FUNCTIONAL PROPERTIES OF SOYBEAN MEAL AS AFFECTED BY ETHEPHON APPLICATION AND RIPENING PERIOD

BY

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ABSTRACT

Soybean plants were sprayed with 0, 1000 and 1500 ppm ethephon to promote the plants towards maturity. The seeds were obtained at ripening periods of 100, 110 and 120 days. The effect of ethephon application and ripening period on functional properties of seed proteins, i.e., protein fractions, protein solubility index (PSI), emulsion capacity (EC), emulsion stability (ES), foam capacity (FC), foam stability (FS), oil absorption (OA) and water absorption (WA) were evaluated.

Increasing ethephon concentration up to 1500 ppm led to increase the globulins and ES. Whereas, 1000 ppm ethephon inhanced PSI at alkali pH values. PSI was in positive relationship with FC, EC and ES. These results were at the maximal values by employing 1000 ppm ethephon.

Albumins and globulins were significantly increased at ripening period of 110 days. A negative relationship was found between ripening period and each of PSI, FC, FS, EC , OA and crude protein content.

The data of the interactions indicate clearly that the application of 1000 ppm ethephon and 100 days ripening period was the best treatment and positively effected all studied function properties.

INTRODUCTION

Soybean (Glycine max L.) is one of the msot cash crop specially in Egypt. Soybean has occupied an extremely wide area that utilized in animal feeding, human food and fat to our food economy than any other single source. Soybean products have a commanding lead as vegetable protein supplements, their use in both traditional and processed foods in gaining increasing acceptance.

Functional properties, define how these proteins can be added to existing foods and how they can replace more expensive protiens traditionally used. To obtain optimum functionality gelation, solubility, emulsifying activity and foaming are required a highly soluble proteins (Lin and Zayas, 1987).

Ethephon is 2-chloroethane phosphonic acid which spontaneously breaks down releasing ethylene at pH 3.5 and above. The respiration rate, maturity of dicotyledonous plants and degradative enzymes such as protease, α -amylase and invertase are reported to increase in ethylene-treated tissues (Krishnamoorthy, 1981).

The target of the present investigation was to evaluate the effect of ethephone application and ripening period on functional properties of soybean seeds.

MATERIALS AND METHODS

Materials:

Sobyean seeds variety "Calland" were grown in the Agricultural Experimental Farm, Fac. Agric., Ain Shams Univ., Shoubra El-Kheima, Kaluobia Governorate in 1988 growing season. The plants were sprayed with ethephon at a concentrations of 0, 1000 or 1500 ppm at flowering stage. The seeds were obtained at ripening periods of 100, 110 days and at full maturity, i.e., 120 days after sowing.

The obtained seeds were air dried till constant moisture content of about 8%. The seeds were crushed followed by fine grinding, defatted and the meal was desolventized under vacuum. The defatted meals were subjected to chemical analysis and functional properties.

Methods:

Chemical composition including total nitrogen and protein fractions such as albumins, globulins, prolamins glutelins and non soluble protein were estimated according

to Pleshkov (1976). Protein fractions were calculated as percentage of true protein.

Protein solubility index (PSI) was determined according to AOAC (1975), on 1% aqueous suspension (w/v) of each sample in distilled water at pH values from 2 to 9. PSI was calculated as percentage of soluble protein based on total protein of sample.

Oil emulsifying capacity (EC) was evaluated in 100 ml of 1% (w/v) aqueous dispersion of each sample at pH 7 by titrating with corn oil until the emulsions collapsed (Marshall et al., 1975) and expressed as ml oil/g sample. The emulsion stability (ES) was recorded in term of the percent aqueous phase separated after several times up to 48 hours (Dipak and Kumar, 1986).

Foam capacity (FC) and foam stability (FS) were determined according to the method described by Dipak and Kumar (1986). One gram of the sample was whipped with 100 ml distilled water at pH 7 for 5 min. using a high speed electric blender. FC was measured in term of volume increase on whipping expressed as percentage of original volume of the liquid. FS was expressed to initial foam volume, after 10, 20, 30, 40, 60 and 120 min.

