

## EFFECT OF LUPINE AS CHEESE BASE SUBSTITUTION ON TECHNOLOGICAL AND NUTRITIONAL PROPERTIES OF PROCESSED CHEESE ANALOGUE

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### ABSTRACT

**Background.** Healthy foods have been met with marked success in the last two decades. Lupine flours, protein concentrates, and isolates can be applied as a substance for enriching different kinds of food systems such as bakery products, lupine pasta, ice cream, milk substitutes. Imitation processed cheese is made from mixtures of dairy and/or non dairy proteins and fat/oils and is variously labeled analogue, artificial, extruded, synthetic and/or filled. Processed cheese can be formulated using different types of cheese with different degree of maturation, flavorings, emulsifying, salts, and/or several ingredients of non-dairy components. Non-dairy ingredients have been used in processed cheese for many dietary and economic reasons. In this study, lupine paste was used to substitute 25, 50, 75 and 100% of cheese in base formula of processed cheese analogue (PCA).

**Material and methods.** Matured Ras cheese (3 months old) was manufactured using fresh cow milk. Soft cheese curd was manufactured using fresh buffalo skim milk. Emulsifying salts S9s and Unsalted butter were used. Lupine termis paste was prepared by soaking the seeds in tap water for week with changing the water daily, and then boiled in water for 2 hrs, cooled and peeled. The peeled seeds were minced, blended to get very fine paste and kept frozen until used.

**Results.** Lupine paste was used to substitute 25, 50, 75 and 100% of cheese in base formula of processed cheese analogue (PCA). The obtained PCA were analysed when fresh and during storage up to 3 months at  $5 \pm 2^\circ\text{C}$  for chemical composition, physical and sensory properties. The histopathological effect of lupines on alloxan diabetic albino rats and nutritional parameters were also investigated. Incorporation of lupine paste in PCA increased the ash and protein contents while meltability and penetration values of resultant products were decreased. Adding lupine in PSA formula had relatively increased the oil index and firmness of products. Feeding rats a balanced diet containing processed cheese enriched with lupine showed marked improvements in islets structure and lowered blood glucose compared to rats fed on basil diet (negative group). Springiness was greatly reduced with increasing the added ratio of lupine in the formula of cheese. All processed cheese produced were sensory acceptable but an overall acceptability was lowered by incorporating lupine in PCA formula. Body and texture score of PCA was the mostly affected by increasing lupine ratio in formula without significant difference up to 50% substitution of cheese base.

**Key words:** processed cheese, analogue, lupine, histology, textural profile, nutrition

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## INTRODUCTION

Healthy foods have been met with marked success in the last two decades. These healthy foods termed “functional foods” are growing rapidly all over the world due to the increased awareness of the consumers on the impact of food on health [Stoon 2002]. Imitation processed cheese is made from mixtures of dairy and/or non dairy proteins and fat/oils and is variously labeled analogue, artificial, extruded, synthetic and/or filled. Processed cheese can be formulated using different types of cheese with different degree of maturation, flavorings, emulsifying, salts, several ingredients, by-product in dairy factories and non dairy components [Caric and Kalab 1993]. Non-dairy ingredients have been used in processed cheese for many dietary and economic reasons. El-Neshawy et al. [1988] manufactured processed cheese of high protein content from blends of Cheddar cheese, whey protein concentrate (WPC), soya bean protein concentrate (SPC) and chick pea flour (CPF). Hussein et al. [2005] studied the quality and acceptability of processed cheese spreads made from total milk protein and casein co-precipitate. Awad and Salama [2010 a] used egg to replace soft cheese in the manufacture of processed cheese spreads.

