



The effect of acetic acid on the elimination of favism-inducing agents, vicine and convicine from dry faba bean seeds

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Abstract

The present study was used acetic acid with different concentrations (0.5, 1.0, 1.5, 2.0 and 2.5%) at various temperature degrees (5, 25, 35 and 45° C) and for many periods of time (6, 12, 18, 24, 30, 36, 42 and 48h) to eliminate vicine and convicine from dry broad beans. By using acetic acid 0.5, 1.0, 1.5, 2.0 and 2.5% at 5° C, the elimination percentages of vicine during the first 6 h of soaking were, 31.03, 51.96, 48.76, 28.22 and 26.69% while the total eliminated of vicine after 48 h soaking, 57.62, 68.89, 65.11, 54.50 and 53.08% respectively. The vicine elimination at 45° C were 66.86, 51.78, 37.65, 33.83 and 63.60% While the total vicine elimination were (80.92, 93.66, 92.89, 71.00 and 68.57% after 48 h of soaking solution). The convicine elimination percentages were 100% after 36 and 48 h at 5° C by using 1.0 and 1.5% acetic acid solution respectively. The convicine elimination was more effective at high temperatures; it was 100% after 30, 24, 24 and 48h at 35° C by using 1.0, 1.5, 2.0 and 2.5% acetic acid, while it was 100% after 24, 30, 42, 42 and 42 h at 45° C respectively. The elimination processes of vicine and convicine were associated with reduction in proteins and carbohydrates contents.

Key words: Dry faba beans, acetic acid, elimination, vicine and onvicine.

تأثير استخدام حامض الخليك في إزالة مسببات مرض تكسر كريات الدم الحمراء، الفاييسين والكونفايسين من بذور الباقلاء الجافة.

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الخلاصة

تم استخدام حامض الخليك بتركيزات (0.5, 1.0, 1.5, 2.0, 2.5 %)، عند درجات حرارة (5, 25, 35, 45 °م) وفترات زمنية (12, 18, 24, 30, 36, 42, 48 ساعة) وذلك لإزالة الفاييسين والكونفايسين من بذور الباقلاء الجافة. لقد وجد عند استخدام 0.5, 1.0, 1.5, 2.0 و 2.5% حامض خليك في درجة حرارة 5° م ان نسب إزالة الفاييسين خلال الست ساعات الاولى من التنقيع كانت 31.03, 51.96, 48.76, 28.22 و 26.69% من حاصل الازالة الكلية (بعد مرور 48 ساعة وصلت الى 57.62, 68.89, 65.11, 54.50 و 53.08% على التوالي) عند استخدام تراكيز من حامض. أرتفعت هذه النسب عند درجة حرارة 45 °م تحت الظروف نفسها الى 51.78, 37.65, 33.83 و 63.60% من الحاصل الكلي لإزالة الفاييسين والذي كان 80.92, 93.66, 92.89, 71.00 و 68.57% بعد مرور 48 ساعة من التنقيع. لقد كانت نسبة إزالة الكونفايسين كانت 100 % بعد مرور 36 و 48 ساعة في درجة حرارة 5 °م باستخدام تركيزي 1.0 و 1.5% حامض خليك على التوالي. كانت إزالة مربب الكونفايسين أكثر كفاءة عند استخدام درجات حرارة عالية، أذ كانت 100% بعد تنقيع الباقلاء الجافة مدة 30, 24, 24 و 48 ساعة في درجة حرارة 35 °م عند استخدام تراكيز من حامض الخليك مقدارها 1.0, 1.5, 2.0 و 2.5% على التوالي، وبماتت الازالة 100% بعد 24, 30, 42 و 42 ساعة في درجة حرارة 45 °م على التوالي. لقد رافق عمليات إزالة الفاييسين والكونفايسين من بذور الباقلاء الجافة انخفاض في محتوى البروتينات والكاربوهيدرات.

الكلمات المفتاحية: الباقلاء الجافة، حامض الخليك، الازالة، الفاييسين والكونفايسين.



Introduction

Faba bean (*Vicia faba*) is one of the oldest crops and ranks sixth in production among the legumes grown in the world. It contains large amounts of protein (20-41%), carbohydrates (51-68%, including 41-53% starch), B vitamins group and minerals (6). Broad beans are widely grown and consumed in Egypt, Mediterranean region, China, North Africa countries, parts of Europe and in addition to our country and neighboring countries. Several anti-nutritional compounds have been identified which compromise the value of faba beans as a source of protein in human foods and animal diets, among these are the glycoside pyrimidines, vicine and convicine (in dry beans) in addition to L-dihydroxy phenylalanine (L-dopa) in fresh green pods. Vicine and convicine are hydrolyzed by intestinal microflora by the action of α -glucosidase to highly reactive free radicals divicine and isouramil (Favism-induced factors) Favim is an acute hemolytic anemia known to occur in susceptible individuals who ingest faba beans(12).

Susceptibility to favism is conferred by a genetic deficiency in erythrocytes glucose-6-phosphate dehydrogenase (G6PD) activity. Divicine and isouramil (L-dopa plays a synergistic role) have been implicated in the onset of favism in humans (5). These compounds cause oxidation of glutathione in the erythrocyte which upsets the intracellular redox balance leading to membrane oxidation and hemolysis. These are of the major anti-nutritional agents in which broad beans are not consumed increasingly as a source of proteins (at the first standing) and carbohydrates. To overcome the problems caused by anti-nutritional factors, a variety of techniques such as soaking, boiling, autoclaving, microwaving, roasting, dehulling, germination, fermentation and supplementation with enzymes have been examined. The present study is a modest contribution to eliminating the most dangerous anti- nutritional factors, which is known overall the world as favism-induced agents, vicine and convicine from broad beans to reduce to some extent their danger to those whose hereditary severe glucose- 6- phosphate dehydrogenase deficiency Therefore, the present

work is studying the effect of acetic acid as soaking solution on the elimination of pyrimidine glycoside, vicine and convicine from dry faba bean seeds.

