Journal of Animal Science and Products (JASP)
International peer-reviewed journal
5 (2): 95-102, 2022

Effects of Dietary Chia Seeds and Oil on Performance, Egg Quality and Serum Constituents in Quails

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ARTICLE INFO

Research Article

Received : 19.08.2022
Accepted : 18.11.2022

Keywords

Chia
Egg quality
Performance
Quail
Serum

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ABSTRACT

In this study, it was aimed to investigate the effects of dietary chia seeds and oil levels in laying quails on performance, external and internal egg quality traits, and serum biochemical properties. Total of 90 female Japanese quails 10 weeks old were randomly allocated to five treatment groups consisting of six subgroups, each containing of 3 quails. Quails were fed for 10 weeks with five treatment diets prepared by adding chia seeds (1 and 2%) and chia oil (0.5 and 1.0 g/kg) to the basal diet (control). Body weight change was improved by dietary addition of 2% chia seeds ($P<0.05$), but other performance traits were not affected by the treatments ($P>0.05$). Compared to control, the supplementation of chia seeds (1 and 2%) and 0.5 g/kg of chia oil to the diet was effective in increasing the eggshell resistance ($P<0.01$). Other egg quality parameters did not affected by the administration of chia seeds and oil to the diet ($P>0.05$). Serum glucose and HDL levels increased with the addition of chia seeds (%1) and oil (0.5 and 1.0 g/kg) to the diet ($P<0.01$ and $P<0.05$, respectively). Serum calcium level, on the other hand, was adversely affected by the addition of high levels of chia seeds (%2) and oil (1.0 g/kg) to the diet ($P<0.01$). As a result, chia seeds was effective in improving eggshell quality, and chia oil was effective in improving serum glucose and HDL levels in laying quails.

Bıldırcınlarda Rasyon Chia Tohumu ve Yağının Performans, Yumurta Kalitesi ve Serum Bileşenleri Üzerine Etkisi

MAKALE BİLGİSİ

Araştırma Makalesi

Geliş: 19.08.2022
Kabul: 18.11.2022

Anahtar Kelimeler

Chia
Yumurta kalitesi
Performans
Bıldırcın
Serum

ÖZ

Bu çalışmada, yumurtlayan bıldırcın rasyonlarına farklı seviyelerde ilave edilen chia tohumu ve yağının performans, yumurta kalitesi ve serum biyokimyasal parametreleri üzerine etkisinin araştırılması amaçlanmıştır. Çalışmada 10 haftalık yaştaki toplam 90 dişi Japon bıldırcını, her biri 3 bıldırcın içeren 6 alt gruptan oluşan 5 muamele grubuna rastgele dağıtılmıştır. Bıldırcınlar, bazal rasyona (chia tohumu ve yağı eklenmeden) chia tohumu (%1 ve %2) ve chia yağı (0,5 ve 1,0 g/kg) ilave edilerek hazırlanan beş muamele rasyonu ile 10 hafta süreyle yemlenmişlerdir. Rasyona %2 chia tohumu ilavesiyle canlı ağırlık artışı sağlanmıştır ($P<0.05$), ancak diğer performans parametreleri muamelelerden etkilenmemiştir ($P>0.05$). Kontrole göre, rasyona chia tohumu (%1 ve %2) ve 0.5 g/kg chia yağı ilavesi yumurta kabuğu kırılma direncini artırmada etkili olmuştur ($P<0.01$). Diğer yumurta dış

Lütfen aşağıdaki şekilde atıf yapınız / Please cite this paper as following;
Yıldız, A., Olgun, O., Gül, E.T., 2022. Effects of dietary chia seeds and oil on performance, egg quality and serum constituents in quails, Journal of Animal Science and Products (JASP) 5 (1):95-102. DOI: 10.51970/jasp.1164458