*Lupinus termis* is perennial cultivated herb belonging to the family fabaceae. It is cultivated in Mediterranean region and Egypt for its edible seeds [Tackholm 1974]. Its seeds so much consumed raw as salted lupines after being de-better by leaching out the alkaloids by soaking the whole seeds in several batches of water over a number of days. *Lupinus termis* is one of the rich plants by alkaloid, amino acids, carbohydrates and proteins with moderate gelatin properties compared to soy proteins [Wäsche et al. 2001]. Lupine is a good source of nutrients, not only proteins but lipids, dietary fiber, minerals and vitamins [Martínez-Villaluenga et al. 2006, Torres et al. 2005]. Lupines contain phytochemicals with antioxidant capacity, such as polyphenols, mainly tannins and flavonids [Oomah et al. 2006]. Interest in lupine production is increasing, due to its potential as a source of protein, or for pharmaceutical purposes due to the high alkaloid content, as a natural component [Gaultier et al. 2003, Smart et al. 2003, James et al. 2004]. The high protein content 25-40% [Erickson 1985] could be used products,

such as pastries, breads, chips and milk substitutes. Lupine flours, protein concentrates, and isolates can be applied as a substance for enriching different kinds of food systems such as bakery products, lupine pasta, ice cream, milk substitutes and sausages [Wasche et al. 2001] and also be a main food component when animal proteins are eliminated. No studies have been published on the use of lupine in processed cheese. Therefore, the objective of the present study was to investigate the effects of lupine terms on the properties of processed cheese analogues. Changes in histopathological of pancreas in alloxan induced diabetic rats, as well as the blood sugar and feed conversion ratio were also examined.

## MATERIAL AND METHODS

### Materials

Ras cheese was manufactured using fresh cow's milk as the procedure of Hofi et al. [1970] and ripened for 3 months at ripening room. Soft cheese curd was manufactured using fresh buffalo skim milk obtained from High Institute of Agriculture Cooperation, Shoubra Khima, Cairo, Egypt. Commercial JOHA emulsifying salts S9s and NO were obtained from BK-Ladenburg corp., Gmbh, Germany. Unsalted butter was obtained from Dina farm, Sadat city. Seeds of *L-Termis* were purchased from the local market. Alloxan monohydrate (2% solution) was used as physiological saline and injected as a single dose of 110 mg/kg body weight subcutaneously within 50-75 seconds.

**Preparation of lupine termis paste.** It was prepared by soaking the seeds in tap water for one week with changing the water daily, and then boiled in water for 2 h, cooled and peeled. The peeled seeds were minced, and blended to get fine paste which then kept frozen until used. The composition of raw materials used is shown in Table 1.

**Manufacturer of processed cheese analogue.** The suitable amounts of raw materials (matured Ras cheese, soft cheese curd, lupine paste, butter, emulsifying salts and water) were added consecutively in laboratory processing Kettle (locally constructed) as mentioned by Awad [1996]. All blends were adjusted to contain 58% moisture, 50% fat/DM and 2.5% emulsifying salts (S9s + No, 1:1). Lupine paste was added to the formula as a substitute of cheeses

**Table 1.** Composition of raw materials used in the manufacture of processed cheese spread

Character assessed	Ras cheese	Soft cheese curd	Lupine paste
Moisture, %	47.46	77.15	69.72
Fat, %	36.00	3.00	9
Protein, %	26.78	10.75	38.00
Ash, %	4.39	2.15	0.72
pH value	6.92	7.05	5.98

**Table 2.** Formulations of different processed cheese analogue with lupine paste, kg/100 kg

Ingredients	Treatments				
	control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
Ras cheese	30.20	20.20	15.20	8.80	–
Soft curd	54.30	39.70	29.70	18.20	–
Lupine paste	–	20.00	32.00	47.10	68.20
Butter oil	10.08	12.55	13.79	15.59	17.48
Emulsifying salts (S9s + No, 1:1)	2.5	2.5	2.5	2.5	2.5
Water	2.92	5.05	6.81	6.81	11.82
Total	100	100	100	100	100

in ratios of 25, 50, 75 and 100%. The mixture was cooked for 10 min at 85-90°C using indirect steam at pressure 2-2.5 kg/cm<sup>2</sup>. The mixture was hot filled into wide mouth glass jars and capped directly after filling. The resultant cheese analogue was analysed when manufactured and after 1, 2 and 3 months of storage in refrigerator (5 ± 2°C). The composition of all different formulations is shown in Table 2.