Materials and methods

Syrian dried beans were brought of soaked in acetic acid solution with concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5% and incubated at 5, 25, 35 and 45 for 48 hours. Samples were withdrawn every 6 hours (6, 12, 18, 24, 30, 42 and 48h) then dried at 40 in air oven. The dried beans were grinded by an electrical grinder and packed in tight plastic packages until usage. The pH value was measured at zero time and at each interval time by using pH-meter (15).

Approximate chemical composition of dried faba beans, protein, moisture and ash contents were determined as described by (1). Total carbohydrates were determined by Lane-Enon method (8). The High Performance Liquid Chromatography (HPLC) was use to determine the vicine and convicine contents of treated and untreated faba bean seeds according to the conditions below:

Column: ODS-II, particle size 3 μ m (50 \times 4.6 mm I.D), Mobile phase of deionized water: methanol (80:20 v/v), the UV detector was set at 280 nm, the flow rate 1.5 ml/min, temperature 40°C, injection volume 20 μ l . The concentrations of vicine and convicine were determined according to standard peaks of pure compounds. The data were statistically analysis according to (17).

Results and discussion

The increasing need for protein in the world has stimulated scientists and agronomists to search for new sources of protein. Faba beans have attracted attention as protein source. The present study is a step to encourage consumers, even those with a genetic deficiency in glucose- 6- phosphate dehydrogenase, to ingest faba beans as a source of protein. (Table, 1) shows the main constituents of dry broad beans. The digestible carbohydrates (the starch and soluble sugars) was more

affected during the elimination of favism-induced factors than the fibers fraction.

Table (1): The main constituents and the favism-induced factors of dry faba beans (on dry basis).

Components	% On dry basis
Protein	30.86
Ash	03.06
Moisture	07.98
*Fibers	10.73
Carbohydrates	47.91
Vicine	18.22 mg/g
Convicine	04.08 mg/g

*Determine by subtract

The elimination of vicine:

(Fig. 1) shows the effect of soaking temperature 5°C on vicine elimination by using different concentrations of acetic acid (0.5, 1.0, 1.5, 2.0 and 2.5%). There was a direct proportional relationship between the percentages of vicine elimination and the time of soaking (9). The first period (the first 6 hr.) was eliminated 31.03, 51.96, 48.76, 28.22 and 26.69% of the maximum elimination of vicine. These percentages, after 24 hr., which represent half of the experiment's time, were 72.54, 79.11, 65.27, 67.88 and 60.28% of the maximum elimination by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid solution concentrations respectively. Therefore, only 15.82, 14.39, 22.61, 17.5 and 21.08% of the total elimination was obtained during the rest of soaking time (the last 24 hr.). At the end of the soaking process, we have get rid of 10.49, 12.55, 11.86, 9.92 and 9.67 mg/g of the initial quantity of vicine (18.22 mg/g- as dry basis) in the dry faba beans. It was found, that the concentration of 1.0 and 1.5% acetic acid respectively (in the present study) are more effective as compared with 0.5, 2.0 and 2.5% to eliminate vicine glycoside at 5° C.

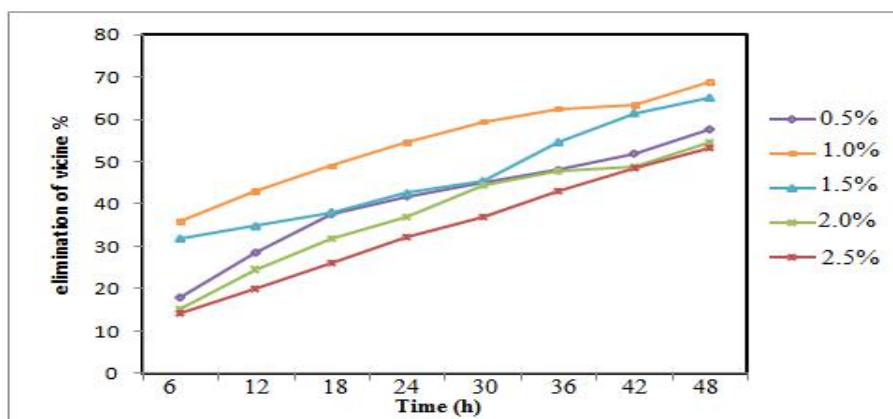


Fig (1): The effect of 5° C soaking temperature on the elimination of dry faba beans vicine, by using different acetic acid concentrations and time periods.

(Fig. 2) shows the effect of 25° C soaking temperature on the elimination of dry faba beans vicine by using different levels of acetic acid concentration. In general, an increasing in vicine elimination (as compared with 5° C) has been observed when the soaking temperature was elevated to 25° C. As in the previous temperature degree, the main quantity of vicine was eliminated after 24 hr. of soaking time; they were 55.41, 66.27, 67.91, 58.62 and 80.01% of the maximum eliminated quantities. At the end of the 48 hr. soaking time, the higher elimination (80.73%) of vicine was taking place at 1.0% of acetic acid concentration, followed by 1.5, 0.5, 2.5 and 2.0% respectively. As shown in Figs 1 and 2, 1.0% acetic acid solution giving high vicine elimination percentages after 48 h at both 5 and 25° C as compared with the other acetic acid concentrations, although the elimination percentage at 25° C is higher by 14.66% . Extraction of vicine and convicine increased with increasing temperature and period of soaking (10) .

