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Association between Serum Clusterin and Cognitive Functions in Obese Egyptian Women; Potential Effects of Dietary Therapy

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ABSTRACT

The present study aimed to demonstrate the effect of using two supplements made from soya bean flour mixed with either 5% turmeric (formula 1) or 5% ginger (formula 2), in junction with a balanced hypocaloric regimen on the cognitive functions of middle aged Egyptian obese women. Seventy two obese women suffering from obesity participated in this study which lasted for 8 weeks, divided into phase (1) and phase (2), each one lasted for 4 weeks. The participants were divided into group (A) and group (B). During the first phase, group (A) consumed a low caloric diet and formula 1, while group (B) consumed formula 2 with the same instructions. During the second phase, both supplements were omitted. Assessment of anthropometric parameters, lipid profile, fasting blood glucose, serum C-peptide and clusterin were determined. Oral evaluation of the mental and cognitive status was performed. The results showed that both supplements improved the anthropometry, the metabolic profile criteria and the serum clusterin level plus the cognitive functions. The data of this study revealed that serum clusterin levels might mirror its contribution in the earliest cognitive impairment in the middle age obese persons. Utilizing nutritional supplements may constitute a promising therapeutic treatment in such condition.

Key words: Obesity, Serum clusterin, Cognitive functions, Soya bean, Turmeric, Ginger.

INTRODUCTION

Clusterin (also named apolipoprotein J, sulfated glycoprotein-2, androgen repressed protein, and complement lysis inhibitor) is a heterodimeric glycoprotein in which α and β chains are interconnected via 5 disulfide bonds [1]. Yu et al. [2] reported that in Caucasian and Asian populations there is a strong association between the single nucleotide polymorphisms in the clusterin gene and Alzheimer's disease (AD). Moreover, a study was done on 2010, has shown that increased plasma clusterin concentrations are significantly related to the severity and progression of AD, Thambisetty et al. [3], who suggesting that plasma clusterin is considered as a potential peripheral biomarker AD. An increased of serum clusterin level may be a relevant peripheral biomarker of cognitive dysfunction in chronic obstructive pulmonary disease, and its level is associated with the disease severity [4]. Clusterin may be related to AD pathogenesis through various mechanisms. In the early stage of AD disease, clusterin, could bind amyloid extracellularly, and inhibit the aggregation of amyloid beta (Aβ) monomers into toxic oligomers. In addition, the neurotoxicity of the amyloid might be reduced by the interaction of clusterin with the molecules involved in signal transduction, DNA repair, cell cycle and apoptosis [5].

Sullivan et al. [6] reported that brain apolipoprotein clusterin plays an important role in cholesterol transport and neuronal lipid metabolism, furthermore, it has a role in inhibition of neuroinflamation which thought to be a major factor in AD pathogenesis, and identified as a key component in cerebrovascular diseases. In addition, it is known that neuroinflamation play an important role in dementia pathogenesis [7] and neurodegenerative diseases [8].

Cross-sectional studies suggest that inflammatory proteins such as C-reactive protein and interleukin-6 are elevated in the blood of individuals with AD compared with controls [9].

Soyabeans

The bioactive soybean phytoestrogens are similar to natural estradiol, so could interact with estrogen receptors in the brain, potentially affecting cognition [10]. In addition, soy isoflavones particular genisetin have been shown to have positive effects on the cognitive function in females and mimic the actions and functions of estrogens on the brain. There is emerging evidence that this effect was achieved by an estrogen receptor-mediated pathway and via the inhibition of tyrosine kinase [11].

Turmeric and Ginger

Curcumin, the most active component of turmeric, has various beneficial properties, such as antioxidant, anti-inflammatory, and antitumor effects. Previous studies have suggested that curcumin reduces the levels of amyloid and oxidized proteins and prevents memory deficits and thus is beneficial to patients with AD [12]. The administration of curcumin was effective in preventing neuroinflammation, as well as cell signaling disturbances triggered by Aβ in vivo. Data suggest that nanoencapsulation of curcumin (curcumin-loaded lipid-core nanocapsules) might constitute a promising therapeutic alternative in the treatment of neurodegenerative diseases [13]. A growing number of experimental studies suggest that 6-shogaol, a bioactive component of ginger, may play an important role as a memory-enhancing and anti-oxidant agent against neurological diseases [14].