**Experimental animals (in vivo analysis).** Clinically healthy male albino rats aged three months and 180 g/rat average body weight were used in the present study. Rats were purchased from the Experimental Animal House, Eyes Research Center, Giza, Egypt.

Rats were fed for one week before starting the experiment on basal diet then divided randomly into three groups each of 7 animals. The basal diet consisted of 15% protein as casein, 10% cellulose as fiber, 10% fat as corn oil, 5% mixture of vitamins and salts and 60% carbohydrate as starch according to During et al. [2000]. The first group was fed for another more week on basal diet (negative control), while the 2<sup>nd</sup> and 3<sup>rd</sup> groups were fed on basal diet supplemented with 20% of control processed cheese without lupine (positive control) and cheese analogue supplemented with 75% lupine paste respectively. The diet given to the 3<sup>rd</sup> group continued for 4 weeks. All biological examinations were carried out in the initial and periodically to follow up the health parameters of experimental animals.

**Chemical analysis.** Samples of cheese analogues were tested for moisture, acidity and ash contents as mentioned in AOAC [1990]. Fat, total and soluble nitrogen contents were determined according to the method described in Ling [1963]. Total carbohydrates were calculated by differences as described by Ceirwyn [1995].

**Physicochemical properties.** Values of pH were measured using a digital pH meter (HANNA), with combined glass electrode (Electric Instruments Limited). Meltability of cheese analogue was tested as described by Aront et al. [1957]. The oil separation index of processed cheese analogues was determined according to Thomas [1973]. Firmness was measured using penetrometer (Kochler Co. Inc., USA) as mentioned by El-Shabrawy et al. [2002] and penetration depth was recorded in units of 0.1 mm. The penetrometer reading is inversely related to firmness of cheese analogue.

**Biological examination.** The changes in body weight of albino rats were recorded weekly. Weight gains (which is the difference between final weight and initial weight), feed consumption (total food consumed during the period of experimental for each group) and feed conversion (feed consumption/weight gain) were calculated. Blood samples were obtained weekly from orbital plexus of the eyes for all rats. The plasma was obtained from blood samples by centrifugation at 1500 rpm for 15 min at an ambient temperature and plasma glucose level was determined according to Trinder [1969].

**Histopathological examination.** Autopsy samples were taken from the pancreas of the sacrificed rats according to the method of Banchroft et al. [1996]. Samples were fixed in 10% formalin saline solution for 10 h, and then washed in tap water for 12 hours. Serial alcohol concentrations were used for dehydration of the tissue samples; tissue specimens were cleared in xylene and embedded in paraffin. The paraffin blocks were sectioned at three micron thickness by sledge microtome. The obtained tissue sections were collected on the glass slides and stained by hematoxylin and eosin stain for light microscopy.

**Sensory evaluation.** Samples of cheese analogues were sensory scored by 8-10 panelists according to the scheme of Meyer [1973] for outer appearance (20 points), body and texture (40 points) and aroma and flavor (40 points). The course of scoring for each sample was repeated three times and all collected data were statistically analyzed according to SAS Institute (1990) using liner Model (GLM). Duncan's multiple range was used to separate among means of three replicates at  $p \leq 0.05$ .

## RESULTS AND DISCUSSION

### Chemical composition of processed cheese analogue

Effect of adding lupine paste on the chemical composition of processed cheese treatment analogues is presented in Table 3. Total solid and fat contents in all processed treatments were in narrow range. This was expected since all the experiments were adjusted in the formula before cooking process. Total protein and ash contents were the lowest in control treatment while adding sweet lupine paste in different ratios increased proportionally the values of total protein and ash in treatments. The higher total protein and ash contents in cheese analogue treatments with lupine paste as a substitution of raw cheese are related to the higher values of protein and ash in lupine compared to soft curd or Ras cheese used in base formula in Table 1. Carbohydrate (as lactose) content was the highest (5.05%) in control treatment of processed cheese. Among analogue treatments, processed cheese with 100% substitution of raw cheese with lupine ( $T_4$ ) had the lowest (2.25%) carbohydrate content, while  $T_1$  showed the highest one (3.71%).