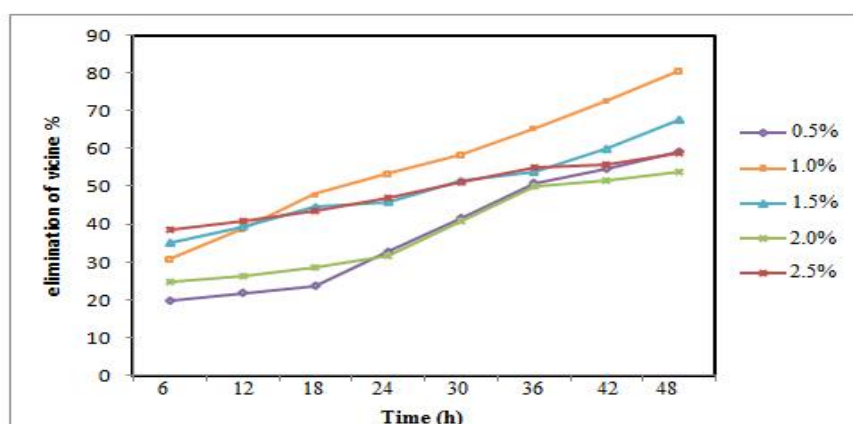


Fig (2): The effect of 25° C soaking temperature on the elimination of dry faba beans vicine, by using different acetic acid concentrations and time periods.

The effect of soaking temperature 35° C on elimination averages of the pyrimidine glycoside vicine was studied by using different acetic acid solution concentrations as eliminated reagents (Fig, 3). It is well known, that temperature increasing leads to more acid dissociation, in turn, high reactivity will be associated with more vicine elimination. Furthermore, high temperature degree facilitates the occurrence of diffusion phenomenon between the faba beans and acetic acid solution which in turn encourages the elimination of more vicine (10). Generally, the elevation in temperature degree is associated with high percentages of vicine elimination. After 24 hr. of soaking in acetic acid solutions at 35° C, 82.62, 67.54, 77.49, 82.76 and 74.37% of the total eliminated vicine were achieved by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid respectively. The higher elimination (82.39%) at 35° C was obtained by using 1.0% acetic acid followed by 1.5, 2.0, 2.5 and 0.5% acetic acid respectively. Although, the concentration of 1.0% acetic acid was slightly giving more vicine elimination, the concentration of 1.5% gave high percentages for the vicine elimination along the experiment time.

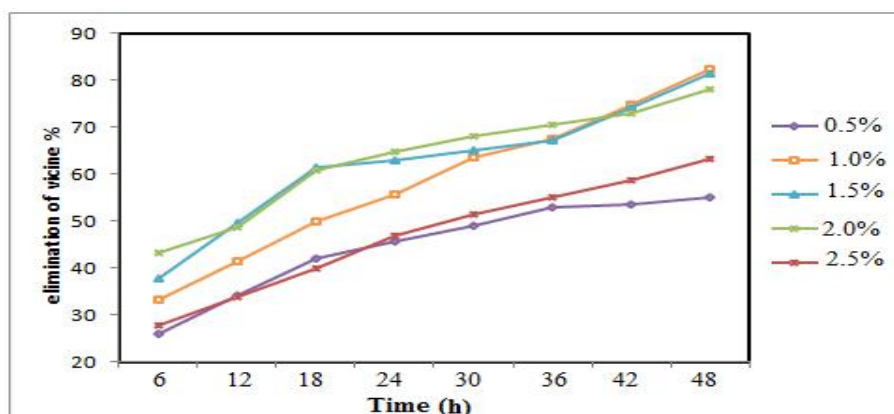


Fig (3): The effect of 35° C soaking temperature on the elimination of dry faba beans vicine, by using different acetic acid concentrations and time periods.

(Fig, 4) shows the effect of applied 45° C for the soaking solution on the elimination the vicine glycoside from faba beans by using different acetic acid concentrations for 48 hr. with interval time of 6 hr. A direct proportional relationship was found between vicine elimination percentages and the time period. A reversal relationship was associated with the elimination of vicine and the concentration of acetic acid solutions (from 1.0% up to 2.5%). 0.5% acetic acid giving higher vicine elimination comparing with 2.0 and 2.5% respectively. At the first stage of elimination (within the first 6 hr.), the vicine elimination percentages represented 66.85, 51.78, 37.64, 33.83 and 63.59% of the total elimination. After 24 hr, these percentages give rise to 77.31, 65.12, 51.13, 67.81 and 77.08% of the maximum elimination (after 48 hr.). In general, the maximum eliminations of vicine by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid at 45° C, are more as compared with these at 35° C (with exception by using 2.0% acetic acid, may be due to instrumental failure). If we arrange the acetic acid concentrations according to their efficiencies, the arrangement will be as follows 1.0 1.5 0.5 2.0 2.5%. As shown in the present Fig and the previous Figs, no acetic acid concentration can be considered as the effective one in the elimination of vicine, it seems, that every it was concentration has different effects depending upon at what temperature degree was it.

Acetic acid appears to enhance the permeability of vicine and convicine through the faba bean hulls (2).

