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Basic Science

Serum Level of the Adipokine "Vaspin" in Relation to Metabolic Parameters: Short – Term Effect of Specific Dietary Therapy

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Key words: Metabolic syndrome; vaspin; dietary therapy; doum (*Hyphaene Thebaica*), whole wheat.

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Abstract

AIM: To investigate the association between the circulating vaspin concentration and both of glucose homeostasis and insulin resistance in metabolic syndrome (MetS) patients, and also to evaluate the metabolic impact of two different dietary therapies on such conditions.

MATERIALS AND METHODS: Fifty eight obese female volunteers suffering from MetS, followed a specially designed dietary therapy consists of a low caloric balanced diet, accompanied by either 30% doum biscuits (group A), or whole wheat biscuits (group B) for four weeks (phase 1). During the next four weeks, they were continued on the hypocaloric diet alone (phase 2).

RESULTS: The health effects of two dietary therapies were more prominent in improving the biochemical markers of the MetS than in the body weight reduction. The lower levels of serum vaspin were significantly increased at the end of the 1st phase in both groups especially group (A). Sustained negative correlations were detected between vaspin level and both of C-peptide and insulin resistance expressed as modified homeostatic model assessment (M.HOMA).

CONCLUSION: The effect of the dietary supplements may play a role in alleviating the impact of the components of the MetS and may also sustain the level of the vaspin in the sensitization of the C-peptide in order to attain glucose homeostasis.

Introduction

Vaspin (visceral adipose tissue-derived serpin; serpinA12) was originally identified as an adipokine, which is predominantly secreted from visceral adipose tissue in Otsuka Long-Evans Tokushima fatty (OLETF), an animal model of obesity and type 2 diabetes. Rat, mouse and human vaspins are made up of 392, 394, and 395 amino acids respectively; exhibit approximately 40% homology with alpha 1- antitrypsin: and are related to serine protease inhibitor family (vaspin 1). Consistent with that higher vaspin serum concentrations and increased vaspin mRNA expression in human adipose tissue were found to be associated with obesity, insulin resistance, and type 2 diabetes in humans. However, the mechanisms how vaspin secretion may be linked to deterioration of glucose metabolism and insulin sensitivity are not entirely understood [1].

The induction of vaspin mRNA expression could represent a compensatory mechanism associated with obesity, severe insulin resistance and type 2 diabetes mellitus; however it is unclear whether a correlation exists between human vaspin serum levels and markers of insulin sensitivity and glucose or lipid metabolism [2]. Vaspin serum concentrations show a food intake-related diurnal variation. Vaspin is also expressed in the skin, hypothalamus, pancreatic islets, and stomach. Administration of vaspin to obese mice improves glucose tolerance, insulin sensitivity, and reduces food intake [1].

Until now molecular target(s) of vaspin and its mode of action are unknown. Thus, identification of the proteases, which are inhibited by vaspin may lead to the development of novel strategies in the treatment of obesity, diabetes and insulin resistance [1]. Vaspin serum concentrations have been shown to

be lower in lean subjects and competitive sportsmen with long-term physical training, but they are increased with weight loss associated with a physical training programme. In conclusion, there is at present no clear proof of a causal link between vaspin and visceral fat accumulation, or insulin resistance [2].

Long-term high-fat diet could induce obesity metabolic syndrome in Sprague Dawley (SD) rats and finally lead to lower vaspin of sera and periepididymal fat, while pioglitazone and chronic calorie-control ingestion could enhance the production of vaspin. It was undoubtedly demonstrated that vaspin expression was strongly associated with insulin sensitivity, serum free fatty acids (FFA), and tumor necrosis factor-alpha (TNF α) [3].

Previous studies on doum (*Hyphaene Thebaica*) had focused on the fruit because of its nutritional value and its anti- inflammatory effect. It was reported that diet supplementation with some Egyptian plants like fennel, carob and doum have a promising anti - inflammatory influence on attenuating the complications associated with the renal dysfunction [4]. Research on the fruit pulp showed that it contains nutritional trace minerals, proteins, and fatty acids, in particular the nutritional essential linoleic acid [5]. Doum was reported to contain important substances including saponins, tannins, and flavonoids [6]. Grains high in insoluble fiber (wheat) moderately lower the blood glucose, blood pressure levels, visceral obesity and also have a prebiotic effect [7].

