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Research Article

Role of macronutrients during pregnancy and lactation in swiss mice

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ABSTRACT

In the present investigation the role of macronutrients (carbohydrates, proteins and fats) during pregnancy and lactation was studied in Swiss mice. To find out the role of macronutrients, selected pregnant females were fed with High carbohydrate (4gm Potato with 2.31gm Wheat + 2.31gm Maize + 0.93gm Gram + 0.45gm Groundnut), High protein (4ml Egg with 2.31gm Wheat + 2.31gm Maize + 0.93gm Gram + 0.45grm Groundnut) andHigh fat (4gm Sesame seeds2.31gm Wheat + 2.31gm Maize + 0.93gm Gram + 0.45gm Groundnut) diet during gestation and lactation. After parturition the body weight (BW) and crown to rump length (CRL) of pups were recorded on 1st day, 7th day, 14th day and 21st day.Statistically significant changes were noted in the BW of pups on 1st day, 14th day and 21stday in all experimental groups. There was no significant change in the CRL on 1st day but significantly changesoccurred on 7th day, 14th day and highly significant changes were noted on 21st day. In the present investigation it was conclude that high protein diet increased the BW and high fat diet reduced the BW of pups when their mothers were fed during pregnancy and lactation. We also conclude that CRL of pups were also reduced during postnatal days in all groups in comparison to control group.

Key words: Body weight, Crown to rump length, Pregnancy and Lactation, Macronutrients, Swiss mice

INTRODUCTION

Nutrition is called as a science of food values, which is evolved from chemistry and physiology. A healthy diet is required for maintaining optimal health throughout life of organism. For women, good nutrition is necessary for preparing the body for the demands of pregnancy. Proteins, carbohydrates, fats, vitamins, minerals, antioxidants and lactating agents are essential nutrients which are necessary for a pregnant women to reduce the adverse birth out comes. Nutritional requirement changes during the different stages of a life span. Pregnancy is the stage when nutritional requirements are higher. Therefore proper nutrition is important, because nutritional status of mother plays a critical role in the outcomes of pregnancy and also in foetal growth and development[1, 2]. Every year all over the world many children are born with low birth weight[3]. Nearly 3.6 million children are dying during neonatal period [4]. More than one third of child deaths are due to maternal and child under malnutrition[5]. Micronutrients supplements to pregnant women reduce adverse pregnancy outcomes and improve maternal nutrition and immune status[6, 7]. Many developing countries provide iron and folic acid supplements at little additional cost to pregnant women [8]. Carbohydrate provide large amount of energy to the body. Since the energy requirement increases during pregnancy so proper carbohydrate intake by mother is important to ensure adequate glucose for the mother's brain metabolism. Even foetus use glucose as a primary source of energy which comes from carbohydrate. Glucose is main metabolic fuel for the developing embryo and foetus [9]. Body fuel is needed for the physical activity and also for proper organ function which is provided by carbohydrates [10. 11]. Romsonet al.[12] observed normal growth and development in dogs fed with carbohydrate-free triglyceride, but survival of foetuses was lower than the dogs which fed with high carbohydrate diet. Women who consume low carbohydrate foods have low weight gain in pregnancy and also have offspring of lower birth weight[13]. It was demonstrated that increased protein content in the diet may improve weight loss and reduce the loss of lean body mass in overweight and obese individuals[14]. There is evidence that increased protein content may lead to increased fat oxidation, perhaps due to the leucine which causes weight loss. Furthermore, weight regain after the low calorie period ends is less when protein intake is high compared to more normal dietary compositions [15]. Thus, high protein intake seems to be quite advisable during weight loss, at least in obese and overweight individuals. Fatty diet cause

obesity, obesity is complex and chronic disease. It is related with many chronic disorders such as Non-Alcoholic Fatty Liver Disease (NAFLD) [16]. In obesity energy intakes increases and energy output concerning body weight and glucose metabolism decrease so it is a severe metabolic disorder [17]. A study conducted by piers et al.[18] shown that diet high in MUFA (mono unsaturated fatty acid) in obese males resulted in weight loss compared with a diet rich in saturated fatty acids.

