

NUTRIENTS CONTENT AND NUTRITIVE VALUE OF SOME GERMINATED AND NON GERMINATED LEGUMES

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ABSTRACT

The present work aimed at studying proximate composition, amino acid profile, and biological evaluation of nutritive value of cooked germinated and ungerminated chickpea and faba bean. Biological evaluation including body weight gain, total food intake, food efficiency ratio, protein efficiency ratio and corrected protein efficiency ratio was assessed in rats in comparison to casein diet. In addition, nitrogen content of rat carcass was determined. Results of proximate analysis of legumes showed that percentage protein, fat, fibers, moisture and calories were increased while percentage ash and Carbohydrates were reduced on germination of faba bean. In germinated chick pea, percentage protein, ash and moisture were higher while percentage fat, crude fibers, carbohydrates and calories were lower compared to ungerminated one. Germination of both legumes produced reduction in total essential amino acids. Germination of either legumes produced reduction in aspartic, threonine, leucine, isoleucine and arginine and increase in valine and tyrosine. Concerning the nutritive value; rats of the test groups that fed on germinated faba bean, germinated chickpea and ungerminated chickpea showed significant reduction in body weight gain, food efficiency ratio, protein efficiency ratio and corrected PER compared to control. Rats fed on ungerminated faba beans showed non significant change in the previous parameters compared to control. The nitrogen contents in rats carcass showed significant reduction in rats fed on ungerminated legumes compared to control fed on casein diet. Nitrogen contents in rat carcass of the group fed on germinated legumes showed non significant change compared to that of control. It could be that the germination of legumes produced increase in %protein and decrease in % carbohydrate. Essential amino acids were reduced on germination of legumes. Protein efficiency ratio of germinated faba bean, germinated chickpea and ungerminated chickpea diets were significantly lower than that of casein diet. Rat carcass nitrogen of ungerminated but not germinated legumes was significantly lower than that of casein diet.

Keywords : Germinated , ungerminated , chickpea , faba bean , amino acids.

INTRODUCTION

Chickpea seems to be an important source of protein in several developing countries (Singh *et al.*, 1991). Faba bean form an important part of diet in developing countries. They may be consumed in the form of immature tender pods, green mature seeds or as dry seeds after cooking (Askar, 1986). Macarulla *et al.* (2001) reported that rats fed on *Vicia faba* diets showed significantly lower body weight and energy intake than rats fed on casein diets. Generally, legumes have been reported to have low nutritive value due to low amounts of sulfur containing amino acids, low protein digestibility and the presence of antinutritional factors. Heat treatment is

usually conducted before the use of legumes in a human diet. This improves the protein quality by destruction or inactivation of the heat labile antinutritional factors (El – Adawy , 2002). Germination may enhance the nutritive value of legumes by inducing the formation of enzymes that eliminate or reduce the antinutritional and indigestible factors in legumes (Greiner *et al.*, 2001). Since the chemical composition of crops varies with crop cultivars, soil and climatic conditions of the area, it is imperative to study the chemical composition of some important food legumes (Chickpea and faba bean) as regard to their protein, amino acids and mineral contents in order to high light their nutritional significance (Iqbal *et al.*, 2006). The aim of the present research was to study the proximate composition, amino acids, *content and* nutritive value of germinated and ungerminated chickpea and faba bean.

MATERIALS AND METHODS

Materials

1- Legumes

Two types of legumes, chickpea (*Cicer arietinum*) and faba bean (*Vicia faba*), leguminosae family were purchased from Agricultural Research Center, Giza, Egypt.

2- Dietary Ingredients

Corn oil, maize starch and sucrose were obtained from local market.

3- Animals

Rats weighed 55-60g. (Sprague Dawly) were used to assess protein efficiency ratio (PER) and corrected protein efficiency ratio (CPER). Animals were obtained from the Central Animal House. National Research Center. They were kept individually in wire bottomed cages at room temperature and relative humidity of about 55%. Food and water were supplied *ad-libitum*.

Methods

1- Preparation of legumes

• Preparation of ungerminated legumes

Faba bean and chickpea were soaked separately in tap water for 24 hours at room temperature. The legumes were removed and cooked with water at 100 C° for 28 minutes in case of faba beans and for 10 minutes in case of chickpea.

• Preparation of germinated legumes

Legumes were soaked in water for 24 hours followed by germination in moist cloth for 72 hours in dark at room temperature. Germinated faba bean and chickpea were cooked at 100°C for 28 minutes and 10 minutes respectively. Both germinated and ungerminated cooked legumes were de hulled and dried in hot air oven at 50°C for 24 hours. Dried legumes were reduced to powder form that pass through 40 mesh sieve.