**Table 3.** Chemical composition (%) of fresh processed cheese analogues as affected by different substitution levels of raw cheese with lupine paste

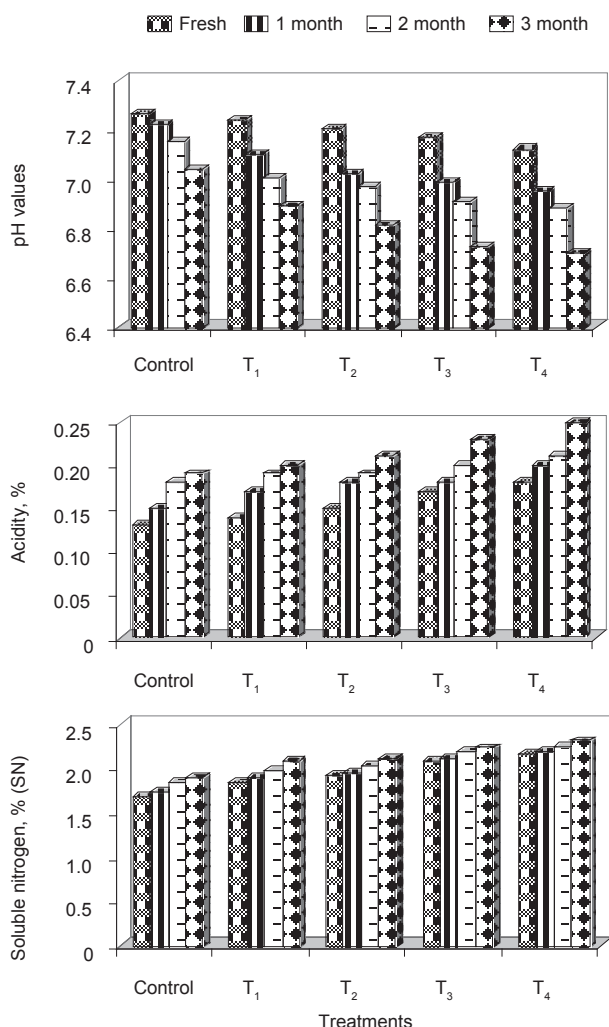
Character assessed	Treatments				
	control	$T_1$	$T_2$	$T_3$	$T_4$
Total solids	41.89	42.70	42.62	42.36	42.05
Fat	20.00	21.50	21.50	21.00	21.00
Protein	13.60	14.12	14.19	14.66	14.88
Ash	3.20	3.37	3.66	3.81	3.92
Carbohydrate*	5.05	3.71	3.27	2.89	2.25

Treatments  $T_1, T_2, T_3, T_4$  with 25, 50, 75 and 100% lupine paste substitution of cheese base respectively.

\*Calculated by difference.

### Values of pH, acidity and SN in cheese analogue

Replacing cheese base in the blend with lupine paste resulted in lowering pH values of processed cheese analogue. This could be due to the low pH of lupine used in the formula (5.98) compared to 6.92 or 7.05 for Ras or soft cheese respectively. Among all treatments are shown in Figure 1 control processed cheese showed highest pH value. Treatments supplemented with lupine paste showed slightly lower pH. The pH indicated a slight and gradually decreases during storage of all treatments. The decrease in pH during storage could be related to the hydrolysis occurred in emulsifying salts and their interaction with proteins. These findings are in agreement with Awad and Salama [2010 a, b]. Changes of acidity had an opposite trend to that occurred in pH being higher in treatments of lupine paste with slight proportional increase during storage period. Similar observation was recorded by Awad [2003]. Incorporating lupine paste in the base formula increased the soluble nitrogen (SN) content compared to control (Fig. 1). During storage, the value of SN increased in all treatments including control. The changes in SN during storage could be the result of enzymatic activity of resistant proteinases present in the product. It could be also due to the hydrolysis of polyphosphate in emulsifying salts which caused more solubilization of proteins. These results are in agreement with those reported by Awad [2003] and Awad and Salama [2010 a, b].



