommended for clover sprouts production because they need less direct labor time and less pench area (1.3 and 2 times greater than 100% respectively while 25% needs 4 times greater), with acceptable sprout length (4 and 5.1 cm respectively). In addition, results are close to the sprout producer expectation range (up to 1:9 sprouts per equal weight of seeds). Moreover, panets can be used as consumer package; therefore, less panets may be used. All the previous results and expectations recommend 75% and 50% seeding density.

3. Effect of number of days of sprouting on yield and sprouts length

Data in **Table (3)** showed that the sprout length and yield increased as the sprouting time increased, and the highest value was noted with 7 days of sprouting time. However sprouting time longer than 5 days showed growth of mould with the sprouts. One possible explanation for this mould is that the moist sponge on the bottom of panet during the long sprouting process would have resulted in additional moisture that encouraged bacterial proliferation.

Table 1. Effect of sprouting methods on clover sprout length and yield (combined data of two experiments)

Methods of sprouting	Sprouts length (cm)	Sprouts yield			
		g/chamber	g per unit volume of seeds (g)	g /m^2 of pench	g/lit of space volume
Glass jar	5.93	104.5	8.70	6781	120.7
Panet (sandwich)	6.04	40.5	9.37	1902	46.7
Panet (strawberry)	6.01	29.0	9.09	2181	42.9
Foam tray (plate)	5.94	54.5	8.58	1913	51.5
Plastic tray	5.89	155.0	7.85	2322	34.5
L.S.D. 0.05	**N.S.**	**8.11**	**0.536**	**245.1**	**4.06**

Table 2. Effect of seeding density (g./panet "strawberry") on clover sprout length and yield (combined data of two experiments)

Treatments	Sprouts length (cm)	Sprouts total yield g/chamber	Sprouts yield (g) per unit volume of seeds (g)
8 g/panet (100%)	3.43	55.8	6.98
6 g/panet (75%)	3.97	50.5	8.41
4 g/panet (50%)	5.08	40.0	10.04
2 g/panet (25%)	5.96	23.3	11.62
L.S.D. 0.05	**0.076**	**1.05**	**0.236**

Table 3. Effect of No. of days of sprouting on yield and sprout length of clover (combined data of two experiments)

Treatments	Sprouts length (cm)	Sprouts total yield g/chamber	Sprouts yield (g) per unit volume of seeds (g)
3 days	2.49	19.4	6.05
4 days	4.26	26.3	8.22
5 days	4.99	29.7	9.29
6 days	6.07	38.1	11.90
7 days	6.99	41.2	12.88
L.S.D. 0.05	**0.064**	**1.21**	**0.375**

4. Effect of seeding rate on radish and rocket green sprout growth and yield

Sprout length, sprout cotyledon dimensions and sprouts yield per m^2 and per unit volume of sowing seeds (g) of radish and rocket grown by four seeding rates are reported in **Table (4)**. The sprout length and yield per m^2 increased significantly as the seeding rate increased, while the sprout cotyledon dimensions decreased as the seeding rate/m^2 increased for both vegetables. Although differences in both radish and rocket sprout yield per unit volume of seeds (g) were not statistically significant, the radish sprouts produced by rate of 80 and 60 g of seeds/m^2 and rocket sprouts by the 40 and 30 g of seeds/m^2 had the highest yield per equal volume of seeds (g). Moreover the sprout cotyledons increased in expanded dimensions as seeding rate/m^2 decreased **(Table 4)** Therefore the lower seeding rate (60 to 80 g/m^2 for radish and 30 to 40 g/m^2 for rocket) can be recommended for producing radish and rocket green sprouts.

5. Effect of sprouting on Proximate analysis

The results of the proximate analysis of clover, rocket and radish sprouts and mature radish and rocket plants are summarized in **Table (5)**. The rocket and radish sprouts studied presented marked differences in protein composition on a dry basis as compared with mature plants. The higher protein content in the sprouts than mature plants on a dry weight basis was considered to be related to the differences in the % dry matter content for sprouts compared with mature plants. However, the radish sprouts protein content decreased on the value per 100 g of edible portion (on a fresh weight basis) as compared with mature radish plants because of less % of dry matter content for radish sprouts compared with mature plants. Germinated rocket and radish seeds had content of fiber (0.69% and 0.54% respectively on a fresh weight basis) whereas, the concentration in mature plants were 0.8 % and 0.87% respectively. However, the clover, rocket and radish sprouts had a satisfactory source of fiber. With the exception of clover (white sprouts), the protein composition of rocket and radish green sprouts analyzed fell within a relatively narrow range (31-36% on a dry weight basis and 1.7 to 2.1% on fresh weight basis). Clover white sprouts contained 54.1% protein on a dry weight basis and 3.7% on fresh weight basis. Clover sprouts showed an increase in protein content of more than 77% and 122% as compared with rocket and radish sprouts respectively for raw sprouts. This increase may be due to legume seeds (clover) compared with non-legume seeds (rocket and radish) since, during the development of the dicot seed on the mother plant, storage molecule, particularly starch, proteins and triglycerides are laid down in the seed. In the legume seed (as clover) a relatively large fraction of these reserves, on a weight basis, is composed of storage protein **(Bau *et al* 1997)**.