The aim of this study was to demonstrate the effect of using two supplements, one was made mainly from soya bean flour and turmeric and the other composed of soya bean flour and ginger, in junction with a balanced hypocaloric regimen to explore their effect on the cognitive functions of middle aged obese women.

MATERIALS AND METHODS

Analytical Methods

Basic and modified formulae were prepared by mixing the soy bean flour with 5% turmeric powder (formula 1), or soy bean flour with 5% ginger powder (Formula 2), then with other ingredients according to table (1). 14.7 ml of dextrose solution (5.93%) and the suitable amount of water were added according to [15], to be formed as Syrian bread. These formulae were baked in a special oven at 200 °C for about 15 minutes. Weight, volume, Specific volume, diameter, thickness and spread ratio of the bread were recorded.

Table (1): Formula composition of Syrian bread (g/100g dry weight)

Raw materials	Formula (1)	Formula (2)
Soy bean flour	60	60
Wheat germ	10	10
Turmeric	5	-
Ginger	-	5
Skim milk	10	10
Sauce	5	5
Corn oil	5	5
Black seed	1.5	1.5
Baking powder	2	2
Salt	1.5	1.5

Chemical Composition of the Bread

Moisture, protein, fat, crude fiber and ash of Syrian bread were determined according to [15]. Carbohydrates were calculated by differences. Individual elements in all samples were determined. Fatty acids, amino acids and polyphenols were determined using standard methods [16,17].

Subjects

Seventy two obese women suffering from obesity, participated as volunteers in this study which lasted for 8 weeks. The participants were informed about the purpose of the study and their permission in the form of written consent was obtained. The protocol was approved by the "Ethical Committee" of the "National Research Centre".

The study was divided into two phases, phase (1) and phase (2) each one lasted for 4 weeks. The patients were divided into two groups, group (A), with mean age 46.53±1.70 years and had a mean BMI of 37.75±1.13 kg/m², and group (B), with mean age 51.82±0.93 and mean BMI 35.75±0.70. At phase (1), group (A) followed a low caloric balanced diet (1000- 1200 K calories), accompanied by the supplement made from soya bean flour mixed with 5% turmeric powder (formula 1) that was made in the form of Syrian bread, two services was consumed with breakfast (40 g) and one service with dinner (20 g) instead of Baladi bread. Group (B) consumed another formula of the bread made from soya bean flour mixed with 5% ginger powder (formula 2) with the same instructions. Phase (2) lasted for 4 weeks in which the volunteers were following only the same low caloric balanced diet with replacement of Syrian bread with the baladi bread. All women were subjected to thorough clinical examination.

Anthropometric Parameters

Body weight, waist circumference and hip circumference were reported. Body mass index (BMI) and waist hip ratio (WHR) were calculated as weight in kg/ height^2 in meter and waist in cm/ hip in cm, respectively [18].

Dietary Recalls

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

Blood Sampling and Biochemical Analysis

Fasting blood samples (12 hour fasting) were drawn from the patients. Glucose and lipid profile were measured by Olympus AU400. Serum C peptide was estimated by ELISA kit. PR. Code=2725-300A. Lot#EIA-27K2G1.Monobind, Inc. Lake Forest, CA (92630) USA, [19]. Modified homeostatic model assessment of insulin resistance (M.HOMA-IR) was calculated, where M.HOMA-IR=1.5+fasting blood glucose x fasting C- peptide/2800 [20]. Serum clusterin was detected by Human Clusterin ELISA Kit cat.No. RD194034200R, Bio Vender-Laboratornimedicinaa.s. 621 00 Brno CZECH REPUBLIC [21].

Cognitive and Mental Evaluation

All subjects were examined at baseline and by the end of the study i.e. after 8 weeks of following the dietary therapy. The following tests were done:

1-Mini Mental State Examination (MMSE)

It is a sensitive and reliable 30-points questionnaire that is used in clinical and research settings to evaluate mental and cognitive status. It is the most commonly used test for complaints of memory problems, it is also used to estimate the severity and progression of cognitive impairment and to follow the course of cognitive changes in an individual over time; thus making it an effective way to document an individual's response to treatment. Administration of the test takes between 5–10 minutes and examines functions including attention, calculation, recall, language, commands and orientation [22].