**Fig. 1.** Changes in pH values, acidity and soluble nitrogen (%) of fresh and stored processed cheese analogue as affected by substitution levels of lupine paste

### Physicochemical properties

**Meltability** values of processed cheese analogues were affected by the substitution of raw cheese with lupine paste is shown in Table 4. Adding lupine paste in base formula decreased the cheese analogue meltability compared to control. The results indicated that treatment with 25% lupine (T<sub>1</sub>) had the highest melting properties compared to other treatments including control cheese. The melting value decreased with increasing the percentage of added lupine being lowest in T<sub>4</sub> with 100% substitution. The lower meltability

of cheese treatments containing lupine may be due to its high casein and total protein contents. During storage the melting values increased in all treatments including control. The changes in meltability during storage could be related to the protein degradation that occurred in the cheese, which led to high SN and increase of cheese flow. These findings are in agreement with those of Awad [2003] and Awad and Salama [2010 b].

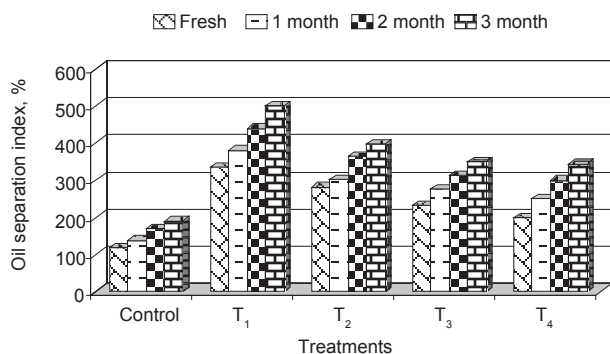
**Firmness of cheese analogue.** The results in Table 4 indicate that the highest penetration value was observed in control treatment. On the other hand, analogue treatments with lupine paste showed lower penetration which means firmer product than control treatment. It is well known that penetrometer reading is inversely related to the cheese firmness. The lower penetration value and so higher firmness in cheese analogue containing lupine paste could be due to the higher total protein content in the blend. These data agree with Tamime et al. [1990] who stated that the firmness of processed cheese was increased by the addition of soy, whey or egg proteins. In stored processed cheese samples, the penetration values decreased

**Table 4.** Meltability and penetration values of processed cheese analogue as affected by using different levels of lupine paste, fresh and stored

Storage period month	Treatments				
	control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
<b>Meltability, mm</b>					
Fresh	45	58	32	25	5
1	53	62	45	34	7
2	65	80	48	41	10
3	75	84	54	48	11
<b>Penetration, mm</b>					
Fresh	31.8	21.6	14.3	13.6	10.5
1	30.5	20.8	12.5	11.3	9.4
2	28.2	20.0	10.3	10.9	8.1
3	25.8	18.3	8.5	7.8	5.6

Treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> with 25, 50, 75 and 100% lupine paste substitution of cheese base respectively.





**Fig. 2.** Oil separation index of processed cheese analogues as affected by substitution level of lupine paste, fresh and during storage period

with prolonging the storage period, i.e., the firmness increased. This could be attributed to the nature of protein in the formula with the affinity to low and degradation changes in the product during storage especially the low pH value. The data agree with Awad [2003] and Awad and Salama [2010 a, b].

**Oil separation index.** The data in Figure 2 indicate that control cheese had the lowest fat separation index compared to samples containing lupine paste either when fresh or during storage. Processed cheese analogue with 25% lupine (T<sub>1</sub>) had the highest oil separation index, while T<sub>4</sub> showed the lowest one. The fat separation decreased with increasing the added percentage of lupine in the formula which could be mainly attributed to the nature of lupine protein that may affect the emulsification degree of the product. The oil index value depends on the state of fat and protein in resultant processed cheese emulsion which can be affected by type and amount of raw materials in the base formula, pH value, cooking time and temperature. The oil index of processed treatments including control was affected by storage period. Storage of processed samples increased the free oil in the product. This may be due to the corresponding changes in pH value and SN content during storage. These findings agree with Awad [2003], Awad and Salama [2010 a, b].