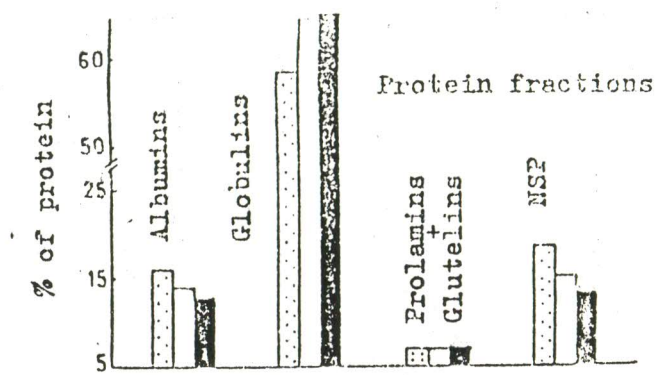
Water and oil absorption were estimated according to Beuchat (1977). One gram of sample was mixed with 10 ml distilled water or corn oil for 30 sec in a 25 ml centrifuge tube. The samples were then allowed to stand at room temeprature for 30 min., centrifuged at 1500 rpm for 30 min., and the volume of the supernatant was noted in a 10 ml graduated cylinder. The results were calculated as g water or corn oil absorbed by 100 g dry sample.

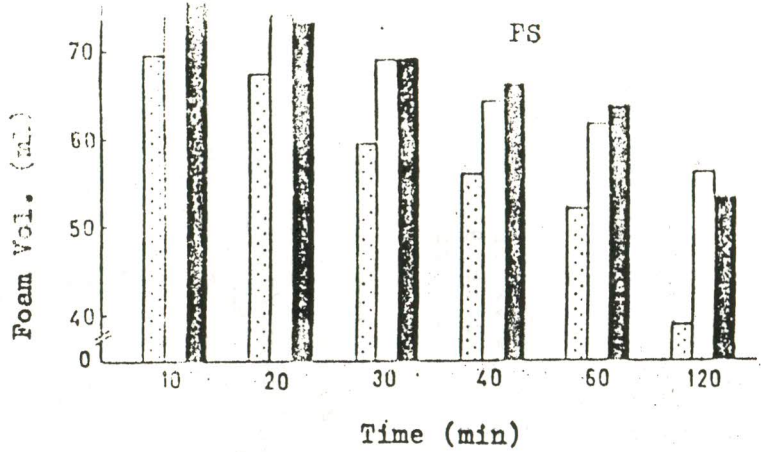
All functional property tests were determined on produced samples adjusted to an equal dry weight basis and were carried out in three replications.

RESULTS AND DISCUSSION

1- Ethephon application:

The data in Fig. (1) idnicate that the application of ethephon increased the biosynthesis of globuline to be at the maximal value when ethephon applied at a rate of 1500 ppm. Albumins and non soluble proteins were markedly reduced as a consequence of increasing ethephon application. Whereas, the concentration of prolamins and glutelins were being stable at all ethephon treatments.





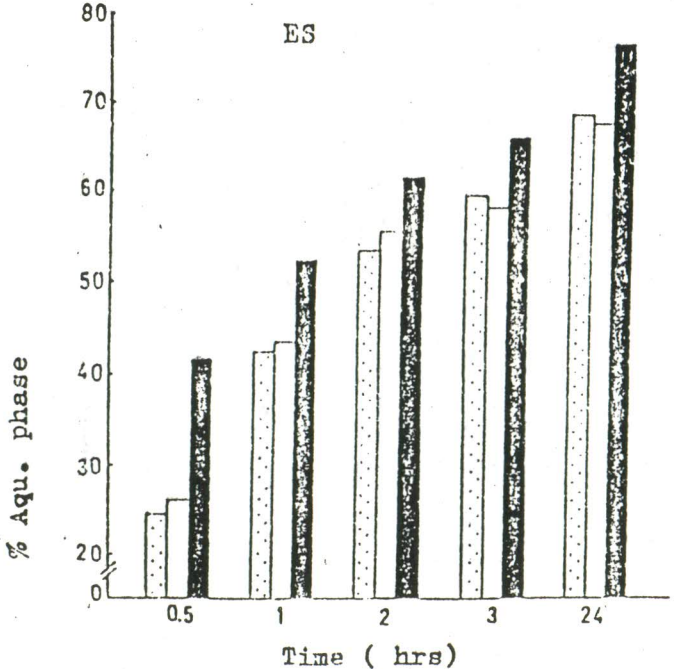


Fig 1. Effect of ethephon application on protein fractions, foam stability (FS) and emulsion stability (ES) on soybean meal.