2-Sleep and Life Style Questionnaire

A questionnaire designed to evaluate subjective sleep quality and number of sleeping hours and their pattern. Evaluation of life style was achieved through questioning: Exposure to sun: time, duration and clothing. General subjective life stresses, mood, tea and coffee consumption, general activity and history of exercising, which were recorded and put on a 3 points scale [23].

Classification and Scoring System

MMSE: 22-26 =1, 26-28=2 and 28- 29=3. Sleeping hours: 4-6 =1, 6-8 =2 and 8-10 = 3. Mood: bad =1, regular =2 and good =3. Tea and coffee consumption (number of cups per day): 0-1 =1, 2-4 =2 and 5-8 =3. Exposure to sun, sleep quality, stress, general activity and exercising: 1=low, 2=medium and 3 =high.

Statistical Analysis

All values were expressed as mean value ±SE. Two tailed student t-test was used to compare between different phases in the same group. 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

From data presented in table (2), it is clear that, the contents of fat, total carbohydrates and total sugars were higher in Syrian bread (1) than the Syrian bread (2). Tables (3) shows that adding either the turmeric or the ginger to the two supplements enriched its total phenols and iron contents, but decreases the zinc.

Table (2): Chemical composition of the two formulae of the Syrian bread

Formula	Protein	Fat	Fiber	T. CHO	Total sugars
1	32.30 ±0.15[b]	7.11 ±0.06[a]	2.55 ±0.02[a]	27.12 ±0.15[a]	9.08 ±0.07[a]
2	34.60 ±0.17[a]	6.96 ±0.09[b]	2.47 ±0.02[b]	17.42 ±0.14[b]	6.28 ±0.05[b]
LSD at 0.05	0.120	0.096	NS	0.035	0.071

T.CHO: Total carbohydrates

Table (3): Iron, zinc and phenol contents in dry tested samples

Samples	Fe (mg/100g)	Zn (mg/100g)	Total phenol (As tannin)
Soy bean flour	102	34.2	5796.98
Tumeric bread	150	30.2	7530.57
Ginger bread	145	10.32	7561.66

Figures (1,2,3) show that addition of the turmeric powder to the soya bean flour increases its content of the linoleic fatty acids (n-6) and linolenic fatty acids (n-3). While ginger powder increases its content of oleic (n-9), linoleic and linolenic fatty acids in various ranges. The monounsaturated Eurcic (n-9) fatty acid was found in allowance range.

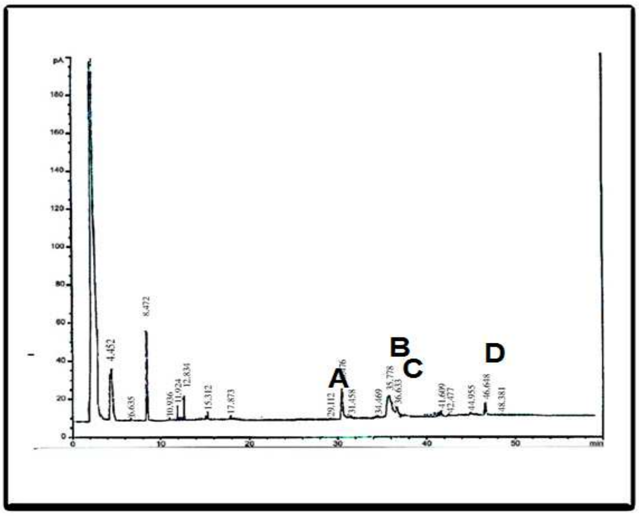

Figure (1): Relative area % of fatty acids content in soy bean, (A) Palmetto-oleic (C16:1) 0.39 %, (B) Oleic (C18:1, n-9) 21.86 %, (C)Linoleic (C18:2, n-6) 5.54 % and (D) Erucic (C22:1, n-9) 2.94