MATERIALS AND METHODS

The proposed experiments were conducted in the Environmental and Developmental Toxicology Research Laboratory, Department of Zoology, University College of Science, Mohanlal Sukhadia University, Udaipur, Rajasthan, India to observe the Role of macronutrients during pregnancy and lactation in Swiss mice.

Animals

Healthy adult female Swiss mice 8-10 weeks old and 30gm average body weight were used for this study. Animals were obtained from the animal house of our department. Male and female mice in the ratio (1:4) were kept in the cages for mating. Femalemice were examined every day in the morning and females showing vaginal plug were isolated and their gestation period were recorded. Presence of spermatozoa in the vagina the following morning was considered day one of gestation. Confirmed pregnant females were housed in polyvinyl chloride cages (270×220×140mm) wrapped with rice husk bedding, and maintained under standard laboratory conditions. The laboratory animals were kept in well ventilated animal room with relative humidity of 70-80%. The room lighting consisted of alternate 12 hours light and dark periods.

The animals had free access to food and water*ad labitum*. The maintenance and handling of the animals were done as per the guidelines of Purpose of Control and Supervision of Experimental Animals, Ministry of Environment and Forests, Government of India. The experimental protocols were approved by the Institutional Animal Ethical Committee of the University (No. CS/Res/07/759).

Experimental design

The selected pregnant females were separated in the following groups (six animals in each group and sub-group), to study the variation in BW and CRL on 1st, 7th, 14th and 21st days.

1. Control group [1 mice receiving (3.85gm Wheat + 3.85gm Maize + 1.55gm Gram + 0.75gm Groundnut) for 6 mice(23.1gm Wheat + 23.1gm Maize + 9.3gm Gram + 4.5gm Groundnut)].

2. Experimental group was further divided in to 3 subgroups.

   Group A-

   High carbohydrate (Potato) [receiving (2.31gm Wheat + 2.31gm Maize + 0.93gmGram + 0.45grm Groundnut + 4gm potato) for 1mice]

   Group B-

   High protein (Egg) [receiving(2.31gm Wheat + 2.31gm Maize + 0.93gm Gram + 0.45grm Groundnut + 4ml Egg) for 1mice]

   Group C-

   High fat (Sesame seeds) [receiving(2.31gm Wheat + 2.31gm Maize + 0.93gm Gram + 0.45grm Groundnut + 4gm Sesame seeds) for 1mice]

Estimation of body weight and crown to rump length

After fostered with different diets, mice were kept separately for 42 consecutive days (21 days of gestation and 21 days of lactation). BW and CRL of the control and experimental animals were taken on 1st, 7th, 14th and 21st days after parturition. BW was estimated by WJ series electronic balance model No.WJ302A. CRL was estimated by measuring scale. The data was analyzed statistically using SPSS v. 17 (SPSS, Chicago, USA). The significance differences among means were carried out using Duncan's multiple range tests at $p< 0.05$. The results are expressed as mean ± SD of four experiments.

RESULTS AND DISCUSSION

Details of the BW in various experimental groups are shown in Table 1 and also in Figure. 1 and CRL in table 2 and Figure. 2. A balanced diet is supplemented, which include carbohydrates, lipids, Proteins, vitamins, minerals, antioxidants and lactating agent helps pregnant women to have healthy babies. It is suggested that infections, infectious diseases and weaken immune system increase the risk to mother and her baby. Due to malnutrition many diseases are caused like kwashiorkor, marasmus, anaemia, eye disease, heart disease and reproductive diseases etc. therefore proper nutrition is important for good health, optimal growth, development and prevention of disease [19]. BMI (body mass index) is measured by dividing a person's weight in kilograms by the square of person's height in meters and multiplying by 100. The term BMI is widely used for body fat and has been correlated with other measure of adiposity [20].The body mass index (BMI) is commonly used for adults obesity detection. Obesity is related to the increased risk of diabetes, heart diseases, strokes, hypertension, dyslipidaemia, several cancers, liver and gallbladder disease, sleep apnea, respiratory problems, osteoarthritis, abnormal menses and infertility [21]. Even in mid-life, adiposity strongly contributes to reduce the probability of healthy long term survival in women [22].