□ Control , □ 1000 ppm, ■ 1500 ppm

2- Ripeining period:

The data in Fig. (3) indicate clearly that non soluble proteins were significantly decreased at ripening period of 110 days. On the contrary, phenomena was noticed for both albumins and globulins which were significantly increased by the same rate at 110 and 120 days. The concentration of prolamins and glutelins was slightly affected, which the ripening period of 100 days obtained an intermediate concentration between 110 and 120 days.

PSI of defatted meal as a function of pH values and ripening period is shown in Fig. (3). The minimum solubility was near the isoelectric point of soy protein (at pH 4). The data indicated celarly a negative relationship between PSI and ripening period due to the seed protein composition. It means that, at full maturity, the soybean protiens were, however, quite insobule at different studied pH values comparing to 100 and 110 days. On the other side, the FS was practically stable versus ripenign period of 100, 110 and 120 days (Fig. 3).

Fig. (3) indicate clearly that ripening periods of 100 and 120 days slightly affected ES of soy meal at pH 7 at a time of 1 hr up to 24 hrs. Prolonging the time from 2 to 24 hours decreased markedly ES of soy meal obtained at 110 days ripening stage comparing to other treatments.

Fig. (2) illucidate that soybean seeds obtained after 100 days had significantly higher PSI, FC, EC, oil absorption (OA) and crude protein content in comparison to 110 and 120 days. Whereas, ripening period was not significantly affect water absorption (WA).

3- Effect of interaction:

The data of the interaction between ripening period and etheplon application (Table 1) indicate clearly that spraying soybean plants will 1000 ppm ethephon at flowering stage and 100 days of ripening period obtained the highest seed yield (1.55 t/fad) and being outweighed those of the other treatments. Additionally, delaying ripening period from physiological maturity (100 days) up to full ripening stage (120 days) decreased markedly the seed yield/fad due to lowering photosynthesis activity and increasing the respiration rate. These findings are in agreement with those of Noureldin et al. (1986). The globulins concentration was in assending relationship with ethephon application and being higher by advancing the seeds towards maturity. Whereas, albumins and non soluble proteins shwoed a reverse trend. These results are true at every ripening period.