2- Chemical analysis of legumes

The powdered germinated and ungerminated dry legumes were chemically analyzed.

2-1 Moisture, protein, fat, crude fiber and ash were determined according to A.O.A.C (2000). Carbohydrates were calculated by difference

2-2 Amino acids composition

Amino acids composition was determined using amino acid analyzer LC 3000 Eppendorf Germany.

Conditions: flow rate, 0.2 ml/min, pressure of buffer from 0 to 50 bar, pressure of reagent, from 0-150, reaction temperature, 123°C.

3- Preparation of experimental diets

Diets:

Different diets (formula 1,2,3,4&5) were prepared. The composition of the experimental diets is illustrated in Table (1). The salt and vitamin mixtures used in the diets were prepared according to Briggs and Williams (1963) and Morcos (1967). A mixture of oil soluble vitamins was administered orally in a dose of 0.1 ml/ rat/ week .

Table (1): Different experimental diets.

Ingredients	Diets				
	Test groups				Control balanced
	1	2	3	4	5
Corn oil	10	10	10	10	10
Cellulose N.N	4	4	4	4	4
Salt mix.	3.5	3.5	3.5	3.5	3.5
Vitamin mix.	1	1	1	1	1
DL- methionine	0.2	0.2	0.2	0.2	0.2
Maize starch	36.865	29.412	30.114	29.639	44.149
Sucrose	18.433	14.706	15.057	14.819	22.075
Dried germinated faba bean	26.002 ⁽¹⁾				
Dried ungerminated faba bean	-	37.182 ⁽¹⁾			
Dried germinated chickpea	-		36.129 ⁽¹⁾		
Dried ungerminated chickpea	-			36.84 ⁽¹⁾	
Casein	-				15.076 ⁽²⁾
Total	100	100	100	100	100

1) Quantities of dried legumes that contain 10g protein.

2) Quantity of casein that contains 10g protein according to A.O.A.C (2000).

The experimental design

This experiment was carried out to determine the protein efficiency ratio (PER) and corrected protein efficiency ratio (CPER) of the studied germinated and ungerminated legumes. The experiment was conducted on 30 growing experimental rats. The rats were divided into five groups, each comprised 6 rats. Rats of groups 1, 2, 3 & 4 were fed on test diets 1, 2, 3 and 4 respectively (Table 1). Rats of the fifth group were fed on balanced casein diet (diet5).

During the period of the experiment the food intake and the rats were weighed twice weekly. The feeding experiment continued for four weeks. After the end of experimental time. Total food intake, body weight gain , food efficiency ratio, protein efficiency ratio and corrected protein efficiency ratio were calculated according to the following equations:

Food efficiency ratio (FER) = body weight gain /total food intake
Protein efficiency ratio (PER) = body weight gain /total protein intake
Corrected protein efficiency ratio (CPER) = PER of test diet × 2.5/ PER for casein

At the end of the experiment, the rats were killed. The body cavities and skull were incised with sharp scissors and the carcass of each group was weighed and then dried to constant weight in a hot air oven at 105 °C for about 3 hours. Water content of the rat carcass was calculated by difference between the carcass weight before and after drying to constant weight. Each dried carcass was then minced and blended in an electric mixer. The nitrogen content of each carcass was estimated according to A.O.A.C. (2000).

Statistical Analysis of Data

The results of animal experiment were expressed as the Mean ±SE. All nutritional parameters were analyzed statistically using student t. test.

RESULTS AND DISCUSSION

1-Chemical Analysis Of Legumes

Chickpea and faba bean are considered as important legumes in the diets of developing countries due to their high contents of protein (Askar, 1986 and Singh *et al.*, 1991), calories, minerals and vitamins (Iqbal *et al.*, 2006). During the present study chickpea and faba bean were germinated then cooked. Also the ungerminated legumes were soaked for 24 hours and cooked. Then both were chemically analyzed to study the changes in their nutrients contents due to difference in treatment.