The aim of this study was to investigate the association between the circulating vaspin concentration in MetS syndrome patients and both glucose homeostasis and insulin sensitivity, in addition to investigating the metabolic impact of two different dietary therapies in such conditions.

Materials and Methods

Materials

Wheat grains (Giza 168) was purchased from Wheat Research Department, Field Research Institute, Agric. Res. Center, Giza, Egypt. Wheat flour (WF) 72% extraction was purchased from the North Cairo Flour Mills Company, Egypt. Dry doum flour was obtained from local herbal shop, Dokki, Egypt. Skimmed milk, sucrose, shortening, corn oil, baking powder, emulsifier, vanilla, bread improver and eggs were purchased from the local market, Dokki, Egypt.

Preparation of flour

Wheat grains (Giza 168) were cleaned, tempered (15% moisture) and milled (Quadrumat Junior flour mill) to 100 % extraction flour. Whole meal wheat flour100 % extraction (WMWF) was well blended with doum flour (DF) to produce individual mixtures containing 0, 20, 25 and 30% replacement levels. All samples were stored in airtight containers and kept at 5-7ºC until required.

Preparation and evaluation of biscuits

Biscuits (basic and modified formulas) were prepared by mixing whole meal wheat flour100 % extraction with doum flour at levels (0, 20, 25 and 30%) with other ingredients. Then 14.7 ml of dextrose solution (5.93%) and the suitable amount of water were added according to AOAC (2000) [8]. These formulas were baked in a special oven at 200 °C for about 15 minutes, Table 1. According to the panel test that was carried out, 30% doum biscuit was the choice, formula (5), to be compared with 100% whole meal wheat flour, formula (2).

Table 1: Composition of mixtures used in manufacture of biscuits.

Ingredients (in grams)	Basic formula1	Modified Biscuits			
		2	3	4	5
Wheat flour (WF 72% extraction)	100	--	--	--	--
Whole meal wheat flour (WMWF)	--	100	80	75	70
Doum flour (DF)	--		20	25	30
Sucrose	50	--	--	--	--
Corn oil	28	5	5	5	5
Baking powder	1.1	1.1	1.1	1.1	1.1
Salt	1.0	1.0	1.0	1.0	1.0
Emulsifier	--	1.0	1.0	1.0	1.0
Skim milk	--	5	5	5	5
Eggs	20	--	--	--	--

Analytical methods of the biscuits

Moisture, crude fiber, ash, protein and fat of biscuits were determined according to standard method [8]. Total carbohydrates were calculated by difference. Individual elements (Ca, P, K, Na, Fe, and Mg) in the two samples of biscuits were determined according to the method described by Chapman and Pratt (1978) [9]. Polyphenols were determined using standard method [10].

Subjects

Fifty eight obese women suffering from metabolic syndrome (MetS), shared as volunteers in this study which lasted for 8 weeks. They were enrolled in program for losing weight in the National Research Center (NRC) after taking approval from the Ethical Committee of the NRC and written informed consent from each of them. The study was divided into two phases, phase (1) and phase (2) each one lasted for 4 weeks. Their mean age was 48.8±0.87 years and had a mean BMI of 38.6± 0.90 kg/m². The patients were divided into two groups, group (A) and group (B). At phase (1), group (A) followed a low caloric balanced diet (1000-1200 K calories), accompanied by the 30% doum biscuits, that was consumed before breakfast (2 biscuits) and before dinner (1 biscuit), each biscuit weighed 20g, while group (B) consumed the whole wheat (0% DF)

biscuits with the same instructions. Phase (2) lasted for 4 weeks in which the volunteers were following only the same low caloric balanced diet. All women were subjected to thorough clinical examination. Blood pressure was recorded.

Anthropometric parameters and blood pressure measurements

Relevant anthropometric measurements were reported including height, weight and minimal waist circumference (MWC) using standard method [11]. Body Mass Index (BMI) was calculated (weight in kg/ height² in meter). Blood pressure for each patient was measured 3 times and the mean was recorded.

Blood sampling and Biochemical analysis

Fasting blood samples (after 12 hour fasting) were drawn from the patients. Fasting blood glucose was determined on fresh samples; other biochemical parameters were performed on fasting sera that were stored at -70 C° until used. Fasting blood glucose (FBG) was determined in fresh samples using glucose oxidase method [12]. Serum total cholesterol, HDL-C and triglycerides were done using; cholesterol proceed No 1010 [13], Stanbio, HDL-C proceed No 0599 StanioLiquicolor [14], and triglycerides proceed No 2100 [15], (Enzymatic method) respectively. LDL-C was calculated according to Friedewald equation [16]; where LDL-C= (Total Cholesterol) - (HDL-C) - (TG/5).