**Texture profile of processed cheese analogue.** The textural properties of processed cheese analogue samples are shown in Table 5. From the obtained results it could be seen that, addition of lupine paste in the blend increased the hardness of cheese treatments

**Table 5.** Texture profile analysis of fresh and stored processed cheese analogues as affected by substitution levels of lupine paste

Parameters	Treatments				
	control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
<b>Fresh</b>					
Firmness, N*	5.901	6.523	8.271	9.680	10.571
Cohesiveness, g/cm	0.294	0.155	0.106	0.047	0.003
Gumminess, N	0.699	0.923	1.558	0.924	0.095
Springiness, mm	0.283	0.266	0.128	0.060	0.020
Chewiness, N	0.654	0.497	0.301	0.094	0.004
<b>3 month</b>					
Firmness, N	7.26	8.69	11.38	13.14	15.69
Cohesiveness, g/cm	0.392	0.196	0.183	0.164	0.145
Gumminess, N	0.846	0.947	2.086	0.280	2.149
Springiness, mm	0.458	0.240	0.215	0.154	0.161
Chewiness, N	1.306	0.699	0.447	0.332	0.367

Treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> with 25, 50, 75 and 100% lupine paste substitution of cheese base respectively.

\*N – newton.

compared to control. The increase in hardness values were proportional to the ratio added of lupine paste in formula of processed cheese. Control cheese had low protein content, which is mainly casein, while treatments contained quantities of lupine protein and lower content of casein. This may explain the differences in textural parameters of cheese due to the difference in the properties of occurring proteins [Fox et al. 2000]. Storage of cheese increased to more extent the hardness. This is may be due to the less availability of water during storage as well as loss of texture integrity generated by proteolysis activities. These observations agree with the results of Awad et al. [2006]. The results in Table 5 also, indicated that the cohesiveness of cheese samples decreased as lupine paste ratio increased in the blend. After 90 days of storage, the cohesiveness value greatly increased in all cheese, and control treatment showed the highest

value. Gumminess showed the maximum values in fresh processed cheese analogue with 50% lupine and in the stored cheese with 75% lupine. Gumminess values increased during storage of all treatments including control with storage. These data agree with the results of El-Baz et al. [2011]. Springiness values were higher in control cheese analogue than those of

other treatments with lupine paste. However, Springiness greatly reduced with increasing the added ratio of lupine in the formula of cheese. During storage, the cheese analogue became springier and springiness value was increased in all analogues including control. Adding lupine paste in cheese analogues formula decreased markedly the cheese chewiness. After 3 month of storage, chewiness greatly increased in all cheese samples including control.

**Table 6.** Sensory evaluation score of analogue type processed cheese supplemented with different ratios of lupine paste during cold storage

Sensory attributes	Treatments				
	control	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
<b>Fresh</b>					
Outer appearance (20)	19	18	18	16	16
Body and texture (40)	38	37	36	34	32
Flavor (40)	38	38	36	35	33
Total score (100)	95 <sup>a</sup>	93 <sup>a</sup>	90 <sup>ab</sup>	85 <sup>bc</sup>	81 <sup>c</sup>
<b>1 month</b>					
Outer appearance (20)	18	17	17	16	15
Body and texture (40)	37	36	34	32	30
Flavor (40)	37	37	36	35	32
Total score (100)	92 <sup>a</sup>	90 <sup>a</sup>	87 <sup>ab</sup>	83 <sup>bc</sup>	77 <sup>c</sup>
<b>2 month</b>					
Outer appearance (20)	18	17	16	15	14
Body and texture (40)	36	34	32	31	29
Flavor (40)	36	35	34	33	31
Total score (100)	90 <sup>a</sup>	86 <sup>ab</sup>	82 <sup>bc</sup>	79 <sup>cd</sup>	74 <sup>d</sup>
<b>3 month</b>					
Outer appearance (20)	17	16	15	15	14
Body and texture (40)	36	32	31	29	27
Flavor (40)	36	35	32	31	31
Total score (100)	89 <sup>a</sup>	83 <sup>ab</sup>	78 <sup>bc</sup>	75 <sup>cd</sup>	72 <sup>d</sup>

Treatments T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> with 25, 50, 75 and 100% lupine paste substitution of cheese base respectively.