Proximate composition:

Table 2 showed the proximate analysis of germinated and ungerminated legumes. It can be noticed that germination of faba beans produced increase of the percentage protein, fat and fibers and reduction of ash content. Germinated chickpea showed higher level of protein and ash than ungerminated one. While fat, fibers and carbohydrate contents of germinated chickpea were low compared to the ungerminated. The moisture contents of germinated legumes were higher than the ungerminated. On the other hand it can be seen that germinated faba beans have the highest content of protein and fibers among the studied treated legumes. Fat content was of the highest value in case of ungerminated chickpea. Germinated chickpea showed the highest content of ash. The highest percentage of carbohydrate was present in ungerminated faba beans. Calorific content of the studied legumes ranged from 346.9 to 374.7 calories per 100g legume. The highest calories belonged to ungerminated chickpea while the least was in case of ungerminated faba beans.

The distinguished feature of legume seeds laid in their high protein content and most legumes fell in the range of 20-30% protein (Wolf, 1977). However it has been cited by Genoves and Iajolo (2001) that protein content in legume grain ranged from 17 to 40%, which cover the range of protein content of the present studied legumes. The same author reported that most legumes (other than soya beans) contained low percentages of fat which

ranged from 2 to 5% which was in agreement of faba bean in present data but not chickpea.

It has been reported by Sidky (1986) that cooked ungerminated chickpeas contained 11.25% moisture, 23.6% protein, 5.93% fat, 52.55% carbohydrate and 3.89% ash. This result was more or less similar to obtained result of ungerminated chickpea concerning the different parameters except for ash and fat. Also, chickpea has been shown by Rincon *et al.* (1998) to contain 41.1% - 47.4% carbohydrates and 21.7% - 23.4% protein. It has also been cited that chickpea contained from 20.92 to 26.20% crude protein, 4.10 to 6.18% crude fat, 56.19 to 60.50% total carbohydrates, 2.80 to 2.92% ash and 2.5 to 5.5% crude fiber (Hallab *et al.* 1974, El- Rify *et al.*, 1986, Ulloa *et al.*, 1988, Ahmed *et al.*, 1990 and Mansour, 1996). The difference in the chemical composition of ungerminated legumes among literature and the present study may be due to difference in crop cultivars, soil and climatic conditions. Previously, it has been cited that germination produced important changes in the chemical composition of legumes including carbohydrate, crude fibers, lipids and proteins (Khalil *et al.*, 2001), which coincided with the current study. Storage compounds and synthesis of structural proteins and cell components take place during germination. Secondary, such compounds as fibres and antinutritional factors changes differently during germination, this changes in nutrients and antinutrients during germination differ according to the type of legumes and the sprouting conditions such as time, temperature and light cycle (Sierra and Vidal - Va lverde, 1999).

Table (2): Proximate analysis of germinated and ungerminated legumes (g/100g) and their calorific content (Calories/ 100g).

Parameter	Ungerminated faba bean	Germinated faba bean	Ungerminated Chickpea	Germinated Chickpea
Protein	24.3	34.7	24.6	24.9
Fat	2.1	2.5	7.1	6.5
Ash	5.3	5.02	5.03	6.1
Crude fibers	1.01	1.2	0.8	0.7
Carbohydrate	57.7	46.8	53.1	51.8
Moisture	9.6	9.9	9.4	10.1
Calorific content	346.9	348.5	374.7	365.3

Each parameter has been evaluated thrice and the obtained data are the means of three values.

A study was carried out by El – Adawy (2002) showed that germination of chickpea produced an increase in crude protein and decrease in fat and carbohydrate which agreed with our present data. The increase in protein might be due to using of seed components and degradation of protein to simple peptides during germination process. However the decrease in fat and carbohydrate might be attributed to their use as an energy source in germination. However the study of El – Adawy (2002) showed no changes in ash percentage and an increase in crude fiber after germination which were not the case in our results.

Reduction of carbohydrate contents in germinated legumes, in the present study, may be due to the complete elimination of carbohydrates such

as raffinose, stachyose and verbascose as a result of germination. Germination decreases level of reducing sugars, sucrose and starch which might be due to hydrolysis to produce monosaccharides which are either used as an energy source during germination or dissolved out in water during germination period.

Amino acids' profile of legumes

Table 3 showed the amino acids content of germinated and ungerminated chickpea and faba beans. From the results of amino acids it can be noticed that generally germination of either of legumes produced reduction in aspartic, threonine, leucine, isoleucine, lysine and arginine and increase in valine and tyrosine. Germination of chickpea resulted in reduction of aspartic acid, threonine, glutamic acid, glycine, leucine, isoleucine, histidine, lysine, and arginine while it produced elevation in serine, alanine, valine, methionine, phenylalanine and tyrosine. Germinated faba bean showed reduced levels of aspartic acid, serine, threonine, alanine, methionine, leucine, isoleucine, phenyl alanine, lysine and arginine compared to the ungerminated. However germination of faba bean increased the contents of glutamic acid, proline, glycine, valine, tyrosine, histidine.