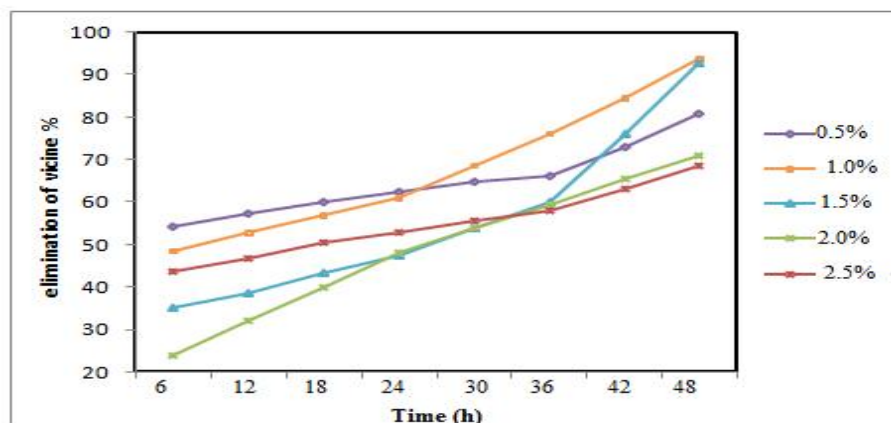


Fig (4): The effect of 45° C soaking temperature on the elimination of dry faba beans vicine, by using different acetic acid concentrations and time periods.

The elimination of convicine:

(Fig, 5) shows the effect of acetic acid solution concentrations on convicine elimination after the faba beans are soaked in these solutions at 5° C. With all the acetic acid concentrations the elimination of convicine is higher than that of vicine at the same conditions. The decrease in convicine content was twice the decrease in vicine content (4). In general, the elimination of convicine is directly proportional with temperature of soaking. A randomized relationship is found between the elimination of convicine and the acetic acid concentration, the similar relation has been observed with vicine elimination. At the first stage of treatment (within the first 6 hr) the acetic acid was eliminate only 22.22, 47.25, 40.61, 20.74 and 19.70% of the total eliminated convicine by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentrations respectively. These results were elevated to 64.59, 83.16, 59.64, 60.95 and 52.14% after 24 hr at the same conditions. It was found that, the elimination of convicine is 100% after 36 hr by using 1.0% acetic acid, while it is so after 48 hr by using 1.5% acetic

acid concentration, the other concentrations are giving less (between 81 to 89% elimination).

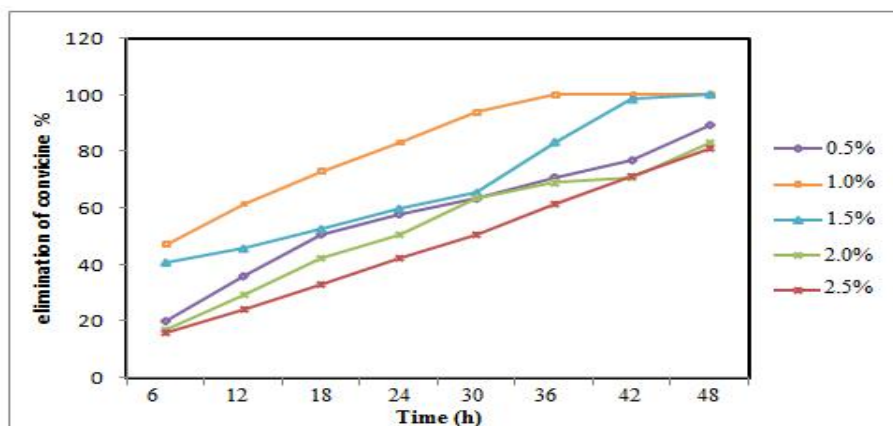


Fig (5): The effect of 5° C soaking temperature on the elimination of dry faba beans convicine by using different acetic acid concentrations and time periods

Generally, the elimination of convicine at 25° C is more comparing with that at 5° C (with some exceptions) The convicine content was affected by the thermal treatments (4). Fig 6 shows the effect of 25° C acetic acid- soaking solution on the elimination of convicine by using different concentrations of acetic acid. Also, 1.0% acetic acid gave 100% elimination for the convicine beginning from 36 hr of soaking, while the same elimination percentage was achieved after 48 hr by using 1.5% acetic acid solution. After 24 h 45.02, 81.00, 67.20, 50.13 and 75.40% of the total eliminated convicine were obtained by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid respectively. The priority of acetic acid concentrations for convicine elimination processes at 25° C as follows 1.0 1.5 0.5 2.5 2.0%.

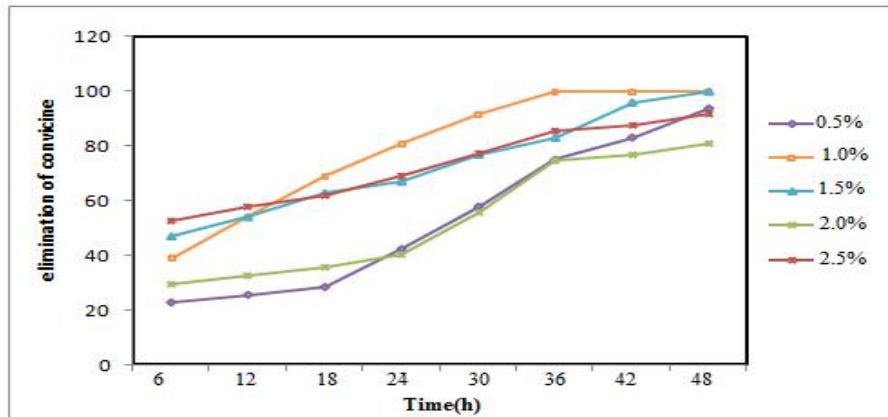


Fig (6): The effect of 25° C soaking temperature on the elimination of dry faba beans convicine by using different acetic acid concentrations and time periods.