Means with the same letter among treatments are not significantly different ( $P \leq 0.05$ ).

### Sensory evaluation

The average score for sensory properties is represented in Table 6. The outer appearance of treatments with lupine as a substitution of cheese up to 25% was most preferable. The appearance became less acceptable with increasing the added ratio of lupine in the base blend. Body and texture of control cheese was much better than treated cheeses. The data also, indicated that addition of lupine in the blend led to less acceptable product. All obtained processed cheese analogue were acceptable but the most acceptable blends of cheese analogue were produced with adding 25% of cheese base as lupine paste which ranked slightly higher total scores than that of other lupine treatments. Statistical analysis among all treatments indicated that the one with 25% lupine was not significantly differed than control. The sensory quality attributes of all treatments including the control decreased during storage. These data agree with the findings of Awad and Salama [2010 a, b] who mentioned that the acceptability of processed cheese decreased with extending the storage period.

### In vivo biological examinations of processed cheese analogue

Feed consumption, weight gain and feed conversion ratio of albino rats as affected by feeding on diet containing processed cheese containing lupine paste are presented in Table 7. The data cleared that treatment group consumed higher level of diet through the treating period. This could be a reflection of better health of rat in treatment group than that in positive or negative group. Therefore the weight gained in treatment group fed on processed cheese fortified with lupine paste was higher than positive or negative group. These results are in agreement with Ghazal [2003]. Feed conversion ratio (FCR) which is the ratio

**Table 7.** Feed consumption, weight gain and feed conversion ratio of albino rats feed on processed cheese with 75% lupine paste substitution of cheese base

Character assessed	Group		
	positive	negative	treatment
Feed consumption, g	861	1 293	1 314
Weight gain, g	-21.25	35.5	79.75
Feed conversion ratio, FCR	40.52	36.42	16.48

between the feed consumption to the weight gained through the experimental period was lower in rat group fed on lupine processed than that of positive or negative group. Therefore, including lupine in the diet of rat resulted in a better health with higher efficiency to convert the consumed diet to weight gained in experimental animals.

#### Effect of feeding a diet containing lupine paste on blood glucose of rats

Blood glucose of albino rats as affected by feeding a diet containing cheese supplemented with 75% lupine paste is presented in Table 8. The data indicated that the blood glucose levels of rats were affected by feeding on a diet enriched with lupine paste. The blood glucose level in positive control group was significantly higher than that of experimental group during the feeding period. At the end of feeding period, the treatment group which fed on lupine enriched diet had the lowest levels of blood glucose. The results are in agreement with those obtained by Abd Elaziz [2011]. Several previous studies were undertaken to understand how some plants which have action on the

**Table 8.** Blood glucose (mg/dl) of albino rats as affect by feeding on processed cheese spreads supplemented with 75% lupine paste

Feeding period week	Group		
	negative	positive	treatment
Zero	381	392	388
2	389	398	209
4	421	406	117

blood glucose. These plants may act on blood glucose through different mechanisms, some of them may have insulin like substances [Collier et al. 1987], some may increase insulin output or inhibit the intestinal absorption of glucose or to the facilitation of metabolites in insulin dependent processes [Jia et al. 2003]. Other may increase beta cells in the pancreas by activating regeneration of these cells [Shanmugasundaram et al. 1990].