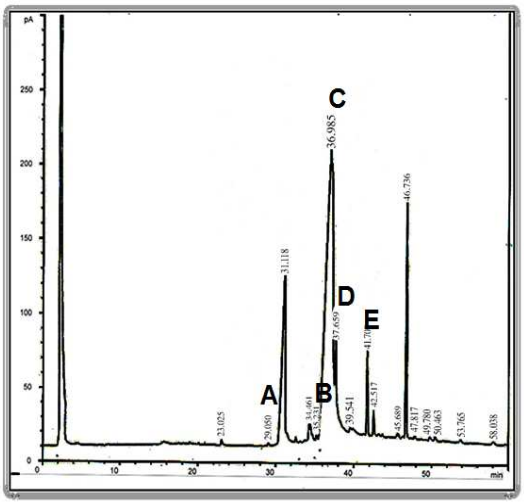

Figure (2): Relative area % of fatty acids content in turmeric bread, (A) Palmetto-oleic (C16:1) 0.12 %, (B) Oleic (C18:1, n-9) 0.18 %, (C)Linoleic (C18:2, n-6) 59.1 %, (D) Linolenic (C18:3, n-3) 8.1 % and Erucic (C22:1, n-9) 7.4 %

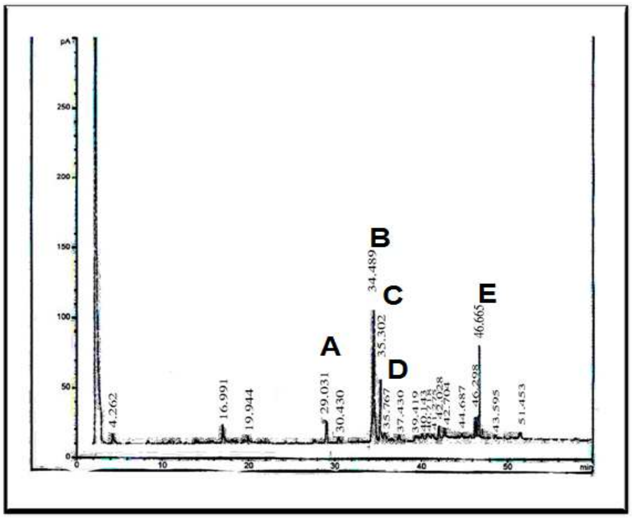

Figure (3): Relative area % of fatty acids content in ginger bread, (A) Palmetto-oleic (C16:1) 5.76 %, (B) Oleic (C18:1, n-9) 31.76 %, (C)Linoleic (C18:2, n-6) 11.63 %, (D) Linolenic (C18:3, n-3) 3.55 % and Erucic (C22:1, n-9) 15.55 %

Table (4) shows the Amino acids levels (mg/g) in tested samples.The three samples have high content of the glutamic acid that followed by the phenylalanine amino acid and the branched chain amino acids Lysine and Leucine. Tyrosine amino acid was found in the two supplements only.

Table (4): Amino acids levels (mg/g) in tested samples

Amino acids	Turmeric bread	Ginger bread	Soya bean flour
Aspartic	15.5	12.3	15.5
Glutamic	119.2	97.8	119.6
Alanine	16.7	15.0	20.2
Methionine	8.6	8.1	9.4
Tyrosine	22.7	19.8	-
Phenylalanine	43.2	39.5	87.2
Histidine	24.6	22.3	29.1
Lysine	16.0	13.6	19.2
Leucine	15.9	13.9	19.8
Isoleucine	3.3	3.0	3.5
Arginine	24.4	16.6	29.9

Table (5) shows the mean± SE & %RDAs of the nutrient contents of the habitual diet and the different types of regimens consumed by the obese subjects. The contents of calories, protein, fat and carbohydrate of the habitual diet were high compared to that of the three different regimens.

Table (5): Nutrient contents of the habitual diet and the three different types of the hypocaloric diet consumed by the obese volunteers.

