



Salvia hispanica L (Chia Seeds) as Brain Superfood-How Seeds Increase Intelligence

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Background

The influence of nutrition on cognitive abilities is undisputed in academic literature [1]. Numerous studies have shown that the effects of polyunsaturated fats and other foods, such as milk, meat or oils are in fact measurable [2].

Omega-3 fatty acids in particular delivered convincing results in several studies. There is justified assumption that with an according diet a) The risk of developing Alzheimer's can be reduced and b) Cognitive performance can be increased. Hooper, et al. have recently proven that verbal intelligence decreased less if omega-3 fatty acids were taken in [3]. Even though other studies could not spot a significant connection between omega-3 fatty acids and the reduction of Alzheimer's specific symptoms [4], Mazza, Pomponi, Janiiri, et al. have found that omega-3 fatty acids play a crucial role in the activity of the nervous system, cognitive development, memory-related learning and the development of brain synapses. The review verifies the effect of omega-3 fatty acids on the anatomical and functional development of the central nervous system [5]. In addition, the studies prove that the omega-3 fatty acid docosahexaenoic acid can be of great benefit in preventing neuronal diseases and supporting mental health [6].

Salvia hispanica L as a source of omega-3

In recent years, chia seeds (*Salvia hispanica* L) have becoming increasingly popular in Europe. The European Union (EU) approved them as a so-called "novel food". The seeds consist of about 25-40% oil and are composed of about 60% ω -3 alpha-linolenic acid (ALA) and 20% ω -6 linolenic acid. The fatty acids are required by the body to stay healthy and cannot be produced synthetically [7]. The chia seeds consist of proteins (15-25%), fats (30-33%), carbohydrates (26-41%), fibre (18-30%), ash (4-5%), minerals, vitamins and contain a high proportion of antioxidants [8].

Studies on chia seeds show a correlation between a) The consumption of predominantly monounsaturated fatty acids and a low intake of polyunsaturated fatty acids and b) The occurrence of cardiovascular diseases, diabetes and metabolic syndrome [9]. Fernandes, et al. have discovered additional medical advantages of chia seeds, which not only cause the reduction of cholesterol and the inhibition of blood clotting but also may prevent stress and epilepsy. Furthermore, research assumes that the consumption of chia seeds during pregnancy can improve the development of the foetus' brain and retina [10]. To what extent the intake of chia seeds may have favourable effects on schoolchildren, students or Alzheimer's patients has been subject to little scientific research thus far. Therefore, this study intends to examine the effects of *Salvia hispanica* L on cognitive abilities by means of a chia intervention.

Methodology

The study is based on the evaluation of tests that measure cognitive performance. They were conducted with students of the Technical University at Dortmund, Germany in the summer of 2017. The order of study distinguished between an intervention group and a control group. The tests were repeated once. In the meantime, the intervention with chia seeds was conducted. Besides the on-site testing, the probands were requested to complete additional tasks.

Study participants

From a total of 34,600 students, two groups were cho-

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sen to participate in the study. The participants were 21.3 years old on average and 96% female. The high percentage of female participants deliberately does not represent the average population, but is oriented towards the significantly higher proportion of Alzheimer's cases attributed to the longer life expectancy of women. None of the participants suffered from allergies, hypertension/hypotension or took blood thinners. One test person stated she was chronically ill.

Randomisation

Following the pre-test, which particularly inquired about health risks in order to prevent the possible blood thinning effect caused by a chia overdose, the participants were randomly selected into two groups.

Interventions/Measures

The participants were divided into two groups: An intervention group and a control group. The participants of the intervention group consumed a daily dose of 5 grams chia seeds over a time period of 21 days. The control group continued to eat as before. The authors of the study consciously chose a low dosage. The European Food Safety Authority (EFSA) approved chia seeds as food in 2009. The authority recommends a maximum daily dose of 15 grams. The participants were explicitly requested to take these guidelines seriously and to only consume the lower chia seed dosage of 5 grams per day.