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ve iç kalite parametreleri, rasyona chia tohumu ve yağı ilavesinden etkilenmemiştir (P>0.05). Serum glukoz ve HDL seviyeleri rasyona chia tohumu (%1) ve yağ (0.5 ve 1.0 g/kg) ilavesiyle artmıştır (sırasıyla P<0.01 ve P<0.05). Diğer taraftan serum kalsiyum seviyesi rasyona yüksek oranda chia tohumu (%2) ve yağı (1.0 g/kg) ilavesinden olumsuz etkilenmiştir (P<0.01). Sonuç olarak yumurtlayan bıldırcınlarda, chia tohumunun yumurta kabuğu kalitesinin iyileştirilmesinde, chia yağının ise serum glukoz ve HDL düzeylerinin iyileştirilmesinde etkili olduğu görülmüştür.

Introduction

In the production of chicken meat, which is one of the important animal protein sources, and eggs rich in biological value, some factors were effective in the search for raw materials and/or additives that would improve both the qualitative and quantitative quality of the product. The first of these factors was the frequently on the agenda of health-related issues. Other factors were the idea of improving the quality of life and raising human awareness of the potential benefits of nutrition in the prevention or control of disease. Subsequently, with this advancement, applied researches in various fields of the poultry industry focused on how this industry would develop to obtain quality products. The use of feeding strategies to improve the quality and chemical composition of animal products is an important connection between animal production, food technology, and human nutrition (Medonça et al., 2020).

Chia (*Salvia hisponica L.*), which was very popular lately and indicated to has high nutritional potential, is an annual plant from the Lamiaceae family and its seeds containing of 90-93% dry matter, 15-25% protein, 30-33% oil, 18-30% cellulose, and 4-5% ash (Ixtaina et al., 2008; Kulczynski et al., 2019). In addition, it is rich in polyunsaturated fatty acids (Alagawany et al., 2020). It was reported that chia seeds contained plenty of carotenoids, sterols, and tocopherols as well as phytochemicals such as phenolic compounds formed from quercetin, kaempferol, myricetin, chlorogenic, and caffeic acid (Capitani et al., 2012; Oliveira-Alves et al., 2017). In addition, Marcinek and Krejpcio (2017) emphasized that its composition was closely related to genetic factors and the ecosystem grown of plant. The oil obtained from seeds of chia is rich in terms of omega-3 fatty acids, has an important potential in the production of omega-3 enriched products/foods (Antruejoet al., 2011). Chia oil is also rich in terms of minerals such as calcium, phosphorus, and iron, and many vitamins especially thiamine, riboflavin, niacin, ascorbic acid, and vitamin A and vitamin E (Bresson et al., 2009).

In the first studies with chia seeds and oil, these were used at a high level as a component of the diet, not as an additive (up to 30% and 6%, respectively) (Ayerza and Coates, 2000; Antruejo et al., 2011). However, to our knowledge, studies are compared chia seeds and oil and also examined of their effects on egg quality is scarce. Therefore, in the current research, it was aimed to examine the comparative effects of chia seeds or oil on performance traits, external and internal egg quality, and some biochemical properties of serum in Japanese quails.

Material and Method

The animal care practices used in the experiment were in accordance with animal welfare rules stated in Article 9 in government law in Turkey (No. 5996).

A total of 90 quails (female) of similar body weight (230.40 ± 7.32 g), at 10 weeks of age were fed as ad-libitum for 70 days with 5 treatment diets added with control, 1% and 2% chia seeds and 0.5 and 1.0 g/kg chia oil to a corn-soybean meal-based basal diet (Table 1). This experiment was conducted with five trial groups of six subgroups, each with three quails (female) and 16-hour lighting program was applied. Birds were weighed individually at the start and end of trial, the body weight change was computed as gram. Subgroups received feeds by weighing them, and at the conclusion of the trial, the amount of feed was consumed per quail each day was estimated by deducting the remaining feeds from the total amount. The number of eggs produced by quails was recorded daily, and expressed as a percentage. After being weighed, the weight of the eggs collected on the last three days of the treatment was calculated to be gram. These data were used to determine egg mass as g/day/quail using the equation (egg production x egg weight) / 100 and feed conversion ratio as g feed/g egg using the equation feed intake / egg mass.