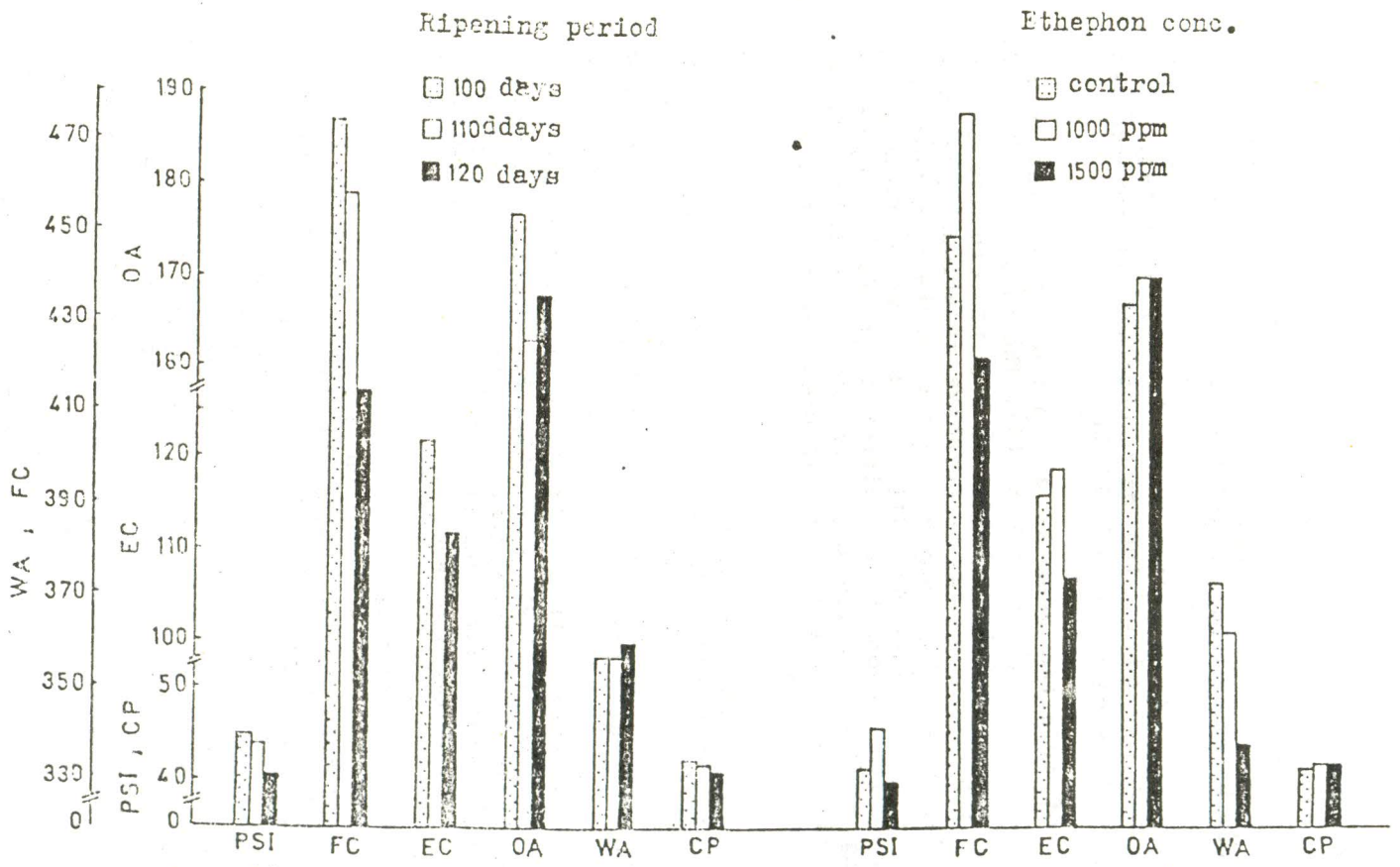
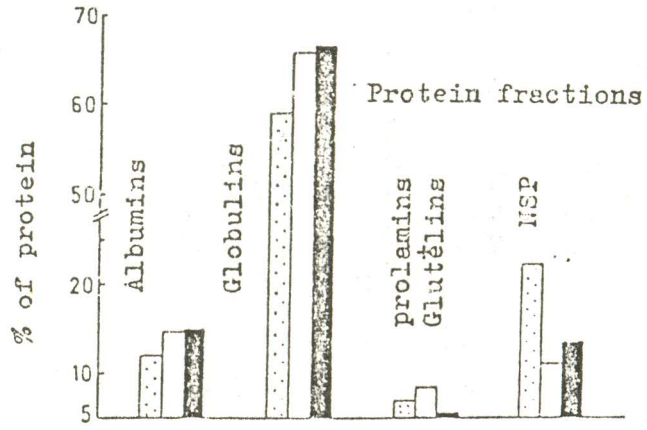
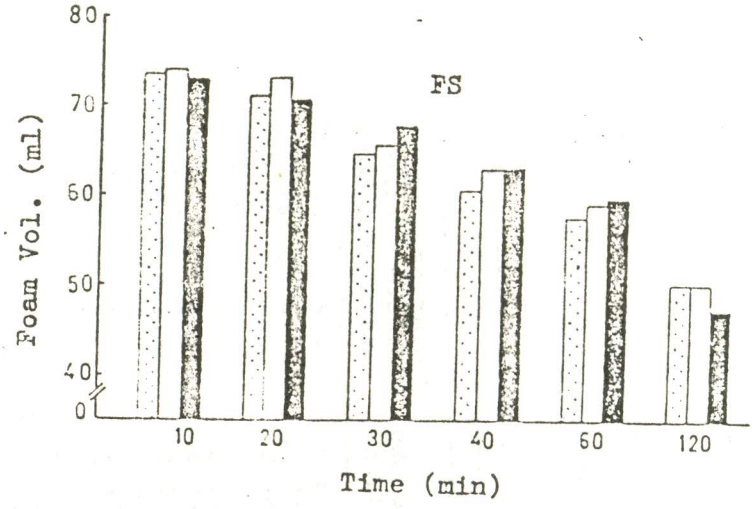