At 35° C (Fig7), the effect of soaking temperature on the elimination of convicine is clear, especially at the end of process (after 48 hr.). A 100% elimination of convicine was occurred after 24 hr by using 1.5 and 2.0% acetic acid concentrations, while at 1.0 and 2.5% acetic acid; the total elimination was obtained after 30 and 48 hr respectively. The initial stage of soaking (the first 6 hr.) was eliminating 36.65, 43.89, 50.69, 61.49 and 34.29% of the total eliminated convicine. After 24 hr. of soaking at 35° C, and by using acetic acid as eliminated factor, 76.53, 86.61, 100.00, 100.00 and 69.10% of the overall convicine were removed by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentrations respectively. The rate and completeness of extraction depends the pH, temperature and volume of the aqueous extracting solution (9).

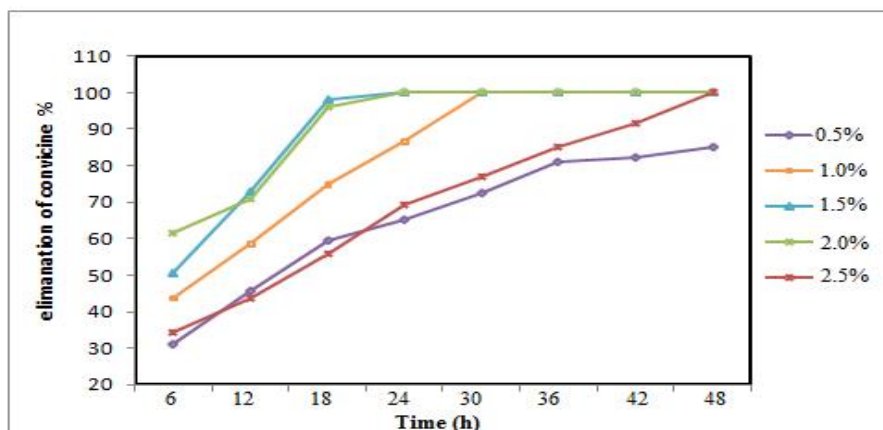


Fig (7): The effect of 35° C soaking temperature on the elimination of dry faba beans convicine by using different acetic acid concentrations and time periods.

(Fig, 8) shows the effect of using 45° C as soaking solution by using acetic acid as eliminated agent. After 48 hr the convicine elimination was 100% with all acetic acid concentrations. This result reflects the action of using high temperature (45° C) on the elimination process. In general, there was a direct proportional relationship between the convicine elimination and the applied temperature. Similar relationship was found with the soaking time. By using 0.5, .1.0, 1.5, 2.0 and 2.5% acetic acid the elimination percentages were 100.00, 98.21, 70.06, 71.33 and 80.80% of the total elimination after 24 hr. To evaluate the use of acetic acid as eliminating agent for the anti-nutritional factors in faba beans, vicine and convicine, it was found, that at 5°C the acetic concentration of 1.0% is more effective than the others concentrations to eliminate vicine, while the concentration of 1.5% is effective is effective to eliminate convicine. At 25° C, also 1.0% acetic acid is more effective to eliminate vicine in addition to its ability to eliminate convicine. By subjected the soaking process in acetic acid to 35° C, the concentration of 1.0% is effective to remove vicine, while the acetic acid of 2.0% is effective to eliminate convicine. At 45° C and by using different concentrations of acetic acid, it was found that the acetic of 1.0%, is more effective to eliminate vicine, but

the acetic acid concentration of 0.5% is more effective to eliminate convicine followed by 1.0% acetic acid concentration. Vicine and convicine are thermostable products and removal or destruction of these causative agents by processing is difficult at low temperature degree comparing with higher temperature (13).

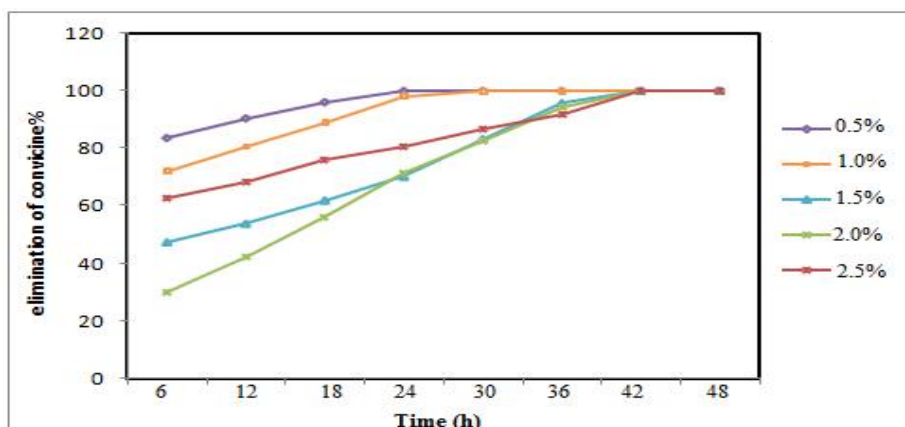


Fig (8): The effect of 45° C soaking temperature on the elimination of dry faba beans convicine by using different acetic acid concentrations and time periods.

The remaining of proteins:

At low temperatures, as the averages of vicine and convicine elimination are not remarkable as compared with the using of high temperature degrees, the protein elimination is going similar. Fig 9 shows the faba beans remaining protein after treated with acetic acid (as vicine and convicine eliminating agent) with different concentrations and various time periods. There was a direct proportional relationship between the protein reducing and the acetic acid concentrations and time proceeding. After 24 h of soaking in acetic acid, the reducing percentages of proteins at 5° C were 4.24, 4.80, 5.22, 6.06 and 6.55% of initial quantity (30.86) by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid respectively. At the end of soaking process these percentages were increased to 8.42, 9.01, 10.69, 11.50 and 11.18% respectively. Extraction of faba bean with acetic acid dose not markedly affects the concentration of protein content (9).