It has been reported that biological value of legumes is not very high due to its poor contents of sulphur containing amino acids, (Methionine, cystine and cysteine). On the other hand legumes' protein has been reported to be rich in lysine (Davidson, et al., 1979 and farzana and khalil, 1999), as could be seen from the present results.

Table (3): Amino acids contents of germinated and ungerminated legumes (mg/ g protein).

Amino acid	Germinated faba bean	Ungerminated faba bean	Germinated chickpea	Ungerminated chickpea
I. Non essential amino acids				
Aspartic acid	72.7	80.5	80.1	91.9
Serine	26.6	34.5	36.9	35.8
Glutamic acid	107.0	105.6	102.2	112.7
Proline	24.6	0.1	8.6	
Glycine	25.2	22.6	26.3	30.0
Alanine	28.5	36.4	51.1	42.6
Tyrosine	23.5	22.9	33.7	24.9
Arginine	29.4	38.2	43.5	49.8
Total	337.5	455.8	382.4	387.7
II. Essential amino acids				
Threonine	36.2	40.4	40.3	43.3
Valine	24.2	20.0	17.6	16.4
Methionine	1.1	23.5	2.6	0.5
Leucine	20.3	28.5	25.3	29.8
Isoleucine	40.3	47.5	49.0	55.6
Phenylalanine	2.1	6.8	11.8	4.9
Histidine	27.6	18.0	25.8	33.4
Lysine	24.2	39.2	32.7	41.4
Total	176	223.9	205.1	225.3

It is noted that the content of total essential amino acids were more or less equal in ungerminated faba bean and chickpea as could be seen from table 3. As a matter of fact germination produced reduction in total essential amino acids of the studied legumes. This result may be due to dissolution out of the amino acids in water during germination period, or the use of amino acids during germination process for growth. Germination has been shown previously to reduce lysine (El - Adawy, 2002) which agreed with the present study. The same author showed the increase of leucine while no change in valine was occurred after germination which did not coincide with our study.

In a study conducted by Kuo *et al.* (2004), *who found that* germination of *phaseolus vulgaris* increased alanine, and lysine and decreased glutamic acid, glycine, arginine and tyrosine with disappearance of histidine. Some of these results agreed and others disagreed with the present study according to legumes type. Kuo *et al.* (2004) also reported that in germinating *phaseolus vulgaris*, the proline content increased which coincided with the result of faba beans in the present study that showed very high increase in proline after germination.

Biological Experiment **Nutritive value of legumes**

It would be claimed that the theoretical quality of protein would depend mainly on its essential amino acid pattern. However, it has been stated long ago (Jelliffe, 1979) that the utilization of amino acids by the body was affected also by calorie intake, by the relative quantities of carbohydrates and lipids, by the nature and quantitative distribution of minerals and by the absence or abundance of various vitamins. Therefore, further information such as biological data would be needed to evaluate the protein value of the studied germinated and ungerminated legumes. The obtained results were expressed in various terms including, weight gain, food efficiency ratio, protein efficiency ratio, corrected protein efficiency ratio and nitrogen content of rat carcass.

Table 4 clarified the different nutritional parameters of growing rats fed on balanced casein diet (control group) and rats fed on different legumes diets (test groups). Rats of test groups that fed on germinated faba bean, germinated chickpea and ungerminated chickpea showed significant reduction in final body weight, body weight gain, food efficiency ratio, protein efficiency ratio and corrected protein efficiency ratio compared to control. The least body weight gain, food efficiency ratio and protein efficiency ratio belonged to rats fed on germinated faba bean diet. Rats fed on ungerminated faba beans showed non significant reduction in final body weight, body weight gain, food efficiency ratio and protein efficiency ratio compared to control. This results reflect a reduction in nutritional value of faba beans was happened as affected by germination.

It was expected that protein efficiency ratio of legumes diet would be lower than that of control diet (casein containing diet) which was due to their deficiency of certain essential amino acids as reported by Farzana and Khalil (1999). In the present study it could be noticed that germination of the studied legumes reduced their protein efficiency ratio and Food efficiency

ratio. Consumption of food intake also was reduced significantly in case of germinated faba beans compared to control group. While non significant change was noticed in total food intake consumed by rats fed on ungerminated faba beans compared to control. This result may reflect the presence of functional components that may produce satiety or appetite suppression on germination of faba beans. The same effect was noticed in germinated chickpea but with lower degree. Generally, legumes have been reported to have low nutritive value due to low amounts of sulphur containing amino acids and low protein digestibility (El-Adawy, 2002).