Table 1 – Variation in the body weight of pups on 1st, 7th, 14th and 21st days when their mothers are fed on high carbohydrate, high protein and high fat diets.

Treatments	Body weight of pups on postnatal days (in gm.)			
	1st day	7th day	14th day	21st day
Control	1.25±0.18[b]	2.74±0.55[a]	4.37±0.56[a]	6.11±0.82[a]
High carbohydrate	1.23±0.06[b]	2.61±0.17[a]	4.19±0.42[a, b]	6.06±0.16[a]
High protein	1.64±0.05[a]	2.91±0.25[a]	4.71±0.18[a]	6.87±0.25[a]
High fat	0.97±0.25[c]	2.21± 0.26[a]	3.59± 0.11[b]	4.13± 0.15[b]
	F-value- 9.745[**]	F-value- 1.589[ns]	F-value- 4.060[*]	F- value- 13.670[**]

Values are expressed as mean ± S.D. for six female Swiss mice/group, P value >0.05 = non-significant (ns), <0.05 = significant (*) and <0.01 = highly significant (**). Mean followed by the same letter within columns are not significantly different (P < 0.05) using Duncan's multiple rang test.

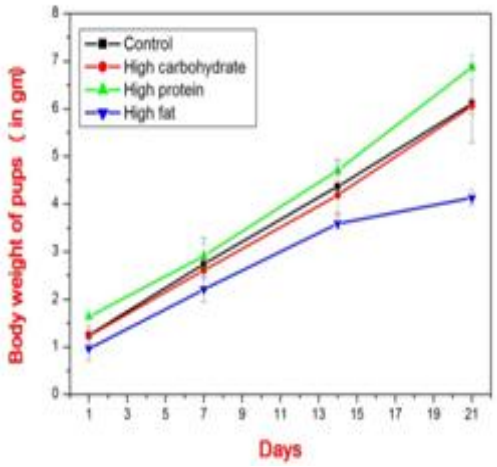

Figure 1 – Body weight of the pups on 1st, 7th, 14th and 21st days when their mothers are fed on high carbohydrate, high protein and high fat diets. Standard deviations (SD) are also presented.

Table 2 – Variation in the crown to rump length of pups on 1st, 7th, 14th and 21st days when their mothers are fed on high carbohydrates, high protein and high fat diets.

Treatments	Crown to rump length of pups on postnatal days (in cm.)			
	1st day	7th day	14th day	21st day
Control	2.35±0.45[a]	3.13±0.48[a]	3.94±0.28[a, b]	4.89±0.49[a]
High carbohydrate	2.37±0.21[a]	2.77±0.21[a, b]	3.37±0.15[a]	4.30±0.17[a, b]
High protein	2.03±0.15[a]	2.63±0.15 [a, b]	3.07±0.12[a]	4.13±0.15[b]
High fat	1.83±0.12[a]	2.23±0.15[b]	2.77±0.12[b]	3.03±0.06[c]
	F-value- 1.895[ns]	F-value- 4.573[*]	F-value- 3.898[*]	F-value- 18.448[**]

Values are expressed as mean ± S.D. for six female Swiss mice/group, P value >0.05 = non-significant (ns), <0.05 = significant (*) and <0.01 = highly significant (**). Mean followed by the same letter within columns are not significantly different (P < 0.05) using Duncan's multiple rang test.