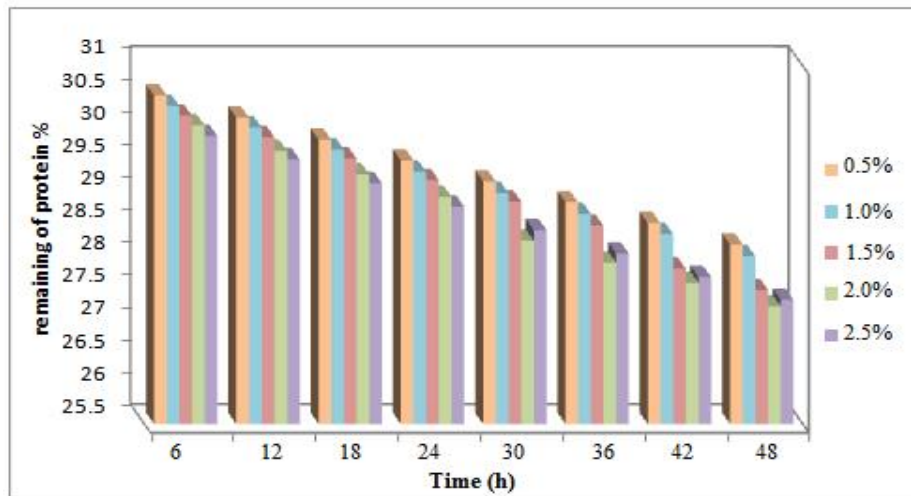


Fig (9): The effect of 5° C soaking temperature on the remaining of dry faba beans proteins by using different acetic acid concentrations and time periods.

(Fig, 10) shows the effect of 25° C on the elimination of faba beans proteins by using different concentrations of acetic acid solutions. It was found that reducing percentages of proteins during the first 6 hr of treatment were 1.52, 3.01, 3.53, 2.01 and 2.50% by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentrations. These percentages were 9.11, 11.50, 10.56, 9.59 and 10.01% of the initial quantity (30.86%) after 48 h. The elimination percentages of proteins at 25° C are more than those at 5° C. If we arrange the acetic acid concentrations according to their abilities to reduce the proteins content of faba beans, it is going to be as fellow 1.5 1.0 2.5 2.0 0.5 %. As shown, it seems that no scientific logic is in harmony with these results. (14) soaking and cooking processes of mung bean seeds were slightly decreased in lysine.

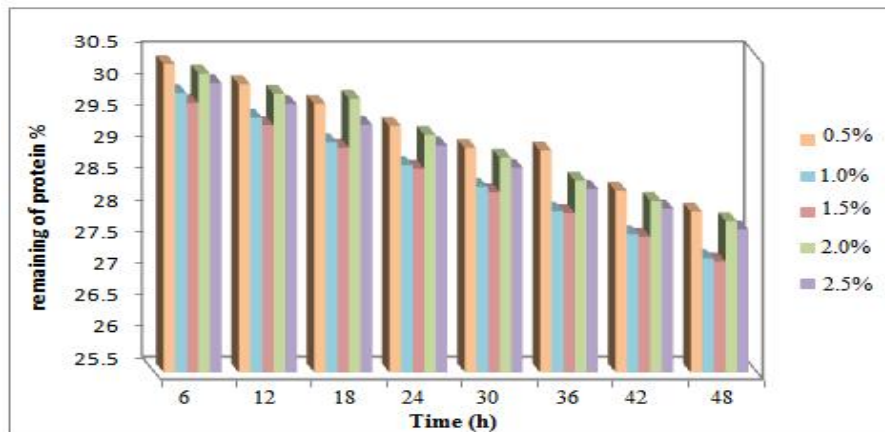


Fig (10): The effect of 25° C soaking temperature on the remaining of dry faba beans proteins by using different acetic acid concentrations and time periods.

(Fig. 11) represents the effect of using 35° C as a temperature of acetic acid solutions on reducing faba bean proteins by using different concentrations and time periods. In general, the protein reducing averages were rise by using 35° C as compared with the previous two temperature degrees (5 and 25° C). After 24 h of soaking in different concentrations of acetic acid the percentages of reduced proteins were 5.51, 6.03, 6.51, 7.03 and 7.52% of the proteins content by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentrations respectively. There was a direct proportional relationship between the proteins loosening and the concentrations of acetic acid solutions (11). Similar relationship was observed with the time proceeding. At the end of soaking processes we have lost 9.53, 10.01, 10.53, 11.02 and 11.50% of the initial quantity of proteins content in the untreated faba beans.

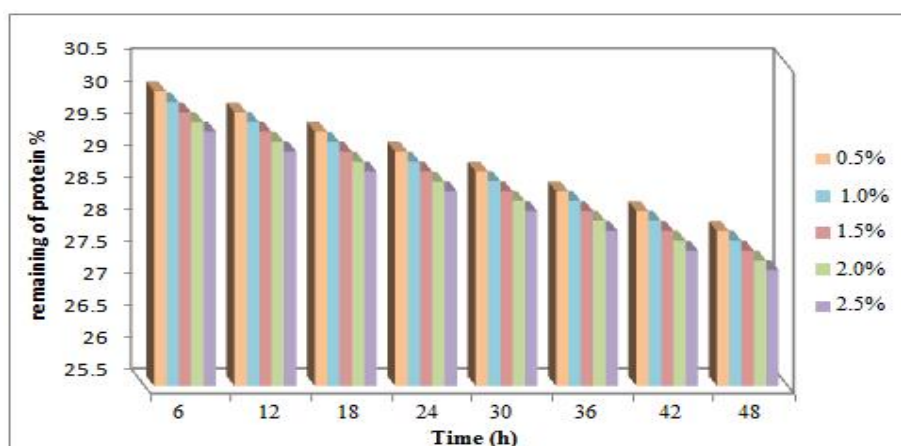


Fig (11): The effect of 35° C soaking temperature on the remaining of dry faba beans proteins by using different acetic acid concentrations and time periods.