Serum C peptide was done by ELISA kit. PR. Code=2725-300A. Lot#EIA-27K2G1. Monobind, Inc. Lake Forest, CA (92630) USA [17]. Modified homeostatic model assessment of insulin resistance (M.HOMA-IR) =1.5+fasting blood glucose x fasting c-peptide/2800 [18]. Quantitative measurement of serum vaspin (visceral adipose tissue-derived serpin) using the RD191097200R Human Vaspin ELISA BioVendor Research and Diagnostic Products, Finland [19].

All the above mentioned parameters were done before the start of the regimen (basal), after 4 weeks and lastly at the end of the study.

Dietary recalls

Collecting detailed data about nutritional habits and food intake through 24 hour recall. Analysis of food items using World Food Dietary Assessment System, (WFDAS), 1995, USA, University of California.

Statistical analysis

All values were expressed as mean value ± SE. Two tailed student t-test was used to compare between the two groups. Correlation between the different parameters was tested by Pearson test. P values <0.05 were considered statistically significant. SPSS window software version 17.0 (SPSS Inc. Chicago, IL, USA, 2008) was used.

Results

Data presented in Table 2 show the proximate composition of the prepared biscuits. Moisture, crude fiber, and ash increased in prepared biscuits with increasing the DF level, whereas protein, fat and total carbohydrates contents decreased in biscuits substituted with DF compared to the biscuit prepared from WMWF without DF. Results indicated that addition of DF to WMWF caused changes in mineral contents (P, K, Ca, Mn, Na and Fe) of biscuits samples supplemented with DF. Determination of the polyphenol content of both type of biscuits showed that the 0% DF biscuit contain 110 mg/100 g while 30% DF biscuit contain 164.3 mg/100 g.

Table 2: Compositions of the two types of the biscuits (/100g).

Constituents	WMWF Biscuits (0% DF)	30% DF Biscuits
Moisture (%)	3.82 ± 0.22	4.80 ± 0.12
Protein (g)	13.5 ± 0.18	11.75 ± 0.34
Fat (g)	7.25 ± 0.35	6.50 ± 0.15
Carbohydrates (g)	75.62 ± 0.77	72.45 ± 0.69
Crude fiber (g)	1.85 ± 0.02	5.60 ± 0.40
Total Ash (g)	1.78 ± 0.12	3.70 ± 0.25
Phosphorus (mg)	187 ± 0.12	305 ± 0.11
Potassium (mg)	115 ± 0.09	290 ± 0.21
Calcium (mg)	40 ± 0.03	70 ± 0.01
Magnesium (mg)	115 ± 0.08	84 ± 0.03
Sodium (mg)	650 ± 0.11	420 ± 0.13
Iron (mg)	3.5 ± 0.03	2.8 ± 0.01
Polyphenols (mg)	110.0 ± 0.12	164.3

Values are means of three determinations ± SE.

Tables 3 & 4 showed a comparison between the different macronutrients and micronutrients and the percent caloric distribution of the habitual diet of the whole sample before starting the regimen and of the two regimens phases.

Table 3: Mean ± SE of the daily nutrients intake at the different phases of the study.

Nutrients	Habitual diet	Regimen with WMWF Biscuits	Regimen with 30% DF Biscuits
Energy (kcal)	2230.02 ± 9.18	1143.39 ± 4.16	1127.18 ± 7.21
Protein (g)	89.74 ± 4.59	58.02 ± 2.33	56.97 ± 3.43
Carbohydrate (g)	265.90 ± 12.88	144.0 ± 6.28	142.33 ± 6.22
Fat (g)	87.19 ± 4.81	34.87 ± 1.64	34.421 ± 2.14
Calcium (mg)	765.37 ± 6.20	519.21 ± 3.25	537.21 ± 5.22
Iron (mg)	16.69 ± 0.97	13.24 ± 0.12	12.82 ± 1.42
Sodium (mg)	3919.55 ± 2.35	2123.46 ± 3.47	1985.40 ± 3.50
Potassium (mg)	2871.25 ± 5.56	2842.14 ± 3.18	2947.14 ± 3.43

The data showed the balanced and healthy distribution of the macronutrients in the two regimens compared to the habitual diet of the patients.