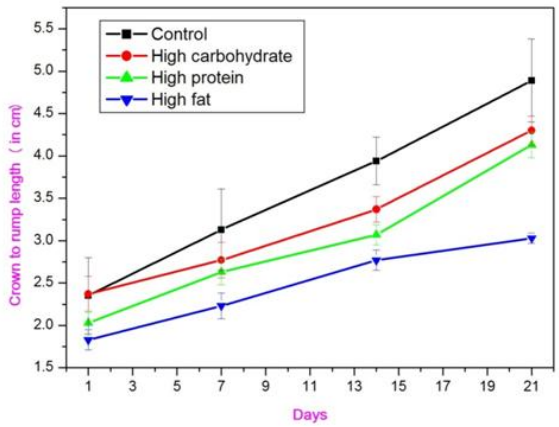

Figure 2 – Crown to rump length of the pups on 1st, 7th, 14th and 21st days when their mothers are fed on high carbohydrate, high protein and high fat diets. Standard deviations (SD) are also presented.

BW and CRL in high carbohydrate group

In the present study BW and CRL are statistically non-significant in high carbohydrate treated group in comparison to control but significant changes are observed when compared with high protein fed group. High carbohydrate diets may be adopted for successful weight management because it is energy restrictive and nutritious [23].Carbohydrates, cereals, fiber and low-glycemic-index foods had a smaller waist circumference and BMI [24]. Low-fat, high-carbohydrate diets have been suggested to promote weight loss in the obese persons[25-27].

BW and CRL in high protein group

BW of pups is significantly different in high protein treated group in comparison to control, high carbohydrate and high fat treated group but CRL is non-significant in comparison to respective groups.Protein seems to act as an appetite suppressant because it can significantly eliminate the calories which people may consume from snacks between their meals. In many clinical investigations U.S. Dietary Guidelines supported the efficiency of high-protein diets for weight loss/fat loss, as well as for improved insulin sensitivity and blood lipid profiles. High protein diet leads to reduced body weight[28-32]. Proteins are the building block of body. It is essential not only to promote liver tissue repair but also helps in preventing fatty infiltration by providing agents such as methionine and choline[33]. It was demonstrated that protein rich diet increases nitrogen in the body tissues, followed by urea production in liver [34]and also decreases urine pH[35]. It was also demonstrated that low protein diet leads to higher level of reactive oxygen species in the body. Study was done in which rats were exposed in utero to a low protein diet; there are fewer but larger liver lobules [36]. It was also found by experiments in rats that protein malnutrition in mother results in decreased postnatal lactase and alkaline phosphatase activities in small intestine which reduce gastrointestinal function in neonates[37].

BW and CRL in high fat group

Highly significant decrease in BW of pups is observed in high fat nurtured group when compared with control, high carbohydrate and high protein treatment group but CRL is not altered in comparison to other group. CRL of pups is decrease in high fat treated group on 21st day in comparison to other groups. High amount of body fat is defined as obesity [38].Fatty diet cause obesity; obesity is complex and chronic disease. It is related with many chronic disorders such as Non-Alcoholic Fatty Liver Disease (NAFLD) [16].Willett [39] suggested that higher percentage of fat in the diet is directly related with higher body weight. When the ethanolic extract of beniseed (sesame) at 3000 mg/kg body weight, with vitamin C administered in sprague-dawley rats it was observed that beni seeds has a potential to increase mean body weights of rats [40]. This is because of the high fat composition of the seeds. According to Alipoor et al. [41]no significant changes in anthropometric indexes like weight and BMI after eating sesame seeds. Some scientist says that sesame seeds consumption resulted in BMI reduction. Sankaret al.[42, 43]observed that Consumption of sesame seeds resulted in weight loss and reductions in body mass index (BMI) in hypertensive diabetic patients. Some scientist says that sesame seeds consumption results in increased BMI. Increase in liver weight was observedin sesaminfed rats at 2-5g/kg [44-48]. Fats are the building blocks for the brain and nervous system. It provides metabolic energy to all the life processes. If we modify the fat components, than normal functioning of body also changes.Fatty acids are important for maternal and infant nutrition[49]. It is postulated that essential fatty acids play important role in pregnancy[50, 51]. During normal pregnancy accretion of fatty acids in a well-nourished woman is 600g fatty acids. Lack of essential fatty acids brings poor vascular growth and consequent coagulation in blood vessels leading to infarctions in the placenta that result in reducedplacental function and low birth weights[52, 49]. High fat diet may contribute in the development of atherosclerosis which leads to a further risk of other cardiovascular events[53, 54]. A low fat diet during pregnancy and lactation helps to prevent metabolic disturbances in the offspring of obese mice with type 2 diabetes mellitus [55].