Nutrient intake	Habitual diet	Hypocaloric Diet with Baladi Bread	Hypocaloric Diet with Turmeric bread	Hypocaloric Diet with Ginger bread	RDAs
	Mean ± SE %RDAs				
Energy (kcal)	2717.53±235.01 123.52%	974.25±152.11 44.28%	904.28±70.59 41.10%	901.02±67.20 40.96%	2200
Protein (g)	91.23±27.30 182.46%	52.63±19.17 105.26%	52.23±14.67 104.46%	53.05±11.34 106.10%	50
Fat (g)	123.57±37.08 190.11%	30.17±16.31 46.42%	28.04±13.20 43.14%	27.18±12.37 41.82	65
Carbohydrate (g)	310.12±60.96 103.37%	123.05±32.51 41.02%	110.75±28.71 36.92%	111.05±24.61 37.02%	300
Dietary fiber (g)	18.83±9.97 75.32%	29.19±10.02 116.76%	35.47±8.91 141.88%	35.60±7.84 142.40%	25

Tables (6) shows the mean ± SE of age, body mass index, waist circumference, waist-hip ratio, and the biochemical parameters among obese subjects at the basal and different phases of dietary therapy. The anthropometric measurements of the two groups decreased significantly ($p<0.05$-0.01) at the end of the two phases. The biochemical results showed significant improvement in the FBG and serum lipids profile values at the end of phase (1) in both groups. The C-peptide concentration and the M.HOMA-IR values and clusterin concentrations significantly decreased at p<0.05-0.01 in both groups at phase (1). In group (B), C-peptide and M.HOMA-IR increased significantly at the end of last phase.

Table (6): Mean ± SE of age, anthropometric and biochemical parameters among obese subjects at the basal and different phases of dietary therapy

Parameters	Group (A) (n= 38)			Group (B) (n=34)		
	Base	Mid	Last	Base	Mid	Last
Age (year)	46.53±1.70			51.82±0.93		
BMI (kg/m²)	37.75±1.13	36.47±1.08**a	36.14±1.11**b	35.75±0.70	34.77±0.71**c	34.61±0.70*d
Waist (cm)	100.50±1.89	93.95±1.89**a	89.64±1.70**b	94.10±1.28	89.29±1.38**c	86.76±1.44**d
WHR (cm/cm)	0.82±0.008	0.80±0.009**a	0.78±0.008**b	0.78±0.01	0.77±0.01**c	0.76±0.01**d
FBG (mg/dl)	112.87 ±4.66	99.53±3.89**a	114.02±4.84**b	119.58±5.48	103.19±4.77**c	106.38±4.20
Triglyceride (mg/dl)	139.28 ±13.10	88.86±8.27**a	118.69±7.91**b	135.24±9.30	103.87±7.37**c	102.09±5.41
VLDL-C (mg/dl)	27.86 ±2.62	17.77±1.65**a	23.74±1.58**b	27.05±1.86	20.77±1.47**c	20.42±1.08
T. C. (mg/dl)	243.54±10.18	185.32±6.62**a	205.09±10.53	217.01±9.05	180.57±7.31**c	183.72±5.99
LDL-C (mg/dl)	167.74±10.16	113.21±7.55**a	129.37±10.44	143.56±8.75	107.99±7.87**c	112.05±5.67
HDL-C (mg/dl)	47.93±1.53	54.33±1.74**a	51.98±1.53	46.39±1.38	51.81±1.29**c	51.25±1.64
Non-HDL (mg/dl)	195.61±10.84	130.98±7.16**a	153.11±10.88*b	170.61±8.93	128.76±7.87**c	132.47± 6.07
Risk factor	5.17±0.29	3.47±0.18**a	3.99±0.26*b	4.73±0.22	3.54±0.18**c	3.63±0.15
C-peptide (ng/ml)	4.93±0.97	3.72±0.85*a	4.05±0.91*b	5.07±0.74	3.59±0.47**c	3.72±0.56
M. HOMA-IR	1.69±0.04	1.63±0.03**a	1.67±0.04**b	1.72±0.04	1.64±0.02**c	1.65±0.03
Clusterin (µg/ml)	138.84±20.25	109.49±9.95*a	112.67 ±8.93	124.87±7.50	99.90 ±4.94**c	99.09 ±5.61

*BMI: Body mass index, WHR: Waist hip ratio, FBG: Fasting blood glucose, TC: Total cholesterol, VLDL-C: Very low density lipoprotein cholesterol, HDL-C: High density lipoprotein cholesterol, M.HOMA-IR: Modified homeostatic model assessment of insulin resistance. *P< 0.05 , **P < 0.01*
a: Basal vs. Mid & b :Mid vs. Last in group A
c: :Basal vs. Mid & d: Mid vs. Last in group B

According to the oral cognitive tests all participants showed marked improvement in sleep duration and quality, cognitive functions, general activity, exercising and mood after intervention,Table (7).