Table 5 showed the mean± SE of age, anthropometric, blood pressure measurements of group A and group B at the start of the study and at

the end of the two phases of regimen. All the anthropometric measurements and the blood pressure values of the two groups decreased significantly at p<0.05-0.01 at the end of phase (1).

Table 4: Percent caloric intake from the three main macronutrients of the habitual diet of the patients and the two different regimens.

Nutrients	Habitual diet	Regimen with WMWF Biscuits	Regimen with 30% DF biscuits
Total Calories	2230.02	1143.4	1127.2
% Calories from protein	16.1	20.3	20.2
% Calories from carbohydrate	47.7	50.4	50.4
% Calories from fat	35.2	27.4	27.5

Significant reduction of all the anthropometric measurements reported in group (A) at the end of phase (2), blood pressure values decreased numerically, while patients of group (B) showed only numerically reduction in the weight, BMI and SBP, but significant decrease in the other parameters.

Table 6 showed the mean value ± SE of the biochemical parameters of the two groups at the three visits. At phase (1), the results showed significant increase in the mean levels of vaspin and HDL-C at p<0.05-0.01 among both groups. However, the percent increase was higher among group (A). The FBG concentration, other lipid parameters, C-peptide and M.HOMA-IR showed significant reduction of the concentration in both groups, also this decrease was higher among group (A), except triglycerides and VLDL-C. At phase (2), the level of HDL-C decreased significantly compared to phase (1) between both groups, the percent decrease was more among group (B), while the other parameters showed significant increase which was higher among group (B) compared to group (A) except of FBG, vaspin and C-peptide. Yet, M.HOMA-IR showed no difference between the two groups.

Table 5: Mean ± SE of the anthropometric & blood pressure measurements of the two samples at the base and at the two phases of the study.

Patient's characteristics	Age (yr)	Height (cm)	Weight (kg)	BMI (Kg/m^2)	Waist (cm)	Abd. 2 (cm)	Hip (cm)	WHR (cm/cm)	Biceps ext.(cm)	SBP (mmHg)	DBP (mmHg)
Basal											
Group (A)	50.3±0.81	157.9±1.01	96.8± 3.21	38.8±1.24	101.9±2.12	122.1±2.34	123.6±2.12	0.83± 0.01	34.5± 0.92	137.7±1.91	91.3±1.42
Group (B)	46.9±0.87	158.0±1.22	96.5± 3.69	38.2±1.33	96.1±2.05	120.1±2,48	122.1±2.33	0.79± 0.01	35.1±1.01	138.2±3.27	89.0±1.75
Phase 1											
Group (A)			93.8± 3.23^{**a}	37.6±1.23^{**a}	97.0±2.09^{**a}	118.8±2.08^{**a}	120.0±1.98^{**a}	0.81±0.01^{**a}	32.6±0.82^{**a}	131.9±2.40^{*a}	86.4±1.17^{**a}
Group (B)			93.8± 3.47^{**c}	37.1±1.22^{**c}	92.1±1.99^{**c}	116.6± 2.29^{**c}	118.8± 2.27^{**c}	0.78±0.01^{**c}	33.2±0.97^{**c}	125.8±3.04^{**c}	84.6±1.44^{**c}
Phase 2											
Group (A)			90.9± 3.73^{**b}	36.6±1.44^{**b}	92.9±2,55^{**b}	116.5±2.49^{*b}	118.2±2.45^{**b}	0.78±0.01^{**b}	31.9±0.97^{*b}	128.4±2.85	83.9±1.04
Group (B)			93.1± 3.61	36.8±1.27	90.7±1.88^{*d}	115.5±2.34^{*d}	116.9±2.21^{**d}	0.78±0.01	32.7±1.01^{*d}	123.6±2.51	82.3±1.64^{*d}
% Decrease											
Group (A)											
Basal vs. Ph1			3.1	3.9	4.8	2.7	2.9	2.4	5.5	4.2	5.4
Ph 1 vs. Ph 2			3.1	2.7	4.2	1.9	1.5	3.7	2.2	2.7	2.9
Group (B)											
Basal vs. Ph 1			2.8	2.9	4.2	2.9	2.7	1.3	5.4	9.0	4.9
Ph 1 vs. Ph 2			0.8	0.8	1.5	0.9	1.6	0	1.5	1.8	2.7