Fig 2. Effect of ethephon concentration and ripening period on protein stability index(PSI) , foam stability (FS) , emulsion capacity (ES), oil absorption (OA), weter absorption (WA) and crude protein percentage (CP) of defatted soybean seeds.





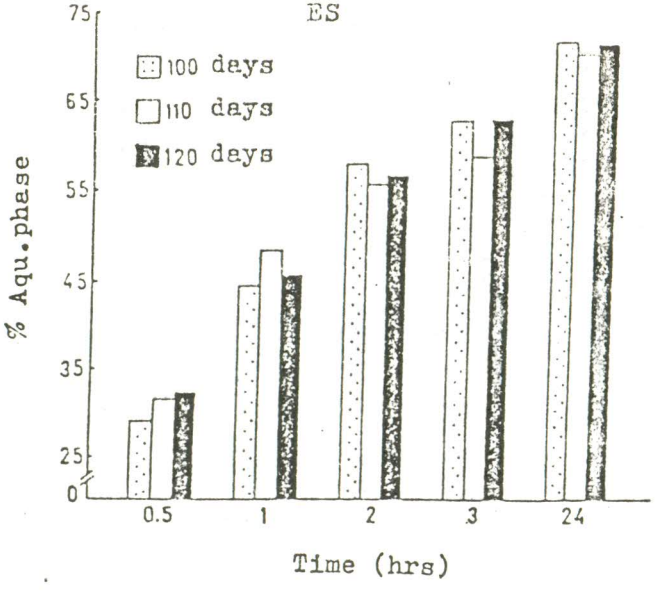


Fig 3. Effect of ripening period on protein fractions, foam stabilty (FS) and emulsion stability (ES) on soybean meal.

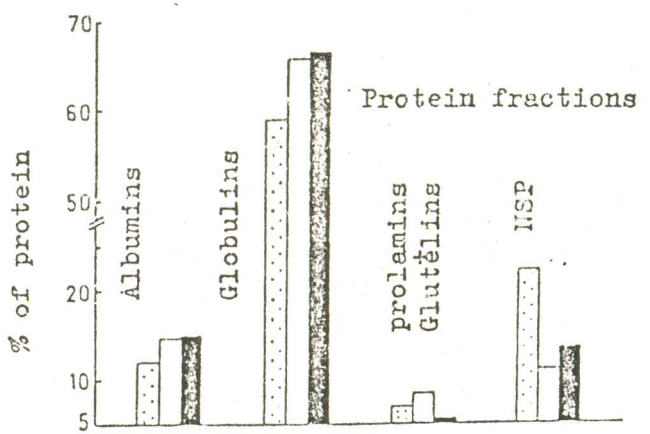
□ loo days , □ llo days, ▨ l2odays

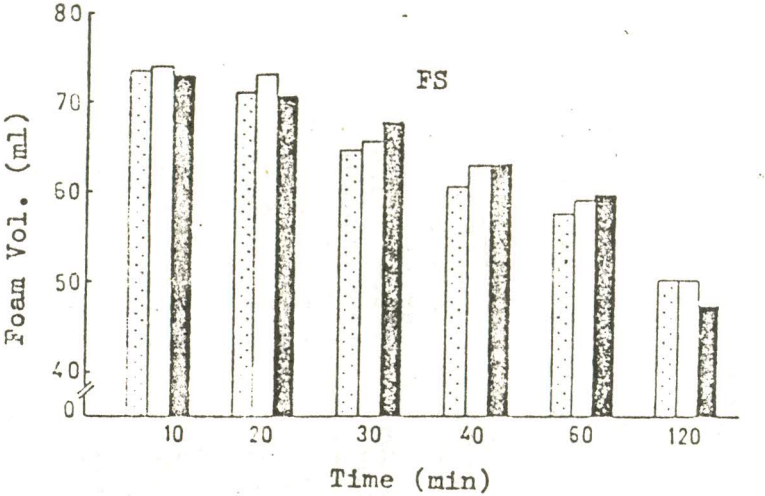
Table 1. Seed yield (T/fad) and protein fractions of soybean meal as affected by ethephon application and ripening time.

