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Research Article

Consumption of Sesame Seeds: Effects on Nutritional and Physiological Parameters in Wistar Strain Rats

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Abstract

Background and Objective: Protein deficiency is a public health problem in developing countries. The search for available and less vegetable protein is recommended as a solution. Nevertheless for their efficient use knowledge of their bio disponibility is recommended. The objective of the present study was to develop sesame seeds as a source of protein to contribute to the resolution of protein-energy malnutrition. **Materials and Methods:** Thus, the overall composition of these seeds was first determined and then an animal experiment was carried out on 12 growing Wistar rats, with soybean as the control food. Two iso-energetic and iso-protein regimes (sesame based diet (SBD), Soybean Based Regime (SBR)) have therefore been formulated. The experiment made it possible to evaluate the growth parameters, blood biochemical and biometrics of the organs of the animals. **Results:** The results for the overall composition gave 7.8% ash, 20.72±0.08% protein, 52.47±0.19% fat, 15.08±0.2% total carbohydrate with an amount of energy of 543.54±1.05 Kcal/100 g MS. In terms of blood biochemical parameters and organ biometrics, the comparative analysis revealed similar values in the rats subjected to the two diets, except the total cholesterol and HDL cholesterol levels, which were higher in the rats subjected to the sesame diet. **Conclusion:** Sesame, therefore, appears to be a good alternative to common vegetable proteins and a means of reducing protein-energy malnutrition.

Key words: *Sesamum indicum*, nutritional quality, rats, malnutrition, protein

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

According to FAO estimates, 11% of the world's population, or 820 million people, suffered from undernourishment worldwide in 2018[1]. Africa would be the region where the proportion of the undernourished population is the highest with 19.9% of the population. Data from the EDS-MICS revealed that acute malnutrition affected 8% of children under five years of age in Côte d'Ivoire with 2% suffering from severe forms[2]. In addition, the North and North-East regions, with a prevalence of more than 39%, had chronic malnutrition profiles close to situations considered critical[3]. Malnutrition is, therefore, a major public health problem in developing countries, particularly in Côte d'Ivoire, and an indicator of food insecurity[4].

Protein deficiency is the most common form of malnutrition in developing countries[5]. Due to their high cost, proteins of animal origin are still inaccessible to a large part of the population[6]. The consumption of vegetable protein sources such as soybeans, groundnuts, cowpeas and peas is, therefore, the ideal alternative for meeting the nutritional needs of this segment of the population. In addition to this economic interest, plant proteins have an interesting nutritional profile. Their high amino acid content (from 22 to 40% of the dry matter of the seed) and their micronutrient composition make them ideal supplements to cereal rations[7,8].

However, in the face of demographic pressure and agricultural constraints, a shortage of known sources of vegetable protein is evident. It's necessary therefore find other options, which could be the development of alternative crops, rich in protein and energy.

Among the many versatile plant species consumed for nutritional and medicinal purposes and identified for industrial use, *Sesamum indicum* is an important plant. The International Plant Genetic Resources Institute (IPGRI) has classified it as a neglected and underutilized crop species and as a "high potential crop"[9]. Sesame is, in fact, rich in fatty acids (45 to 55%), proteins (19 to 25%), and minerals[10].

The present work was undertaken to position sesame as a source of protein in the diet for food diversification and the reduction of protein-energy malnutrition.

MATERIALS AND METHODS

Study area: The studies were carried out in Abidjan, at the Biology and Health Laboratory of the Felix Houphouet Boigny University from March to September, 2021. The rats used for the study also come from this laboratory.

Materials

Animals: The animal material was composed of 12 rats aged approximately 60 days and weighing an average of 65 g. These rats came from the animal house of the Biology and Health Laboratory of Félix Houphouët-Boigny University.

Plants: The sesame seeds were purchased in the town of Ouangolodougou, in Northern Côte d'Ivoire and transported in plastic bags by bus to the city of Abidjan.

Other ingredients: Soybeans, "MAIZANA" brand corn starch and "SUCRIVOIRE" sugar, "OLEO" brand sunflower oil were the lipid source and a vitamin and mineral supplement "VITAMIX SUPER" was purchased in trade in Abidjan.

Methods

Production of sesame flour: For the preparation of sesame flour, the whole seeds were sorted and then ground to a powder using a blender (Moulinex, France). The resulting flour was then stored in the refrigerator for future use.