a&c: Basal vs. Phase 1 b&d: Phase1 vs. Phase 2 Significant at *p<0.05 **p<0.01

Table 7 showed the correlation coefficient between the vaspin concentration and the different MetS criteria in the two groups. No significant correlations were reported between the vaspin concentrations and the different criteria in group (A), at the basal and at the end of the two periods of intervention. Group (B) showed significant negative correlation with FBG, C-peptide and M.HOMA, at the end of phase (1), while at the end of phase (2) significant positive correlation with body weight, BMI, MWC, SBP and DBP and significant negative correlation HDL-C, C-peptide and M.HOMA.

Table 6: Mean ± SE of the biochemical parameters of the two groups at the three different visits.

Bioche-mical parame-ters	Vaspin (ng/ml)	FBG (mg/dl)	Triglyceride (mg/dl)	VLDL-C (mg/dl)	T. cholesterol (mg/dl)	LDL-C (mg/dl)	HDL-C (mg/dl)	Non-HDL-C (mg/dl)	Risk factor	C-peptide (ng/ml)	Modified HOMA
Basal											
Group (A)	0.23±0.08	128.9±7.14	188.5±13.68	37.7±2.74	224.7±6.0	139.9±4.87	47.1±1.06	177.6±6.26	4.9±0.17	2.76±0.22	1.64±0.02
Group (B)	0.40±0.20	106.3±7.13	136.0±8.64	27.2±1.73	209±9.21	137.8±8.94	43.9±2.01	165.0±9.37	4.9±0.27	2.73±0.22	1.61±0.01
Phase (1)											
Group (A)	0.31±0.10^{*a}	106.9±6.06^{**a}	149.0±11.68^{**a}	30.0±2.34^{**a}	195.3±7.49^{**a}	105.7±5.97^{**a}	59.6±1.44^{**a}	135.7±7.56^{**a}	3.3±0.16^{**a}	2.21±0.22^{**a}	1.59±0.01
Group (B)	0.41±0.01^{*c}	89.5±3.10^{*c}	107.1±6.71^{**c}	21.4±1.34^{**c}	181.8±6.64^{**c}	106.2±6.07^{**c}	54.2±2.05^{**c}	127.6±6,70^{**c}	3.4±0.18^{**c}	2.43±0.20^{**c}	1.58±0.01
Phase (2)											
Group (A)	0.28±0.11^{*b}	111.3±5.67	156.2±13.88	31.2±2.78	211.0±6.32^{*b}	124.3±5.62^{*b}	55.5±2.45^{*b}	155.5±7.90^{*b}	4.1±0.25^{**b}	2.27±0.19	1.59±0.01
Group (B)	0.42±0.20	92.7±2.16	122.6±8.51^{*d}	24.5±1.70^{*d}	204.9±10.03^{**d}	130.9±9.44^{**d}	49.5±1.82^{*d}	155.4±9.72^{**d}	4.2±0.23^{**d}	2.47±0.22	1.58±0.01
% Change											
Group (A)											
B vs. Ph 1	17.4	-17.1	-20.5	-20.4	-13.1	-24.5	26.5	-23.6	-32.7	19.9	-3.1
Ph1 vs. Ph 2	-9.4	4.1	4.2	4	8.0	17.6	-6.9	14.6	24.2	2.7	0
Group (B)											
B vs. Ph 1	2.5	-15.8	-21.3	21.3	13.0	-22.9	23.5	-22.7	30.6	-11.0	-1.9
Ph1 vs. Ph 2	2.4	3.6	14.5	15.9	12.7	23.3	-8.7	21.8	23.5	1.7	0

Group (A) a: Basal vs. Phase (1) b: Phase (1) vs. Phase (2) Group (B) c: Basal vs. Phase (1) d: Phase (1) vs. Phase (2). Significant *P<0.05 **P<0.01.

Table 7: Correlation coefficients between vaspin (ng/ml) and different criteria of MetS.