The lipid content of the sprouts was relatively low (0.38-2.44 g % on a dry weight basis and 0.03-0.16 % on fresh weight basis). Raw clover sprouts had the lowest content of lipid. Therefore, all these sprouts can be recommended for lose weight.

Concerning carbohydrates, data in **Table (5)** showed that raw radish sprouts had the lowest content of carbohydrate (1.01 g %) than raw clover and rocket sprouts (1.26 and 1.93 g% respectively). The lower values for carbohydrates in radish sprouts than clover sprouts may be of primarily a result of the higher in water content radish sprouting.

Values for total ash are also shown in **Table (5)**. The data showed that raw clover sprouts had the lowest content of ash (0.25 g %) than radish (1.0 g %) and rocket (1.41 % g). These lower values for ash in clover sprouts than radish or rocket may be a result of sprouting in air and water only for clover compared with sprouting in soil media for rocket and radish which may absorb more mineral from the medium (soil).

In conclusion, seed sprouts are easy to produce and require no special equipments or knowledge and can be grown throughout the entire year.

Sprouts are low in fat, good source of fiber, protein and minerals. Moreover, fresh sprouts provide two important things in our diet- a steady year-round source of vitamins and a high concentration of food enzymes. Both keep the body's enzyme activity high. Enzymes are the most vital factor that sustains body's life processes.

Clover sprouts grown for food purposes are simply miniature plants, harvested just after seed germination. The simplest method of production is to take clover seeds, place them in a quart jar and cover them with water for 12 hr. (overnight) to start the process (hydroponically grown). Green radish and rocket sprouts grown in soil in natural sun light until full cotyledon expanded during cool season. Radish and rocket sprouts are tender baby vegetable high in chlorophyll, enzyme, protein and minerals content in addition to most important "nutrient" the life force. Green radish and rocket sprouts are delicious addition to salads.

Table 4. Effect of seeding rate (g/m²) on sprout length and yield of rocket and radish green sprouts (combined data of two experiments)

Treatment	Sprout length (cm)	Sprout Cotyledon dimensions			Sprout yield g/m²	Sprouts yield g./g. of seeds
		Length (cm)	Width (cm)	Length × width (cm²)		
	(a). Rocket sprouts (11 days old)					
30 g	7.49	1.14	1.32	1.52	508.5	16.95
40 g	7.77	1.02	1.15	1.18	696.5	17.40
50 g	8.11	0.94	1.04	0.98	799.5	16.00
60 g	8.43	0.89	1.00	0.90	922.5	15.40
L.S.D. 0.05	**0.378**	**0.058**	**0.088**	**0.154**	**56.61**	**N.S.**
	(b). Radish sprouts (8 days old)					
60 g	9.70	1.53	2.08	3.21	1077	18.00
80 g	9.80	1.48	1.92	2.85	1452	18.25
100 g	10.95	1.40	1.83	2.57	1625	16.25
120 g	11.80	1.30	1.81	2.33	1857	15.50
L.S.D. 0.05	**0.788**	**N.S.**	**0.202**	**0.621**	**256.7**	**N.S.**

Table 5. Effect of sprouting on proximate components (g %) of clover, rocket and radish sprouts

Proximate components (g %)	Clover sprouts		Rocket			
	Value per 100 g of dry weight	Value per 100 g of edible portion	Value per 100 g of dry weight		Value per 100 g of edible portion	
			Sprouts	Mature leaves	Sprouts	Mature leaves
Water "moisture"	10.20	93.8	6.80	6.90	93.71	94.19
Protein "N×6.25"	54.10	3.73	31.10	28.00	2.10	1.57
Total lipid "fat"	0.38	0.03	2.41	2.13	0.16	0.13
Carbohydrates, by differences	18.25	1.26	28.57	27.91	1.93	1.74
Fiber, total dietary	13.42	0.93	10.23	12.82	0.69	0.80
Ash	3.65	0.25	20.89	22.24	1.41	1.39

Table 5. Cont.

Proximate components (g %)	Clover sprouts		Radish			
	Value per 100 g of dry weight	Value per 100 g of edible portion	Value per 100 g of dry weight		Value per 100 g of edible portion	
			Sprouts	Mature leaves	Sprouts	Mature leaves
Water "moisture"	10.20	93.8	7.10	7.40	95.66	94.79
Protein "N×6.25"	54.10	3.73	35.90	32.35	1.68	1.82
Total lipid "fat"	0.38	0.03	2.44	1.82	0.11	0.10
Carbohydrates, by differences	18.25	1.26	21.72	21.18	1.01	1.19
Fiber, total dietary	13.42	0.93	11.48	15.48	0.54	0.87
Ash	3.65	0.25	21.36	21.77	1.00	1.23

Chlorophyll in green sprouts is the first product of light and therefore contains higher energy than any other elements and it is anti-bacterial, washes drug deposits from the body and neutralizes toxins in body. Chlorophyll has been shown to be effective in overcoming protein deficiency anemia.

Finally the germinated clover could be developed as an effective ingredient of sheep protein source of the diets against the "protein energy malnutrition" of poor countries. Development of food products from germinated clover may be promising way to increase the versatility and utility of clover. To date the advantages and disadvantages of this process in Egypt have not been thoroughly established for wide utilization of germinated clover seedlings in human foods, specific dietary or even therapeutic purposes. Further investigation and comprehensive studies are required for testing sprout safety; fortunately it's acceptable by panelist's evaluation.

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