Determination of the overall composition of sesame seeds: The determination of moisture and dry matter content, protein content, fat content, ash content and sesame seeds was carried out according to the methods described by AOAC[11]. The total carbohydrate content was calculated by difference[12]. The energy value was calculated according to the method of the FAO[13].

Determination of growth parameters

Experimental scheme: Animal experimentation was done according to the method of Bernard *et al.*[14]. It lasted 24 days and took place in two phases: An acclimatization phase of 3 days, during which the animals were fed with a standard food and a 21 days growth phase.

Diets: Two iso-caloric (480 kcal/100 g MS) and iso-protein (10%) diets were prepared (Table 1):

- A soy-based control regime (SBR)
- A sesame-based diet (SBD)

Feeding and growth measurement: The food was fed *ad libitum* once a day, in the form of pureed food with some water added to avoid wastage. The dry matter of the reconstituted products was measured daily on samples taken for this purpose. The next day, before distribution, the refusals (leftovers and wastage) were collected, weighed and then put

Table 1: Composition of the different diets

	Diets	
Ingredients	SBD	SBR
Crushed sesame seeds	48.26	-
Crushed soy-beans	-	32.49
Maize starch	35.77	33.46
Sugar	10	10
Sunflower oil	-	18.05
Minerals	3	3
Vitamins	2.97	3
Proteins (%)	10	10
Grass energy (kcal/100g M.S.)	480	480

SBD: Sesame based diet, SBR : Soybean based regime, Gross energy of the diets is calculated by referring to the combustion values of the different nutrients based on 4 kcal for 1 g of protein, 4 kcal for 1 g of carbohydrate and 9 kcal for 1 g of fat

in an oven (MEMMERT, 854. Schwabach, Germany) at 70°C for 24 hrs to determine their dry matter content. The quantities of food consumed were obtained by the difference between the quantities distributed and the leftovers. Clean water, renewed frequently, was also served *ad libitum* to the animals.

The rats were weighed at the beginning of the experiment, then every three days and a final time on the last day of the experiment.

Expression of growth parameters: Total dry matter ingested (TDMI), total protein ingested (TPI), weight gain (WG) feed efficiency ratio (FER) and protein efficiency ratio (PER) were expressed.

Determination of blood biochemical parameters and organ biometrics

Blood and organ collection: At the end of the experiment, the rats were sacrificed by a section of the jugular vein after anesthesia with ether. Blood samples were then collected and the organs (heart, liver, kidneys, spleen and abdominal fat) were removed and weighed.

Measurement of blood biochemical parameters: The blood samples were preserved in Vacutainer hemolysis tubes and immediately stored in a cooler containing ice before being sent for analysis of the biochemical parameters to the Biochemistry Laboratory of the University Hospital Center (CHU) of Cocody (Abidjan Côte d'Ivoire). Once in the laboratory, the blood was centrifuged at 3000 rpm for 5 min to obtain the serum which, in turn, was stored at -20°C. These serums were stored in hemolysis tubes, on which biochemical analyzes were performed using an auto-analyzer (HITACHI 902-Roche, Japan).

Creatinine, urea, blood glucose, total proteins, triglycerides (TG), total cholesterol, HDL cholesterol and LDL cholesterol were measured.

The dosage of the different elements was done kinetically, colorimetrically or by using the flame photometry option of an automaton (CLIMA MC 15).

Determination of organ biometrics: Organ weight was expressed as a percentage of the live weight of the animal obtained during the last weighing.

Statistical analysis: The data collected were analyzed using STATISTICA software version 7.1. The data, expressed as Mean±Standard deviation, were compared using Tukey's HSD test with a significance level set at 5%.

Graphical representations were made with Graphpad Prism 9 software.

Ethical consideration : Rats were treated according to good laboratory practices[15]. The experimental protocols were conducted by the protocols for the protection of experimental animals of the European Council on Legislation 2012/707[16].

RESULTS

Overall composition of sesame seeds: Chemical analysis shows that sesame seeds contain 3.93±0.01% of water, 96.07±0.09% of dry matter, 7.8% of ash, 20.72±0.08% of protein, 52.47±0.19% of fat, 15.08±0.2% of total carbohydrate. The corresponding amount of energy was 543.54±1.05 Kcal 100 g DM^{-1} (Table 2).