Parameters	Group (A) (no.=34)			Group (B) (no.= 24)		
	Basal	Phase (1)	Phase (2)	Basal	Phase (1)	Phase (2)
Age (yr)	0.076	-0.040	0.048	-0.280	-0.284	-0.298
Weight (kg)	-0.190	-0.187	-0.200	0.082	0.134	0.566**
BMI (kg/m^2)	-0.237	-0.230	-0.250	0.089	0.152	0.680**
MWC (cm)	-0.074	-0.086	-0.111	0.139	0.166	0.715**
SBP (mmHg)	-0.293	0.000	0.020	0.248	-0.100	0.583**
DBP (mmHg)	-0.185	0.162	0.318	0.232	0.043	0.667**
FBG (mg/dl)	-0.206	-0.225	-0.241	-0.180	-0.573**	0.184
TG (mg/dl)	-0.156	-0.102	-0.115	-0.108	0.014	0.214
HDL-C (mg/dl)	-.0282	0.016	-0.281	-0.042	-0.049	-0.438**
C-peptide (ng/ml)	-0.264	-0.164	-0.155	-0.348	-0.524**	-0.445**
M.HOMA	-0.210	-0.161	-0.910	-0.286	-0.504*	-0.485**

Numbers presented in this table are the value of r =correlation coefficient; *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

Discussion

It has been reported that abnormality in the circulating level of vaspin is related to BMI, visceral obesity and insulin sensitivity in the metabolic syndrome patients. The objective of this study was to explore the effect of special diet therapy on the different MetS criteria and to assess the variation in vaspin concentration in this condition. In this context the findings of this study showed the beneficial healthy effects of the two different dietary therapies used. However, it is important to report that this effect was more prominent in improving the related biochemical markers of the MetS than its effect on body weight reduction. Furthermore, in the phase (2), stopping the use of these dietary supplements that were used in conjunction with the hypocaloric regimen in phase (1) of the study was followed by an increase of biochemical parameters: FBG and the lipid profile, with a decrease in the HDL-C in spite of the continual decrease in the body weight, BMI and MWC. This finding could be attributed to the active biological nutritional contents of the doum fruits and the whole wheat which could be of great merit for the use with such patients.

Controversial results were reported concerning the association between vaspin concentration and the MetS criteria. Studies in animals indicated that vaspin is an endogenous insulin sensitizer [20], and that it is elevated in overweight and obese type 2 diabetes [21]. However, in humans the effect of vaspin on insulin sensitivity is uncertain and the correlation between vaspin and BMI is also unclear [19]. Youn et al. [22] reported that elevated vaspin levels are associated with decreased BMI together with improvement in insulin sensitivity and fitness level. Data of this study indicated that in group (A), elevation of the MetS components was accompanied by lower levels of serum vaspin concentration compared to group (B). In addition vaspin concentrations were significantly increased after the first 4 weeks of dietary therapy in both groups, especially in group (A). It is interesting to notice here that the percent increase of the serum vaspin concentration in group (A) was nearly similar to the percent decrease of the levels of FBG and C-peptide, but less decrease was found in the calculated M.HOMA. In phase (2), the variations in vaspin in both groups were insignificant.

Correlation analysis revealed mostly no significant correlations throughout the duration of the study. However, the elevated levels of vaspin such as in the case of group (B) at the end of phase (1) were significantly negatively correlated with FBG, C-peptide and M.HOMA values; while at the end of phase (2) there was a reversal to positive significant correlations with BMI, MWC, SBP and DBP while the negative correlations were sustained with C-peptid and the MHOMA. In this condition we can conclude that the association between the MetS criteria was revealed at higher levels of the vaspin. The role of vaspin as an anti-inflammatory adipokine was suggested by Auguet et al. [23], who reported that vaspin may have a compensatory role in the underlying inflammation of obesity as evidenced by being negatively correlated with the inflammatory markers. Hida et al. [20] reported that administration of recombinant human vaspin improved insulin sensitivity and glucose tolerance and reversed the expression of those genes that could promote insulin resistance such as leptin, resistin and TNF-α in diet-induced obese mice. This is in agreement with our findings regarding the detected lower levels of the vaspin in group (A) patients which exhibited high levels of all MetS components, which are well known to be associated with high levels of the inflammatory markers. In addition, the elevation of the serum vaspin concentration at the end of phase (1) in both groups could be attributed to the anti-inflammatory properties of the two supplements working in synergism with vaspin.

In conclusion, the effect of the supplements may play a role in alleviating the impact of the components of the MetS and to sustain the level of the vaspin in the sensitization of the C-peptide in order to attain glucose homeostasis.

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