Method of testing

After having divided the subjects into the according groups, several tests were performed on-site, which aimed to examine the participant's cognitive abilities (in particular memory performance). Additionally, verbal intelligence was tested by means of the sentence recognition test of the Clinic of Psychiatry and Psychotherapy at the Ludwig Maximilian University in Munich, Germany [11].

The probands were requested to answer 31 questions of the sentence recognition test in the category "difficult". Furthermore, the participants had to assemble a LEGO airplane consisting of 111 pieces (view blueprint). Thereby, the time was measured from start to completion of the airplane. The correlation between the ability to assemble LEGO bricks and intelligence was demonstrated by Richardson, Hunt and Richardson [12]. The retest enabled us to measure how well the work steps had been memorised and, thus, revealed memory performance.

Moreover, a classical memory test was conducted. The participants were asked to memorise 14 terms within one minute (view chart). After 60 minutes, the probands were asked to write down the memorised terms. All tests were repeated after an intervention period of three weeks.

Results

In total, the test group that participated in the intervention performed significantly better in the retest than the comparison group.

Memory test

As expected, both the probands of the intervention group and probands of the comparison group could remember less terms after three weeks than after the initial query made after one hour. At first, both group participants behaved nearly identically. The subjects of the intervention group remembered 7.9 terms on average, and the subjects of the control group remembered 7.6 terms on average. After three weeks, the difference was clearly visible. The control group, whose participants had not changed their diet, could only remember 5.4 terms on average. The intervention group, whose participants had consumed chia seeds, could remember 6.6 terms on average. This means that the intervention group only forgot 16.5% of the memorised terms, while the control group forgot almost twice as much, namely 29%. However, with a p-value of 0.74, the testing cannot be rated as statistically significant.

Sentence completion test

As the degree of difficulty of the sentence completion test was very high, both test groups could only answer 7.0 (intervention group) and 6.4 questions (control group) correctly on average. Similar to the memory test, the difference increased enormously after the intervention period-now the intervention group could answer 6.3 questions correctly, and the control group only 2.6 questions on average. This means that the verbal intelligence of the intervention group increased 142% compared with the control group. If converting these results analogously to the test methods of the University of Munich, they show an increase of the verbal intelligence quotient from 106.3 vIQ to 118.0 vIQ. In comparison, the verbal intelligent quotient of the control group increased from 102.7 vIQ to 112.9 vIQ.

With a p-value of 0.037, the testing is rated as statistically significant.

Applied intelligence/LEGO testing

The assembly of the 111-part aircraft took 41 minutes and 41 seconds on average during the first testing. Both groups completed the assembly in nearly the same time, with only a few minutes difference. And expectedly, both groups managed to improve due to the repetition effect. Yet, the intervention group performed much better than the control group-now the intervention group assembled the airplane 14 minutes and 59 seconds faster on average. The control group was only 2 minutes and 31 seconds faster.

This test series has a significance of $p = 0.048$, hence the effect is highly probable.

Discussion

In the authors view, the basic assumption is confirmed that chia-rich nutrition has positive effects on cognitive abilities. This was proven in particular not only by the two tests with high significance but also by the memory task, which indicates that a dietary intake of *Salvia hispanica* L can positively impact memory abilities.

The authors were notably surprised by the significant differences in the progress of learning. Further studies should investigate if these results can be confirmed in the long term. With all appropriate scientific caution, it appears to be evident thus far that in an aging society, dealing with the increase of cognitive diseases such as Alzheimer's or dementia, the daily consumption of *Salvia hispanica* L is highly recommendable.

The examined test group consisted of young adults. All participants were still studying at a university level. Future research should place an emphasis on schoolchildren in order to evaluate if the positive results demonstrated by the chia group can be improved in younger ages, especially before puberty. There might be an even more life changing effect on the educational experience. Beside that the authors do not expect many differences between gender groups, but further research should investigate whether and to what extent there are variations.

The authors are convinced by now that the valid statement can be made that the intake of *Salvia hispanica* L leads, with significance, to an improvement of applied intelligence and verbal intelligence. Insofar, the classification of *Salvia hispanica* L as a "superfood", respectively brain superfood, is scientifically justified.

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