Growth parameters

Total dry matter ingested (TDMI) and Total protein ingested (TPI): The dry matter ingested by the rats was 4.54±0.81 g/day for the rats on the sesame-based diet (SBD) and 4.56±0.26 g/day for the rats on the soy-based diet (SBR). The consumptions were similar in the rats of the two diets (p>0.05).

The TPI of the rats fed the SBD diet were 0.45±0.08 g/day where as those of the rats fed the SBR diet were 0.46±0.09 g/day. Statistical analysis of these results revealed no significant difference between them (p>0.05).

Weight gain in rats: Rats fed the sesame based diet (SBD) had a mean weight gain of 0.34±0.09 g/day, while those fed the soy-based diet (SBR) had a mean weight gain of 0.36±0.08 g/day (Fig. 1). There was no significant difference between the set weight gains (p>0.05).

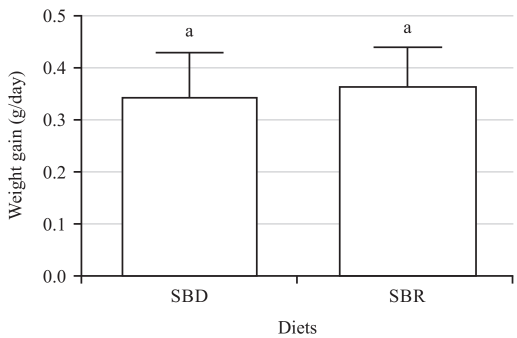

Fig. 1: Weight gain of rats subjected to different diets

Table 2: Over all composition of sesame seeds (*Sesamum indicum*)

Parameters	Content
Humidity (% FM)	3.93±0.01
Dry matter (% FM)	96.07±0.09
Ash (% DM)	7.8
Proteins (% DM)	20.72±0.08
Fat (% DM)	52.47±0.19
Total carbohydrates (% DM)	15.08±0.2
Energy (kcal/100 g DM)	543.54±1.05

Table 3 : Blood biochemical parameters of rats at the end of the experiment

	Diet	
Parameters	SBD	SBR
Urea (g L^{-1})	0. 21±0.08^{a}	0.2±0.07^{a}
Creatinine (mg L^{-1})	5.50±1.00^{a}	5.25±1.50^{a}
Blood glucose (g L^{-1})	0.79±0.15^{a}	0.89±0.29^{a}
Total protein (g L^{-1})	59±2.7^{a}	62±10.6^{a}
Triglycerides (g L^{-1})	0.39±0.14^{a}	0.43±0.14^{a}
Cholesterol total (g L^{-1})	1.13±0.12^{a}	0.80±0.08^{b}
HDL (g L^{-1})	0.86±0.10^{a}	0.50±0.14^{b}
LDL (g L^{-1})	0.19±0.05^{a}	0.22±0.05^{a}

Values expressed as mean±standard deviation of 6 rats, ^{a,b}On the same line: Means followed by different letters are significantly different (p<0.05)

Food efficiency ratio (FER) and protein efficiency ratio (PER): Calculation of the assimilation of the different diets gave the same food efficiency ratio of 0.08±0.01 for the rats on the SBD diet and for those on the SBR diet.

In terms of protein utilization of the different diets, the SBD values obtained are 0.75±0.15 for the SBD diet and 0.79±0.09 for the SBR diet. These values are not significantly different (p>0.05).

Biochemical blood and biometric parameters of organs

Kidney parameters:

- **Urea:** The values obtained after blood analysis (Table 3) revealed similar levels of urea in rats fed the SBD and SBR diets, with values of 0.21±0.08 and 0.27±0.07 g L^{-1}, respectively
- **Creatinine:** The creatinine levels are also close in the two groups (Table 3) with 5.50±1.00 g L^{-1} for the rats subjected to the SBD diet and 5.25±1.50 g L^{-1} for those fed with the diet SBR (p>0.05)

Liver parameters:

- **Blood glucose:** The analyses showed blood glucose levels of 0.79±0.15 g L^{-1} for the rats on the SBD diet and 0.89±0.29 g L^{-1} for those subjected to the SBR diet (Table 3). The differences observed are not statistically significant (p>0.05)
- **Total protein:** The analyzes revealed similar total protein contents in the rats on the SBD diet (59±2.7 g L^{-1}) and in those on the SBR diet (62±10.5 g L^{-1}) (Table 3)
- **Triglycerides:** The triglyceride levels obtained in the rats on the SBD and SBR diets (Table 3) do not show any significant differences between them and are respectively 0.39±0.14 g L^{-1} and 0.43 0.14 g L^{-1}
- **Total cholesterol:** The highest values for total cholesterol were observed in rats on the SBD diet (1.13±0.12 g L^{-1}). Rats on the SBR diet, had levels of 0.80±0.08 g L^{-1} (Table 3). These results are significantly different (p<0.05)
- **Low density lipoproteins (LDL):** For low density lipoproteins (LDL), the rats of the two groups had similar values (0.19 0.05g L^{-1} for the SBD diet and 0.22±0.05g L^{-1} for the SBR diet) (Table 3)
- **High-density lipoproteins (HDL):** The high density lipoprotein (HDL) levels were observed, for the highest, in the rats subjected to the SBD diet (0.86±0.10 g L^{-1}) and for the lowest in the rats subjected to the SBR diet (0.50 0.14 g L^{-1}) (Table 3). The differences observed at this level are significant (p<0.05)

Biometric parameters of organs:

- **Heart:** The calculation of the relative organ weight of the rats from the different diets revealed similar values for the heart in the rats from the two diets, respectively of 0.36±0.06 and 0.43±0 .06 for the rats on the SBD diet and those on the SBR diet (Table 4)
- **Kidneys:** Rats on the SBD diet had an average relative kidney weight of 0.5±0.06, while those on the SBR diet have an average weight of 0.74±0.07 (Table 4). However, the weight difference is not significant (p>0.05)
- **Liver:** The average relative weight of the livers of the rats on the SBD diet is 3.26±0.36 and that of the rats on the SBR diet is 3.78±0.55 (Table 4). These results are similar according to the statistical analyzes carried out

Table 4: Relative organ weights of rats on different diets

	Diet	
Parameters	SBD	SBR
Heart	0.36±0.6[a]	0.43±0.06[a]
kidneys	0.58±0.06[a]	0.74±0.07[a]
Liver	3.26±0.36[a]	3.78±0.55[a]
Rate	0.14±0.02[a]	0.21±0.05[a]
Abdominal fat	1.72±0.85[a]	1.57±0.91[a]

Values expressed as mean±standard deviation of 6 rats, [a]On the same line: Means followed by different letters are significantly different (p<0.05)

- **Rate:** Rats on the two diets had similar relative weights 0.14±0.02 for the rats on the SBD diet and 0.2±0.05 for the rats on the SBR diet (Table 4)
- **Abdominal fat:** Calculation of the relative weight of the abdominal fat taken from the rats of the different diets revealed similar values of 1.72±0.85 for the rats subjected to the SBD diet and 1.57±0.9 for the rats subjected to the SBR diet (Table 4)

DISCUSSION

Analysis of the chemical composition of sesame seeds revealed that they contain a large number of nutrients. The water content obtained was 3.93±0.01 g/100 g FM. This proportion of water being low, sesame seeds can therefore be considered dry seeds. The low water content also indicates that sesame seeds can be stored for a long time without great risk of microbial contamination[17]. Zebib *et al.*[18] also found similar moisture content in their studies in Ethiopia, with values varying between 3.17 and 3.96%. Indian researchers have agreed on a rate of 3.62±0.32 g/100 g FM obtained after analysis of brown sesame seeds.

At the ash level, the analyzes showed a rate of 7.8%, higher than those obtained[19,20]. These authors respectively obtained ash contents of 4.58 and 5.5 %. The ash content was however lower than that of Kouamé *et al.*[17], which is 9.4%. This difference could be explained by the difference in the varieties grown, the seasons, and the types of soil, but also by the effect of the sun. The ash content obtained also demonstrates the richness of sesame seeds in minerals, the main ones being calcium, potassium, magnesium, iron and zinc[19].

The protein content is 20.72%. This result is similar to those of researchers[17,21-23] who, respectively obtained rates of 23.27% in Côte d'Ivoire, 20 in Congo, 22 in Morocco and 21% in Turkey. However, lower values were reported by Ogbonna and Ukaan[24] and Hassan[25], of 19 and 18.92%, respectively in Nigeria and Egypt. The highest protein levels were obtained in Sudan by Ojiako *et al.*[26] with a rate of 34.4%. These results suggest that sesame seeds are important plant sources of protein composed of approximately 77% essential amino acids (lysine, isoleucine, methionine, cystine, tryptophan and phenylalanine etc.)[26]. They could therefore be used to solve protein-energy malnutrition.