45° C is a high temperature as compared with the previous temperature degrees. Heat treatment can improve the nutritional quality of faba beans by improving or destroying other thermo labile anti-nutritive factors (such as vicine and convicine) (7). The present study shows that using high temperature degree for the soaking solutions giving more elimination for vicine and convicine, but on the other side, it was encourage losing more proteins. Fig 12 shows the effect of using 45° C as temperature of acetic acid- soaking solutions on reducing faba beans proteins by using different concentrations of acetic acid. The percentages of total eliminated proteins at the end of this experiment were 11.02, 11.50, 12.02, 12.51 and 12.99% of the initial quantity by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentrations respectively. The direct relationship between acetic acid concentrations and time proceeding with the percentages of proteins reducing are also found at this temperature degree. After 24 h of soaking at 45° C 7.03, 7.52, 7.97, 8.49 and 8.94% of the initial percentage of proteins was removed. Legumes (such as faba beans) have been important source of protein, their seeds play an important role in the traditional diet of many peoples of the world and are a valuable basic material for the food and animal feed industries. The protein is rich in lysine, and is therefore complementary to cereals in lysine balance. The main protein

fractions are albumins and globulins; these fractions are different in their amino acid composition, molecular weight and physico-chemical properties. Legume seeds can be used not only as meat replacers but also as components of rational nourishment and food for vegetarians.

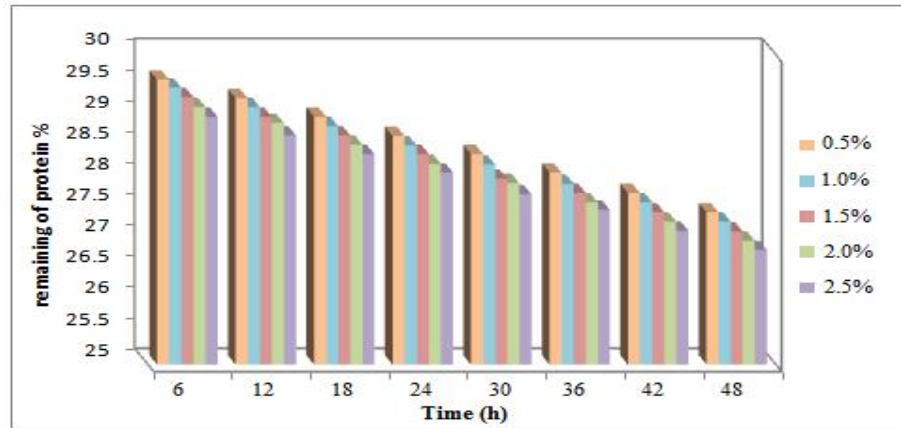


Fig (12): The effect of 45° C soaking temperature on the remaining of dry faba beans proteins by using different acetic acid concentrations and time periods.

The remaining of carbohydrates:

5° C is a low temperature, so it is not expected to make more changes in the main constituents of faba beans (such as proteins and carbohydrates), even used with acetic acid as eliminating agent for anti-nutritional factors, such as vicine and convicine. Fig 13 shows the effect of acetic acid concentrations on total carbohydrates content of faba beans after soaking for 48 h at 5° C. At the end of this experiment (after 48 h) the percentages of eliminated carbohydrates of the initial (58.64% as dry basis) were 3.61, 7.21, 10.01, 12.79 and 15.60% by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid solutions.

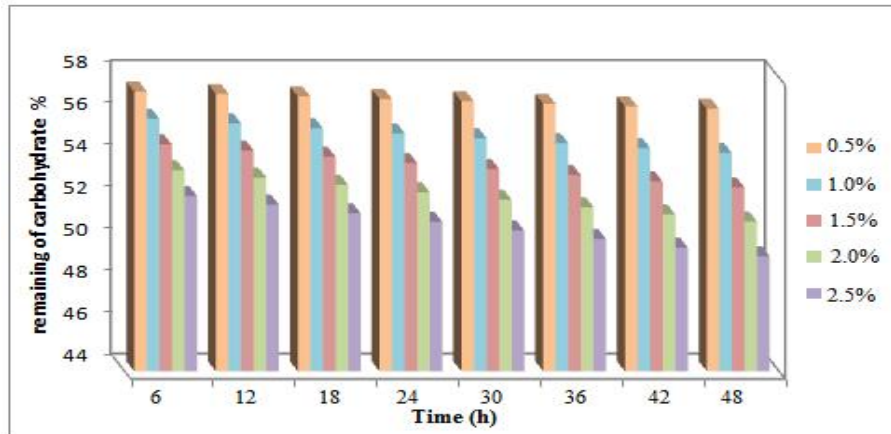


Fig (13): The effect of 5° C soaking temperature on the remaining of dry faba beans carbohydrates by using different acetic acid concentrations and time periods.

(Fig, 14) shows the effect of acetic acid as soaking solution at 25° C on total faba beans content of carbohydrates throughout time proceeding. In general, more carbohydrates are removed at this temperature degree comparing with 5° C. After 48 h, and by using 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid concentration, 17.29, 18.99, 20.70, 22.41 and 24.10% of the initial quantity of carbohydrates in faba beans were removed. Most of the eliminated carbohydrates are starch and simple sugars rather than fibers (16).