Table (7) Cognitive functions tests presented as percentage of obese women at base line stage and after 2 months of intervention

Variable	Score (1) %		Score (2) %		Score (3) %	
	Before	After	Before	After	Before	After
MMSE	10.7	4.3	80.5	86.7	8.8	9
Sleeping hours	31.2	20	59.3	71.5	9.5	8.5
Sleep Quality	38.3	31.8	36.9	43.2	24.8	25
Exposure to sun	48.5	47	31.3	33	20.2	20
Stress	15.3	17	49	48	35.7	35
General Activity	23	11.5	55	65.5	22	23
Exercising	41.8	36.4	50.1	55.6	8.1	8
Mood	26.4	18.6	55.6	62	18	19.4
Tea and coffee consumption	14.3	24	79.5	71	6.2	5

MMSE: Mini Mental State Examination

DISCUSSION

The brain is the mystro of the human body and most complex organ in spite of its small size three-pounds. It is the responsible of cognitive functions, controller of behavior, interpreter of the senses, and leader of body movement. Cognition is the mental activity or procedure of acquiring knowledge, information, production of language, and comprehension through experience, thought, and the senses. It incorporates processes such as intelligence, memory, learning, attention, consideration, evaluation and judgment, calculation and thinking, decision making and problem solving, etc [24].

The middle-aged patients with diabetes have more prominent cognitive decline than people without diabetes. hence, cognitive function should be early assessed and monitored in middle-aged people with type 2 diabetes [25].

The main aim of this study was to explore the effect of some of biological active ingrediants in two supplements, made from soy bean flour with either 5% turmeric or 5% ginger on cognitive functions. Data of this study showed the advantageous impacts of the two dietary treatments on the oral cognitive functions tests. All participants showed marked improvement in sleep duration and quality. Individuals with lack of sleep have a tendency to have slower digestion systems and more elevated amounts of cortisol, the hormone that stimulate fat storage [26] Likewise, these supplements ameliorated the tested biochemical parameters including the clusterin level. Thambisetty et al. [3]

demonastrated that increased clusterin concentration in the plasma could be used as a predictive test of presence of more fibrillar amyloid-beta burden in the the temporal lobe of the brain.

Chemical analysis of the two supplements revealed its high contents of the antioxidant polyphenol which have been hypothesized to have a defensive impact against age-related cognitive impairement by inhibiting the oxidative stress pathways [27]. Products riched in polyphenols (curcumin, green tea, resveratrol, quercetin, epigallocatechin-3-gallate, extract derived from elderberry, and others) have an antioxidant role which protect neuronal cells against any oxidizing agents [28].

In addition, Soybean is rich in monounsaturated fatty acids (MUFAs) polyunsaturated fatty acids (PUFAs) such as linoleic fatty acid (n-6) and alpha-linolenic fatty acid (n-3), furthermore, soybean is relatively low in unhealthy saturated fatty acids [29]. This study showed that addition of the turmeric powder to the soya bean flour increases its content of the n-6 and n-3, while ginger powder increases its content of oleic (n-9), n-6 and n-3 fatty acids in various ranges. The monounsaturated Eurcic fatty acid was found in allowance range. Cognitive impairment (of both vascular or degenerative origin) and age-related cognitive decline can be related to dietary fatty acids contents. Risk of cognitive impairement is declined in people who consumed food rich in PUFA and MUFA. These findings were confirmed by studies in which high intakes of n-3PUFA, n-6PUFA, MUFA, and weekly fish consumption providing large amount of n-3PUFA protected against high risk of intellectual or cognitive functions decline and prevented or delayed the onset of dementia [30]. In that condition, it could be suggested that the elevated unsaturated fatty acids (MUFA and PUFA) and the high levels of antioxidant polyphenols in the two supplements could act synergistically in improving cognitive performance and improve clusterin levels.