Table (4): Nutritional parameters of growing rats fed on balanced diet (control group) and rats fed on different legumes diets (test groups).

Groups parameters	Control group	Test group			
		Germinated faba bean	Ungerminated faba bean	Germinated chickpea	Ungerminated chickpea
Initial body weight (g)	49.917	50.35	50.067	49.9	49.922
Mean ± SE	±2.086	±1.198	± 0.797	± 1.749	± 1.852
Final body weight (g)	140.833	95.167 ^e	130.767	108.15 ^e	113.283 ^b
Mean ± SE	±2.34	±9.215	± 4.137	± 2.899	± 1.884
Body weight gain (g)	90.917	44.817 ^e	80.7	58.25 ^e	63.362 ^e
Mean ± SE	±2.97	±8.988	± 4.244	± 1.949	± 1.771
Total food intake (g)	285.3	217.85 ^c	275.733	264.767 ^b	275.8
Mean ± SE	±5.171	±18.784	± 15.332	± 5.172	± 13.919
Food Intake g/ day	11.412	8.714 ^c	11.029	10.591 ^b	11.032
Mean ± SE	±0.207	±0.751	± 0.613	± 0.207	± 0.557
Food efficiency ratio	0.319	0.206 ^d	0.295	0.219 ^e	0.233 ^e
Mean ± SE	±0.008	± 0.029	± 0.015	± 0.005	± 0.014
Total protein intake (g)	28.533	21.785	27.573	26.477 ^b	27.58
Mean ± SE	±0.517	± 1.878	± 1.533	± 0.517	± 1.392
Protein efficiency ratio	3.187	1.995 ^d	2.948	2.199 ^e	2.327 ^e
Mean ± SE	±0.089	± 0.292	± 0.146	± 0.056	± 0.136
Corrected protein efficiency ratio	2.5	1.565 ^d	2.312	1.726 ^e	1.826 ^e
Mean ± SE	±0.069	± 0.229	± 0.115	± 0.044	± 0.107

Values significantly differ from the control:

a: p < 0.05 b: p < 0.025 c: p < 0.01 d: p < 0.005 e: p < 0.001

However some authors claimed that germination of legumes may enhance the nutritive value of legumes through enzyme formation that may reduce the antinutritional factors (Greiner *et al.*, 2001), this suggestion opposed the reduction of nutritive value on germination. Although chickpea in present study were undertaken different treatments such as soaking, germination, dehulling and cooking that were reported to reduce antinutrients,

however it still has low nutritive value. Chickpea was reported to contain several antinutritional factors that decrease the protein utilization as proteases and amylase inhibitors, lectins, polyphenols, certain sugars, raffinose, stachyose and phytic acid (Singh *et al.*, 1991). Vioque *et al.* (1999) claimed that the only way to overcome antinutrients is by isolation of chickpea protein. Although germination may reduce antinutrients in legumes as reported previously by (Bau *et al.*, 1997), and increase the percentage protein as seen from the present study however it reduced ash (mineral contents in case of faba beans only) contents and essential amino acids as could be noticed from the current study. This might have a hand in the further reduction of protein efficiency ratio of the germinated legumes in the present study. Cooking treatment after soaking and germination of legumes in the present study have been reported previously to reduce antinutrients (*tannins and saponins*) more than germination (El- Adawy, 2002). So this may clarify some how the higher protein efficiency ratio of ungerminated compared to germinated. It has been also cited that germination and cooking reduced vitamins content in legumes. Cooking reduced riboflavin, thiamin, niacin and pyridoxine, where as germination reduced thiamine and niacin (El – Adawy, 2002) which may share in the reduction of PER of the studied legumes compared to casein. It has been reported that feeding *Vicia faba* diet produced reduction in body weight gain compared to casein diet (Macarulla *et al.*, 2001). This result agreed with the present results concerning germinated *Vicia faba* but disagreed with the results of ungerminated *Vicia faba*.

The nitrogen contents in the carcass of rats fed on the tested legumes diets and the control casein diet could be seen in table, 5. It is noticeable that rat carcass of the groups fed on ungerminated legumes showed significant reduction compared to control rats fed on casein diet. Nitrogen contents in rat carcass of the groups fed on germinated legumes showed non significant change compared to that of control. This clarified better protein utilization on germination of legumes. This result was not in agreement with the PER of the present results that showed that PER was higher in ungerminated than germinated legumes fed groups.