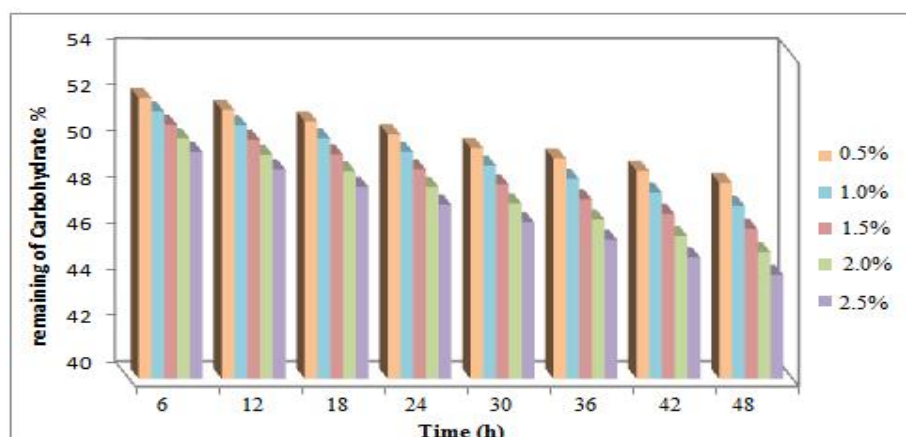


Fig (14): The effect of 25° C soaking temperature on the remaining of dry faba beans carbohydrates by using different acetic acid concentrations and time periods.

(Fig, 15) illustrates the effect of soaking at 35° C on the total carbohydrates by using different acetic acid concentrations for 48 h by 6 h interval time. The averages of carbohydrates reducing are increased at 35° C comparing with 5 and 25° C. Heat treatment produces a reduction in total carbohydrate (16). At the first stage of soaking (the first 6 h), 12.33, 13.44, 14.56, 15.69 and 16.81% of the initial quantity of proteins have been removed from faba beans when 0.5, 1.0, 1.5, 2.0 and 2.5% acetic acid were used respectively. The percentages were increased to 19.37, 21.28, 23.17, 25.08 and 25.99% after 48 h respectively.

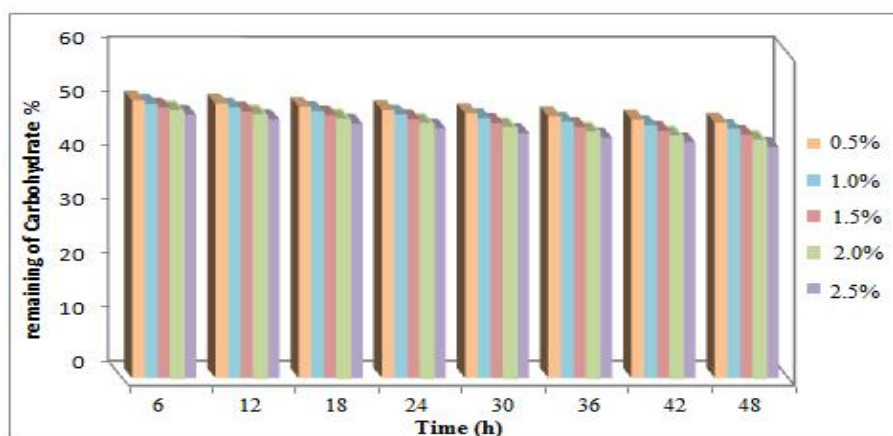


Fig (15): The effect of 35° C soaking temperature on the remaining of dry faba beans carbohydrates by using different acetic acid concentrations and time periods.

At relatively high temperature degree we must expect that the elimination of carbohydrates occurred with highly reducing percentages. Fig 16 shows the percentages of remaining carbohydrates at 45° C by using different acetic acid concentrations. After 24 h of soaking at 45° C by using acetic acid solutions with concentrations of 0.5, 1.0, 1.5, 2.0 and 2.5%, the total carbohydrates was respectively reduced by 15.76, 17.26, 18.74, 20.24 and 21.74% of the initial quantity of carbohydrates (58.64%). At the end of this experiment (after 48 h) the previous percentages rose to 19.90, 21.84, 23.81, 25.77 and 27.73% at the same conditions. Thus, by using acetic acid as eliminating agent for vicine and convicine, more than quarter (27.73%) of the total carbohydrates was removed after 48 h at 45° C and acetic acid concentration of 2.5%. (3) The effects of preconditioning on the nutritional values of the legumes showed that preconditioning temperatures may be valuable tools for partially eliminating antinutritional factors.

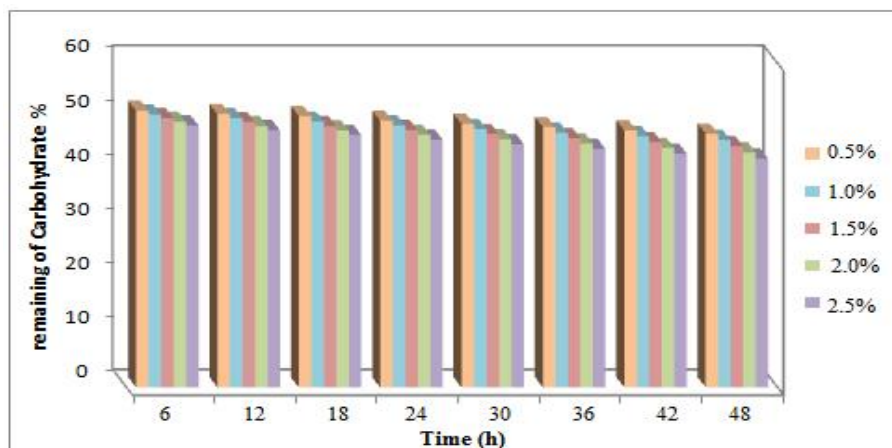


Fig (16): The effect of 45° C soaking temperature on the remaining of dry faba beans carbohydrates by using different acetic acid concentrations and time periods.

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