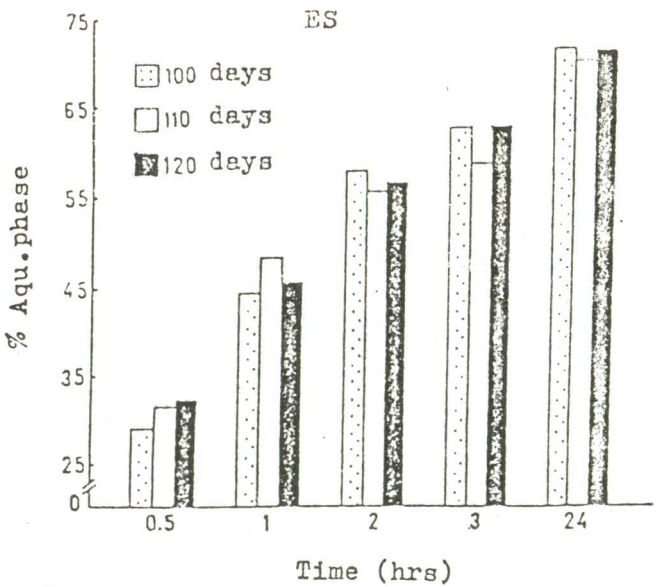
Days to ripening	Ethephon conc. ppm	Seed yield (T/fad)	% of protein			
			Albumins	Globulins	Prolamins + gllutetins	Non soluble protein
100	0	1.14	13.2	54.7	6.7	25.4
	1000	1.55	12.6	58.6	7.0	21.8
	1500	1.22	10.7	64.1	6.8	18.3
110	0	0.92	17.5	60.8	8.8	12.8
	1000	1.20	13.5	67.4	8.2	10.9
	1500	1.02	13.3	68.8	8.1	9.7
120	0	0.82	17.2	60.4	5.2	17.2
	1000	0.98	15.3	67.7	4.9	12.1
	1500	0.89	12.8	70.6	6.0	10.6

Table 2. Protein solubility index (PSI) of soybean meal as a function of pH values, ethephon application and ripening period.

Days to ripening	Ethephon conc. ppm	PSI at pH values							
		2	3	4	5	6	7	8	9
100	0	50.4	10.4	7.6	9.7	18.3	41.5	45.7	47.6
	1000	48.1	8.9	5.6	10.7	14.9	48.3	49.9	51.7
	1500	52.3	14.6	6.4	9.6	17.6	44.7	47.3	49.5
110	0	38.7	10.0	7.1	10.9	13.2	46.3	49.6	51.4
	1000	55.1	8.9	7.0	8.9	16.7	48.8	51.2	53.9
	1500	45.0	10.0	6.7	9.3	11.7	37.2	40.9	42.2
120	0	31.9	8.1	5.2	9.3	16.9	41.1	39.6	40.6
	1000	47.3	8.0	6.5	9.2	15.0	42.9	45.8	46.4
	1500	30.9	8.4	7.8	9.9	12.5	38.2	47.1	48.5







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	1500	52.3	14.6	6.4	9.6	17.6	44.7	47.3	49.5
110	0	38.7	10.0	7.1	10.9	13.2	46.3	49.6	51.4
	1000	55.1	8.9	7.0	8.9	16.7	48.8	51.2	53.9
	1500	45.0	10.0	6.7	9.3	11.7	37.2	40.9	42.2
120	0	31.9	8.1	5.2	9.3	16.9	41.1	39.6	40.6
	1000	47.3	8.0	6.5	9.2	15.0	42.9	45.8	46.4
	1500	30.9	8.4	7.8	9.9	12.5	38.2	47.1	48.5

Protein solubility index (PSI) of defatted meal as a function of pH values was widely different over the pH range of 2-9, probably due to the differences in seed protein composition. The application of 1000 ppm ethephon obtained soybean protein characterized by higher PSI especially at alkali pH values than the control and 1500 ppm ethephon (Fig. 2).