Table 1. Basal diet and its calculated nutrient contents
Tablo 1. Bazal rasyon ve hesaplanmış besin madde içeriği

Ingredients	g/kg	Nutrient contents	
Corn	544.0	Metabolizable energy, kcal ME/kg	2900
Soybean meal	343.7	Crude protein (g/kg)	200.0
Soybean oil	36.7	Calcium (g/kg)	25.0
Limestone	56.0	Available phosphorus (g/kg)	3.5
Dicalcium phosphate	11.5	Lysine (g/kg)	10.9
Salt	3.5	Methionine (g/kg)	4.5
Premix[1]	2.5	Cysteine (g/kg)	3.7
DL methionine	2.1	Methionine + cysteine (g/kg)	8.2
Total	1000.0		

[1]Premix was supplied to one kgdiet; Manganese: 80 mg, Iron: 60 mg, Copper: 5 mg, Iodine: 1 mg, Selenium: 0.15 mg, Vitamin A: 8.800 IU, Vitamin D_3: 2.200 IU, Vitamin E: 11 mg, Nicotine acid: 44 mg, Cal-D-Pan: 8.8 mg, Riboflavin: 4.4 mg, Thiamine: 2.5 mg, Vitamin B_{12}: 6.6 mg, Folic acid: 1 mg, Biotin: 0.11 mg, Choline: 220 mg.

In broken, cracked, and damaged eggs were counted during the experiment and expressed as a percentage of the total number of eggs. Egg external and internal quality traits were determined from the eggs that collected in the last three days of the trial. In order to test the eggshell breaking resistance (kg), supported systematic pressure was applied (Egg Force Reader, Orka Food Technology, Israel) to the blunt of the egg. Eggs detected shell breakage resistance were broken on a glass surface and after cleaning the remains in the shell, these were dried at room temperature in three days and weighed, then the relative weights of the eggshells were calculated as the ratio of the egg weight (Gül et al., 2022). Immediately after, the yolk and albumen heights were measured with a height gauge and their length and width were measured with the digital calliper. From these data, the albumen index with the albumen height/((albumen width+albumen length/2)×100 formula, the yolk index with the (yolk height/yolk width)×100 formula, and the Haugh unit with the 100 x log (albumen length+7.57-1.7 x egg weight 0.37) formula (Haugh, 1937) were calculated.

Blood (3 ml) was collected from one quail randomly chosen from each subgroup at the

final of the trial (10th week) that had a similar body weight. Blood were centrifuged at 4000 rpm for 10 minutes. The separated serum was kept at -20 °C until analysis, and the concentrations of glucose, cholesterol, HDL, triglycerides, ALT, AST, albumin, globulin, total protein, creatinine, urea, calcium, and phosphorus were assessed using commercially available kits (DDS® Spectrophotometric Kits, Diasis Diagnostic Systems Co., Istanbul, Turkey).

The effects of the trial diets on quail performance, external and internal egg quality, and serum traits was examined using a one-way ANOVA. A planned multiple comparison of means was looked at with Duncan's multiple range test if an ANOVA revealed significant differences among averages (main effect). $P<0.05$ was used to identify statistical variations, while $P<0.10$ was used to define trends. The SPSS Package 23 was used for all statistical analysis (IBM SPSS Statistic 2017).

Results and Discussion

The effect of addition of chia seeds and oil to laying quail diets on performance traits was demonstrated in Table 2.