The lipids of the sesame seeds analyzed were estimated at 52.47%. Ahuja *et al.*[19] however, obtained a lower lipid level of around 43.22%, while Hassan[25] obtained high erones (between 56 and 60%).

Carbohydrates, the value of which was obtained by calculation, were estimated at 15.08%. This value is lower than that reported by Ojiako *et al.*[26] (23.4%) and higher than that of Ahuja *et al.*[19] (9.76%). These differences could be due to soil type, cultural practices, genetic and environmental factors[4].

It, therefore, appears that sesame seeds are foods rich in protein, but also in lipids and minerals. Given these results, it was, therefore, appropriate to assess the impact that sesame seeds could have on growth during an animal experiment.

This experiment carried out on growing Wistar rats gave, in terms of dry matter and protein consumption (TDMI and TPI), similar results in rats subjected to the SBD diet and in those subjected to the SBR diet, respectively of 4.54±0.81 and 4.56±0.26 g/day for TDMIs and 0.45±0.08 and 0.46±0.09 g/day for TPI. These consumptions were significantly lower than those obtained by Hama-Ba *et al.*[4] and by Disseka *et al.*[27] in rats of the same strain and at the same physiological stage. This difference could be explained by the fact that the different diets were administered without prior cooking, which probably negatively affected the organoleptic properties of the formulated foods.

Weight change followed the same trend, with similar weight gains in rats fed the sesame and soy diets. The values obtained (0.34±0.09 and 0.36±0.08 g/day) were much lower than those of Hama-Ba *et al.*[4]. The difference observed could be due to the composition of the plans. The authors administered, in addition to the protein sources used, cereals, rich in energy and having remarkable effects on the weight change of the animals[28]. Another explanation could be the presence of anti-nutritional factors. Soybeans indeed contain many kinds of anti-nutritional factors, such as trypsin inhibitor, lectin, α-amylase inhibitor factor, goitrin, soybean antigen, etc.[29]. Sesame seeds contain tannins and phytic acid[30]. These items certainly affected the effectiveness of the foods and proteins consumed by the rats.

Beyond growth parameters, the effect of sesame seeds was also evaluated on blood biochemical parameters and organ biometrics.

Analyzes revealed similar levels of urea, blood glucose, creatinine, triglycerides, LDL and total protein in rats on both diets (SBD and SBR). Total cholesterol and HDL levels were higher in rats on the RSE diet. Moreover, the LDL levels observed were remarkably lower than the norms reported[31]. These results were similar to those obtained by Hama-Ba *et al.*[4] and Disseka *et al.*[27], during studies on the nutritional quality of sesame and soy foods. The triglyceride levels observed are close to the standards reported[31]. Concerning creatinine, the low levels recorded could be due to an insufficient weight evolution of the rats.

At the organ level, the rats of the two diets had equivalent relative weights. The results obtained were consistent with those reported[4,27,32].

Sesame is, therefore, a good alternative to common vegetable proteins, although it should be consumed in moderation or de-oiled form due to its high-fat content. It is also a rich food source that can help reduce protein-energy malnutrition.

CONCLUSION

This study was undertaken to valorize sesame seeds as sources of protein in the diet of populations. Determination of the overall composition of sesame seeds revealed a significant protein content (20.72%), but also a high -fat content (52.47%) and ash content (7.8%). After animal experimentation

Days, similar effects on organ growth and biometrics were observed in rats of the two diets (sesame and soy). At the level of biochemical parameters, the effect of sesame seeds was noticed in the levels of total cholesterol and HDL cholesterol. Sesame is, therefore, a good alternative to common vegetable proteins, although it should be consumed in moderation or de-oiled form due to its high-fat content. It is also a rich food source that can help reduce protein-energy malnutrition. To take full advantage of all the benefits associated with the consumption of sesame, further studies could be carried out.

SIGNIFICANCE STATEMENT

Protein deficiency is a public health problem in developing countries. The search for available and less vegetable protein is recommended as a solution. Nevertheless for their efficient use knowledge for their biodisponibility is recommended. The result of the present study indicate that sesame and soybean seeds have similar nutritional and physiological parameters in rats that consume them. Therefore sesame seed flour can be used as weaning flour to combat malnutrition. However further studies are needed.

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