At pH 7, the control treatment had the lowest foam stability (FS) till 120 min., while ES of 0 and 1000 ppm ethephon had no significant differences and being lower than the application of 1500 ppm ethephon.

Fig. (2) indicate that, at pH 7, PSI was in positive relationship with FC and EC. The significant highest results were obtaiend when the plants sprayed with 1000 ppm ethephon. The high PSI might be attributed to the higher polarity or/and lower molecular weight of synthesized protien. The same conclusion was preceded by Altschol and Wilck (1985), who indicated that the reduction of protein molecular weight was accompanied by increasing its PSI, EC and FC.

Good foam forming of seed proteins at pH 7 was obtained by employing 1000 ppm ehtephon as compared to the other treatments. It means that, there was a positive relationship between PSI and FS. This observation was confirmed with those obtained by Kinssella et al. (1985). It was cleared that the treamtent with 1000 ppm ethephon had a desirable effect on the hydrophilic and hydrophobic groups which inhanced the solubility of the soy proteins that required to obtain optimum foaming activity.

Oil absorption (OA) did not differ due to ethephon application, whereas, water absorption (WA) was markedly reduced. These results could be attributed to the reduction of surface and itnerfacial tension of the water and form structural continuous, cohesive films around air vacuoles. This property is dependent on the increase of PSI (Nakai, 1983). The poor FC at 1500 ppm ethephon and control treatments might be due to an increase in the net charge density since it prevents protein-protein interactions requried in a continuous film around the air bulks.

The data in Fig. 1 and 2 indicate that EC, ES and percentage of emulsion volume remained after 24 hours of soy protiens, empolyed with 1000 ppm ethephon, were the highest. It means that this treatment maximized the stability and the ability of emulsion to retain its maximum volume over time which positively corelated with PSI.

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Table 3. Functional properties of soybean meal at pH 7 as affected by ethephon application and ripening date.

Days to ripening	Ethephon conc. ppm	PSI	FC	EC	Oil abs. %	Water abs. %
100	0	41.5	450	122	171	378
	1000	48.3	507	129	180	377
	1500	44.7	465	116	179	315
110	0	46.3	489	113	162	377
	1000	48.8	490	112	163	349
	1500	37.3	395	100	163	345
120	0	41.1	409	114	169	365
	1000	42.9	430	116	168	361
	1500	38.2	405	106	167	355

Table 4. Foam stability of 1% dispersion of soybean meal in water at pH 7.0 as a function of ethephon application and ripening date.

Days to ripening	Ethephon conc. ppm	Foam volume (%) at room temp. (20°C) after time (min.)					
		10	20	30	40	60	120
100	0	65.0	65	53	53	48	40
	1000	80.0	75	74	64	63	56
	1500	76.0	73	67	65	61	54
110	0	72.0	72	63	60	54	41
	1000	77.0	76	65	63	61	56
	1500	73	72	69	67	62	54
120	0	71	67	63	56	54	36
	1000	71	71	69	66	61	55
	1500	76	74	71	67	64	51

On the other side, the concentration of prolamins and glutelins were practically stable being in descending relationship with ripening period as follows: 100, 110 and 120 days, respectively.

The PSI was reduced by incrasing the pH value reaching its minimal value at pH near isoelectric point (pH 4) followed by furtehr increases till pH 9. PSI was practically had no differences at pH 4 in all studied interactions (Table 2). The variation was increased at the other pH values especially at pH 7 and spraying the plants with 1000 ppm ethephon at ripening periods of 100 and 110 days. These results were positively affected on FC and EC (Table 3). Meanwhile, ethephon application had no significant effect on oil absorption at every ripening period but the highest results were obtained at 100 days. WA at 1000 ppm had an intermediate position between the control and 1500 ppm ethephon.