Table 5: Nitrogen content in rat carcass of the different experimental groups.

Groups	Germinated faba bean	Ungerminated faba bean	Germinated chickpea	Ungerminated chickpea	Control
Mean	9.716	7.287 ^e	8.571	8.676 ^b	9.538
SE	± 0.826	± 0.153	± 0.451	± 0.097	± 0.169

Values significantly differ from control:

a:p<0.05 b:p<0.025 c:p<0.01 d:p<0.005 e:p<0.001

Conclusion:

Finally, it could be concluded that the germination of legumes produced increase in %protein and decrease in % carbohydrate. Essential amino acids were reduced on germination of legumes. Protein efficiency ratio of germinated faba bean, germinated chickpea and ungerminated chickpea diets were significantly lower than that of casein diet Rat carcass nitrogen of

ungerminated but not germinated legumes was significantly lower than that of casein diet.

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المحتوى الغذائي والقيمة الغذائية لبعض البقوليات المنبته والغير منبته
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يهدف هذا البحث الى دراسة التغييرات التي يمكن أن تحدث في التركيب الكيماوى والأحماض الأمينية والقيمة الغذائية للحمص والفاول المنبت والغير منبت والمطهى . والتقييم الحيوى للقيمة الغذائية يتضمن تقدير وزن الجسم المكتسب ، المأخوذ الغذائى الكلى ، نسبة كفاءة الغذاء ، نسبة كفاءة البروتين ، نسبة كفاءة البروتين المعدلة فى الفئران . بالإضافة الى تقدير محتوى النيتروجين فى: *rats carcass* . ولقد أظهرت نتائج التحليل الكيماوى للبقوليات موضع الدراسة أن نسبة البروتين والدهون والألياف والرطوبة والسرعات الحرارية ارتفعت فى الفول المنبت بينما إنخفضت نسبة الرماد والكربوهيدرات . أما فى حالة الحمص المنبت فقد أظهرت النتائج ارتفاع نسبة البروتين والرماد والرطوبة بينما انخفضت نسبة الدهون والألياف الخام والكربوهيدرات والسرعات الحراية بالمقارنة بالحمص الغير المنبت . وتسبب إنبات البقوليات موضع الدراسة فى تقليل نسبة الأحماض الأمينية الأساسية وإنبات أى من البقوليات ينتج عنه إنخفاض فى تركيز حمض الأسبارتاك والثريونين والليوسين والأيزوليوسين والأرجنين وزيادة فى تركيز الفالين والثيروزين . أظهرت نتائج تقدير القيمة الغذائية أن المجموعات المختبرة التى تغذت على الفول المنبت والحمص المنبت والحمص الغير المنبت إنخفاض معنوى فى وزن الجسم النهائى، وزن الجسم المكتسب، نسبة كفاءة الطعام، نسبة كفاءة البروتين، نسبة كفاءة البروتين المعدلة مقارنة بالمجموعة الضابطة السالبة التى تم تغذيتها على الوجبة القياسية (الكازين) ولقد أوضحت نتائج الدراسة أن المجموعة التى تغذت على الفول الغير منبت لم تظهر تغير معنوى فى وزن الجسم النهائى، وزن الجسم المكتسب، نسبة فاعلية الغذاء، نسبة فاعلية البروتين ونسبة فاعلية البروتين المعدلة بالمقارنة بالمجموعة الضابطة . أظهرت النتائج أن محتوى النيتروجين فى *rats carcass* إنخفض إنخفاضاً معنوياً فى المجموعة التى تغذت على البقوليات الغير منبته بالمقارنة بالمجموعة الضابطة السالبة التى تغذت على الكازين أما بالنسبة للبقوليات المنبته فإن محتوى النيتروجين فى الفئران لم يظهر تغيير معنوى بالمقارنة بالمجموعة الضابطة .

نستخلص ان إنبات البقوليات يتسبب فى زيادة نسبة البروتين ونقص نسبة الكربوهيدرات . تقل الأحماض الأمينية الأساسية الكلية فى حالة إنبات البقوليات . إنخفض نسبة كفاءة الغذاء للفول المنبت والحمص المنبت والغير المنبت انخفاضا معنوياً عن المجموعة التى تغذت على الوجبة القياسية (الكازين). نسبة النيتروجين فى تجربة *rats carcass* التى تغذت على البقوليات الغير منبته كانت أقل من المجموعة التى تغذت على (الكازين).

قام بتحكيم البحث

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