CONCLUTION

From the present study we conclude that the macronutrients play an important role in the diet of a pregnant woman. High protein diet significantly increases the BW but not induces the obesity in the pups. According to the general hypothesis, high fat diet increases the BW, but it reduces the BW of pups when their mothers are fed with high fat diet during pregnancy and lactation. CRL is unaffected during pregnancy and early lactation in all studied groups in comparison to control but at the end of lactation significant reduction in CRL is observed. By analysing overall results of the present investigation it can be established that by nourishing carbohydrate, protein and fat in diet, different animal groups show variation in body weight and body length. It means that different combinations of diet affects the development of body and other factors which governs the growth of various systems in the body. So we can say that this study provide us a basic platform to evaluate the role of various combination of diet during pregnancy and lactation and focus our attention on the issue that whether these macronutrients play any role in the development of the organism.

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REFERANCES

1. Labuschagne IL, Ackerberg TS, Lombard MJ. Optimal nutrition during pregnancy and lactation. Prof.Nurs. Today 2012; 16: 26-28.
2. Kaiser L, Allen LH. American Dietetic Association. Position of the American Dietetic Association: nutrition and lifestyle for a healthy pregnancy outcome. J. Diet. Assoc.2008; 108: 553-561.
3. Regional and Global Estimates New York, United Nations Children's fund and world health organisation. 2004.
4. Black RE, Cousens S, Johnson HL et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet. 2010; 375: 1969-1987.
5. Black RE, Allen LH, Bhutta ZA et al. Maternal and Child Undernutrition Study Group: global and regional exposures and health consequences. Lancet. 2008; 371: 243-260.
6. Allen LH. Multiple micronutrients in pregnancy and lactation: an overview. Am. J. Clin. Nutr. 2005; 81: 1206S-1212S.
7. Bhutta ZA, Ahmed T, Black RE et al. What works? Interventions for maternal and child undernutrition and survival. Lancet. 2008; 371: 417-440.
8. Shrimpton R, Shrimpton R, Schultink W. Can supplements help meet the micronutrient needs of the developing world? Proc. Nutr. Soc. 2002; 61: 223-229.
9. Koski KG, Hill FW. Effect of low carbohydrate diet during pregnancy on parturition and postnatal survival of the new-born rat pup. J. Nutr. 1986; 116: 1938-1948.
10. CDCP (Centers for Disease Control and Prevention). Protein.2008.http://www.cdc.gov/nccdphp/dnpa/nutrition/nutrition_for_everyone/basics/protein.htm
11. Australian Indigenous Health Info Net. Nutrition Background information. 2013. http://www.healthinfonet.ecu.edu.au/health-risks/nutrition/reviews/background-information.