The application of ehtephon at different ripening periods not only affected FC, but also foam stability (Table 4). Using 1000 ppm ethephon at 100, 110 or 120 days of ripening periods obtained the highest FS at time up to 120 min followed by 1500 and control treatments, respectively.

The ES determined as percentage aquous phase separated after time hours was determined and the results are shown in Table (5). The data indicate that minimum aquous phase separated and the highest emulsion percentage after 24 hrs were found when the plants treated with 1000 ppm ehtephon at all studied ripening periods. Increasing the concentration of ethephon significantly inhibited FS and its percentage after 24 hours.

Table (5): Emulsion stability of 1% dispersion of soybean meal in water at pH 7 as a function of ethephon application and ripening date.

Days of ripening	Ethephon conc. ppm	% aq. phase separated at room temp. (20°C) after time (hrs)						Emulsion % after 24 hrs
		0.25	0.5	1.0	2.0	3.0	24	
100	0	0	20	40	52	61	67	68.5
	1000	0	22	40	56	56	64	71.6
	1500	32	45	54	66	71	84	20.4
110	0	0	20	44	52	58	70	65.7
	1000	0	28	49	54	54	68	67.0
	1500	0	46	52	60	63	72	63.0
120	0	0	34	44	56	60	69	65.4
	1000	0	28	42	56	64	70	67.1
	1500	0	34	51	58	64	74	63.6

From the previos data, it could be concluded that the application of 1000 ppm etherphon and ripening period of 100 days was the best treatment and positively affected all studied functional properties.

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تأثير الايثيفون
ومدة النضج على الصفات النوعيه لكسب فول الصويا

محمد سامى العبال * سالم حسن الديب ** ناديه يحيى احمدعطيه ***

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*** قسم الكيمياء الزراعيه - كلية الزراعه بمشتهر - جامعة الزقازيق/فرع بنها

تم رش نباتات فول الصويا بتركيزات صفر، ١٠٠٠ ، ١٥٠٠ جزء فى المليون من مركب الايثيفون وذلك لتشجيع النباتات ناجية الانضاج واخذت البذور على فترات نضج مختلفه بعد ١٠٠ ، ١١٠ ، ١٢٠ يوم . وقد تمت دراسة تأثير المعاملة بالايثيفون ومراحل النضج على الخصائص الوظيفيه لبروتينات البذور والتى تشمل أنواع البروتين ودرجة الذوبان ، السعه الاستحلابيه وثبات المستحلب ، القدرة على تكوين الرغوه ودرجة ثباتها وكذلك القدرة على امتصاص الزيت والماء .

وقد دلت النتائج على أن زيادة تركيز الايثيفون حتى ١٥٠٠ جزء فى المليون ادت الى زيادة كل من بروتين الجلوبيولين والقدرة على ثبات المستحلب بينما كان تركيز ١٠٠٠ جزء فى المليون من الايثيفون قد حسن من درجة ذوبان البروتين عند قيمة الـ pH القلويه . وقد لوحظ أن درجة ذوبان البروتين على علاقة طرديه مع كل من القدره على تكوين الرغوه ودرجة ثباتها وكذلك ثبات المستحلب وقد وصلت النتائج اقصاها عند استخدام الايثيفون بتركيز ١٠٠٠ جزء فى المليون،

وأشارت النتائج الى أن هناك زيادة معنويه لكل من الالبيومين والجلوبيولين عند مرحلة نضج ١١٠ يوم وقد وجدت علاقه عكسيه بين مرحلة النضج وكل من معامل الذوبان والقدرة على تكوين الرغوه وثباتها والسعه الاستحلابيه وامتصاص الزيت وكذلك محتوى البروتين الخام .

وقد دلت النتائج بوضوح على أن المعامله بالايثيفون عند تركيز ١٠٠ جزء فى المليون عند مرحلة نضج ١٠٠ يوم كانت افضل معامله وكان لها تأثير ايجابى على الخصائص الوظيفيه المدروسه .