The results of this study showed that both types of bread contain considerable amounts of tyrosine, phenylalanine, glutamine and branched-chain aminoacids which could influence the level of clusterin that indicate brain functions improvement. Brain function is influent by the aromatic amino acids ingested in food (tyrosine, tryptophan, and phenylalanine) which are the precursors for biosynthesis of the neurotransmitters dopamine, serotonin, and norepinephrine. Variation in the production of the neurotransmitters directly modify their release from neurons, which impact brain function [31].

The branched-chain amino acids (BCAAs) valine, leucine and isoleucine have an important biochemical role in the brain through direct and indirect ways (energy production; protein synthesis; synthesis of the amine neurotransmitters from tyrosine, tryptophan and phenylalanine aromatic AA). There is a link between diet consumed and production of the amine neurotransmitters (serotonin, dopamine and norepinephrine) via several metabolic reasons (BBB is permeable to BCAAs; liver can not metabolize all BCAA ingested and passes directly into the systemic circulation leading to abrupt elevation of their plasma concentration and result in increasing their uptake into brain), plasma concentrations of BCAA rise appreciably and in proportion to the dietary protein content [32]

The acidic amino acids (aspartate and glutamate) act as neurotransmitters, however, they can not cross the blood brain barrier from the circulation even at high concentrations, except in a few small areas that have fenestrated capillaries [33]. So, ingestion of proteins rich in glutamate and/or aspartate has no impact on the level of acidic amino acid in the brain and consequency on the brain function [31]. Choi et al. on 2009 [34] stated that serotonin synthesis and tryptophan concentrations in brain neurons are sensitive to which protein is found in a food meal.

Data of this study were in line with Korol and Pisani [35] who stated that time of exposure and dose of estrogen can modulate cognition. Their study suggested the sufficiency of activation of a single estrogen receptor type to augment the learning techniques, Korol and Pisani [35] concluded this phenomena following the usage of different estrogenic compounds (isoflavonegenistein found in soybeans, estradiol hormone) that are selective for estrogen receptors. In this context, the isoflavonegenistein found in soybean will allow us to propose a relationship between cognition functions and soya isoflavone.

Accumulation of fat tissue in obese person lead to increase in the secretion of some cytokines and inflammatory cells (IL-6, TNF-α, CRP, and others), these cytokines may interfere with the sensitivity of cells to insulin action to suppress lipolysis [36]. High prevalence of type 2 DM in obese persons is a sequence of insulin resistance which predict the likelihood of developing AD and dementia through different pathophysiological mechanisms (metabolic, hormonal, and vascular) [37]. On 2010, Wagner et al. [38] shown the benefit of isoflavones to improve insulin sensitivity and glycemic levels in postmenopausal diabetic women. Soy protein with its high content of isoflavones may influence insulin action through different mechanisms, one of them is by binding to peroxisome proliferator-activated receptors (PPARs) which are known to be associated with insulin action. Moreover, the two supplements used in this study, turmeric and ginger reported to have antihyperglycemic effects. Nishiyama et al. [39] indicate that both sesquiterpenoids and curcuminoids in turmeric exhibit hypoglycemic impacts via PPAR activation as one of the mechanisms, while Lim et al. [40] reported that the main pharmacological properties of ginger include antihyperglycemic effects. In this study improving of the C-peptide concentration, the M.HOMA values, clusterin values which is presented as a cognitive functions parameter, and oral cognitive tests of the patients after the dietary intervention add further backing and support to this recommended link.

CONCLUSION

The data of this study could lead us to estimate that serum clusterin levels might mirror its contribution in the earliest neurodegenerative processes associated with cognitive impairment in the middle age obese persons. In addition, utilizing supplements contain bioactive ingredients made from soya bean fortified by either turmeric or ginger may constitute a promising therapeutic treatment in such condition. So proper dietary measures or supplementation with specific micronutrients may open new ways for the prevention and management of cognitive decline and dementia.

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