12. Romson DR, Palmer HJ, Muiruri KL et al. Influence of a low carbohydrate diet on performance of pregnant and lactating dogs. J. Nutr. 1981; 111: 678-689.
13. Shiell AW, Campbell-Brown M, Haselden S et al. High-meat, low-carbohydrate diet in pregnancy: relation to adult blood pressure in the offspring. Hypertension. 2001; 38: 1282-1288.
14. Layman DK, Walker DA. Potential importance of leucine in treatment of obesity and the metabolic syndrome. J. Nutr.2006; 136: 319S-323S.
15. Paddon-Jones D, Westman E, Mattes RD et al. Protein, weight management, and satiety. Am. J. Clin. Nutr. 2008; 87: 1558S-1561S.
16. Altunkaynak Z. Effects of high fat diet induced obesity on female rat livers. Eur. J. Gen. Med. 2005; 2: 100-109.
17. Akiyama T, Tachibana I, Shirohara H et al. High-fat hypercaloric diet induces obesity, glucose intolerance and hyperlipidemia in normal adult male Wistar rat. Diabetes Res. Clin. Pract. 1996; 31: 27-35.
18. Piers LS, Walker KZ, Stoney RM et al. The influence of the type of dietary fat on postprandial fat oxidation rates: monounsaturated (olive oil) vs saturated fat (cream). Int. J. Obes. 2000; 26: 814-821.
19. Soumya D, Siddiqui AA. A Prime Concern on Good Nutrition versus Good Health. J. Food Process Technol. 2011; 2: 132.
20. Bouchard C. BMI, fat mass, abdominal adiposity and visceral fat: where is the "beef?" Int. J. Obes. (Lond). 2007; 31: 1552-1553.
21. Malnick SD, Knobler H. The medical complications of obesity. QJM 2006; 99: 565-579.
22. Sun Q, Townsend MK, Okereke OI et al. Adiposity and weight change in mid-life in relation to healthy survival after age 70 in women: prospective cohort study. BMJ 2009; 339: b3796.
23. Bowman SA, Spence JT, A Comparison of Low-Carbohydrate vs. High-Carbohydrate Diets: Energy Restriction, Nutrient Quality and Correlation to Body Mass Index. J. Am. Coll. Nutr. 2002; 21: 268-274.
24. Toeller M, Buyken AE, Heitkamp G et al. Complications Study Group. Nutrient intakes as predictors of body weight in European people with type 1 diabetes. Int. J. Obes. Relat. Metab. Disord. 2001; 25: 1815-1822.
25. Dreon DM, Frey-Hewitt B, Ellsworth N et al. Dietary fat: carbohydrate ratio and obesity in middle-aged men. Am. J. Clin. Nutr. 1988; 47: 995-1000.
26. George V, Tremblay A, Depres JP et al. Effects of dietary fat content on total and regional adiposity in men and women. Int. J. Obes. 1990; 14: 1085-1091.
27. Prewitt TE, Schmeisser D, Bowen PE et al. Changes in body weight, body composition, and energy intake in women fed highand low-fat diets. Am. J. Clin. Nutr. 1991; 54: 304-310.
28. Baba NH, Sawaya S, Torbay N et al. High protein vs high carbohydrate hypoenergetic diet for the treatment of obese hyperinsulinemic subjects. Int. J. Obes. Relat. Metab. Disord. 1999; 23: 1202-1206.
29. Skov AR, Toubro S, Ronn B et al. Randomized trial on protein vs carbohydrate in ad libitum fat reduced diet for the treatment of obesity. Int. J. Obes. Relat. Metab. Disor.1999; 23: 528-536.
30. Brehm BJ, Seeley RJ, Daniels SR et al. A randomized trial comparing a very low carbohydrate diet and a calorie-restricted low fat diet on body weight and cardiovascular risk factors in healthy women. J. Clin. Endocrinol. Metab. 2003; 88: 1617-1623.
31. Foster GD, Wyatt HR, Hill JO et al. A randomized trial of a low-carbohydrate diet for obesity. N. Engl. J. Med. 2003; 348: 2082-2090.
32. Samaha FF, Iqbal N, Seshadri P et al. Low-carbohydrate as compared with a low-fat diet in severe obesity. N. Engl. J. Med. 2003; 348: 2074-2081.
33. Navder KP, Lieber CS. Nutritional support in chronic disease of the gastrointestinal tract and the liver. In: Nutritional Aspects and Clinical Management of Chronic Disorders and Diseases. CRC Press, 2003; pp307-320.
34. Morens C, Gaudichoni C, Metges CC et al. A high-protein meal exceeds anabolic and catabolic capacities in rats adapted to a normal protein diet. J. Nutr.2000; 130: 2312-2321.
35. Fellstrom B, Danielson BG, Karlstrom B et al. The influence of a high dietary intake of purine rich animal protein on urinary urate excretion and super saturation in renal stone disease. Clin. Sci. 1983; 64: 399-405.
36. Almeida JR, Mandarim-de-Lacerda CA. Maternal gestational protein-calorie restriction decreases the number of glomeruli and causes glomerular hypertrophy in adult hypertensive rats. Am. J. Obstet. Gynecol. 2005. 192: 945-951.
37. Zeman FJ, Shrader RE, Allen LH, Persistent effects of maternal fetal deficiency in postnatal rats. Nutr. Rep. Int. 1973; 7: 421-436.
38. Seidell JC, Deurenberg P, Hautvast JG. Obesity and fat distribution in relation to healthcurrent insights and recommendations. World Rev. Nutr. Diet. 1987; 50: 57-91.
39. Willett WC. Is dietary fat a major determinant of body fat? Am. J. Clin. Nutr. 1998; 67: 556s-562s.
40. Ukwenya VO, Oluyemi KA, Ashamu E etal.Profertility effects of alchoholic extract of sesame in male Sprague-Dawley rats. Internet. J. Nutr. Wellness. 2008; 5:121-127.
41. Alipoor B, Haghighian MK, Sadat BE et al. Effect of sesame seeds on lipid profile and redox status in hyperlipidemic patients. Int. J. Food Sci. Nutr. 2012; 63: 674-678.
42. Sankar D, Rao MR, Sambandam G et al. Effect of Sesame Oil on Diuretics or ß-blockers in the Modulation of Blood Pressure, Anthropometry, Lipid Profile, and Redox Status. Yale. J. Biol. Med. 2006a; 79: 19-26.
43. Sankar D, Rao MR, Sambandam G et al. A pilot study of open label sesame oil in hypertensive diabetics. J. Med. Food. 2006b; 9: 408-412.