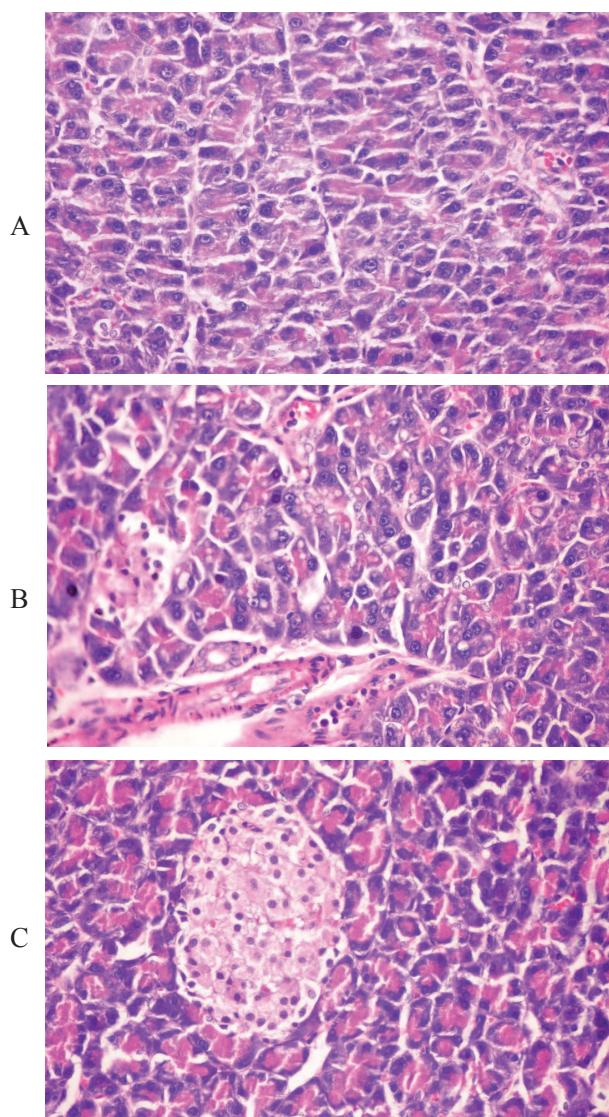
#### Histopathological examinations

Histological examinations of pancreas from rats fed on different diets are shown in Figure 3. Rats fed on balanced diet containing control processed cheese (Positive group) showed atrophy, hypertrophy and congestion of blood vessels and necrosis in islets of langerhans. Feeding rats on balanced diet containing processed cheese enriched with lupine paste showed marked improvements in islets structure after 30 days compared to rats fed a basil diet (negative group). Our results are coincided with Hall et al. [2005] who attributed the hypoglycemic effect of lupine termis to the higher protein content that stimulating a higher insulin response. It could be also attributed to the actions of various phytochemicals and dietary fiber found in lupine termis. Mohamed and El-Shorbagi [1993] and Knecht et al. [2006] found that lupine termis contain saponin, alkaloids and Tannin. Saponins have hypoglycemic activity which may be due to the inhibition of liver glycogenesis or glycolysis and that lead to a pronounced hypoglycemic effect.

#### CONCLUSION

Adding lupine paste in cheese analogue formula decreased the meltability, penetration and fat separation in the processed product. Cohesiveness and springiness values were decreased with adding lupine paste to analogue formula. All obtained processed cheese analogue were acceptable but the most acceptable blend was produced with substituting 25% of cheese base as lupine paste. Incorporating lupine in the diet of rat resulted in a better health with higher efficiency to convert the consumed diet to weight gained in experimental animals and treatment group which fed on lupine enriched diet showed the lowest levels of blood glucose. Marked improvements in islets structure after





**Fig. 3.** Pancreas of rat from: A – negative group showing normal pancreatic acini, B – positive group showing vacuolations of epithelial lining pancreatic acini and necrosis of islets in langerhans, C – treatment group showing no histopathological changes

30 days compared to rats fed a basil diet was noticed in rats fed on balanced diet containing processed cheese enriched with lupine paste. New processed cheese analogue can be successfully made using lupine paste as source of protein which improve nutritive and health value of resultant.

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