44. Sugano M, Inoule T, Koba K et al. Influence of sesame lignans on various lipid parameters in rats. Agric. Biol. Chem. 1990; 54: 2669-2673.
45. Fujiwara FY, Sawada UR, Kuzuyama M et al. Effects of sesamin on fatty acid composition of liver of rats fed n-6 and n-3 fatty acid rich diet. J. Nutr. Sci. Vitaminol. 1995; 41: 217-225.
46. Gu JL, Wakizono Y, TsujitaA et al. Effects of sesamin and alpha tocopherol individually or in combination on the polyunsaturated fatty acid metabolism chemical mediator production and immuno globulin levels in Sprague-Dawley rats. Biosci. Biotech. Biochem. 1995; 59: 2198-2202.
47. Nakabayashi A, Kitagawa Y, Suwa Y et al. alpha-Tocopherol enhances the hypocholesterolemic action of sesamin in rats. Int. J. Vit. Nutr. Res. 1995; 65: 162-168.
48. Yamashita K, Lizuka Y, Imai T et al. Sesame seeds and its lignans produce marked enhancement of vitamin E activity in rats fed a low tocopherol diet. Lipids. 1995; 30: 1019-1028.
49. Gopalan C, Patnaik R. Essential fatty acids in maternal and infants nutrition. Indian J. Biochem. Biophys. 2002; 39: 303-311.
50. Hornstra G, Al MD, Van Houwelingen AC et al. Essential fatty acids in pregnancy and early human development. Eur. J. Obstet. Gynecol. Reprod. Biol. 1995; 61: 57-62.
51. Allen KG, Harris MA. The role n-3 fatty acids in gestation and parturition. Exp. Biol. Med. (Maywood). 2001; 226: 498-506.
52. Althabe O, Laberre C, Telenta M. Maternal vascular lesions in placentae of small gestational age infants. Placenta. 1985; 6: 265-276.
53. Jennings JR, Kamarck TW, Everson-Rose SA et al. Exaggerated blood pressure responses during mental stress are prospectively related to enhanced carotid atherosclerosis in middle-aged Finnish men. Circulation. 2004; 110: 2198-2203.
54. Light KC, Girdler SS, Sherwood A et al. High stress responsivity predicts later blood pressure only in combination with positive family history and high life stress. Hypertension. 1999; 33: 1458-1464.
55. Gallou-Kabani C, Vige A, Gross MS et al. Resistance to high-fat diet in the female progeny of obese mice fed a control diet during the periconceptual, gestation, and lactation periods. Am. J. Physiol. Endocrinol. Metab.2007;292:E1095-1100.