Table 2. Effects of dietary chia seeds and oil levels on performance in layer quails
Tablo 2. Rasyon chia tohumu ve yağı seviyesinin yumurtlayan bıldırcınlarda performansa etkisi

Parameters	Control	Chia seeds, %		Chia oil, g/kg		SEM	P-value
		1	2	0.5	1.0		
Body weight change, g	14.25^{b}	18.75^{ab}	33.58^{a}	20.42^{ab}	8.33^{b}	4.802	0.021
Egg production, %	93.21	91.90	92.14	91.29	91.86	1.056	0.851
Egg weight, g	12.97	13.35	12.57	12.79	12.82	0.308	0.515
Egg mass, g/day/quail	12.09	12.27	11.58	11.69	11.78	0.324	0.559
Feed intake, g/day/quail	30.72	30.82	31.61	31.62	30.27	0.479	0.246
Feed conversion ratio, g feed/g egg	2.55	2.52	2.74	2.72	2.58	0.064	0.092

^{ab}Within row, the different letters shows statistically different at $P<0.05$. SEM: Standard error mean

The performance traits were not statistically affected by chia seeds and oil added to the layer quail diets, except for body weight change ($P>0.05$). Body weight change of quails fed with diet added 2% chia seeds was considerably higher than the control and 1.0 g/kg chia seeds supplemented groups ($P<0.05$). However, Ayerza and Coates (2001 and 2002) reported that the use of chia seeds up to 30% in laying hen diet did not affect body weight. In the current study, the reason of body weight change in the group fed with diet supplemented 2% chia seeds was higher than the control group could be the additional energy provided by chia seeds. In studies related to this, McClements et al. (2009) and Koh et al. (2015) pointed out the linolenic acid content of chia as the reason for the body weight gain. In addition, phenolic compounds in chia seeds increased the feed efficiency of quails, and this improvement could be reflected in body weight gain.

The effects of supplementation of chia seeds and oil to laying quail diets on external and internal quality parameters of eggs are given in Table 3.

Table 3. Effects of dietary chia seeds and oil levels on egg quality in layer quails
Tablo 3. Rasyon chia tohumu ve yağı seviyesinin yumurtlayan bıldırcınlarda yumurta kalitesine etkisi

Parameters	Control	Chia seeds, %		Chia oil, g/kg		SEM	P-value
		1	2	0.5	1.0		
Albumen index	2.82	2.74	2.49	2.78	2.88	0.177	0.600
Yolk index	49.35	48.05	47.49	48.44	48.05	0.853	0.700
Haugh unit	91.12	90.78	88.61	89.50	91.66	1.488	0.625
Damaged egg rate, %	0.00	0.91	1.03	0.52	0.39	0.373	0.571
Eggshell breaking strength, kg	1.37^{B}	1.61^{A}	1.65^{A}	1.55^{A}	1.32^{B}	0.055	0.001
Relative eggshell weight, %	8.40	8.11	8.35	8.17	8.08	0.152	0.529

^{A,B}Within row, the different letters shows statistical different at P<0.01. SEM: Standard error mean

Egg external and internal quality characteristics did not affected by the addition of chia seeds and oil to diet, except for the eggshell resistance (P>0.05). Eggshell resistance was found statistically higher in groups with chia seeds (1 and 2%) and chia oil with the level of 0.5 g/kg added to the diet compared to the control and containing of 1.0 g/kg chia oil groups (P<0.01). It can be said that the administration of chia seeds to diet instead of chia oil (0.5 g/kg) was more effective in advancement the eggshell breaking strength. There was not found research in the literature evaluated the effect of chia seeds or oil on the egg external and internal quality. However, chia seeds are rich in quercetin (Pellegrini et al., 2018), and administration of quercetin to the diet is known to improve eggshell quality (Liu et al., 2013; Amevor et al., 2021). It is hypothesized that quercetin by increasing oestrogen production and with this increase showed by improving the calcium metabolism, and thus the eggshell quality in birds.

The effects of administration of chia seeds (1 and 2%) and oil (0.5 and 1.0 g/kg) to laying quail diets on serum biochemical parameters are shown in Table 4.

Treatments did not affect serum cholesterol, AST, ALT, total protein, albumin, globulin, urea creatinine, and phosphorus concentrations (P>0.05). The serum glucose concentration increased with the addition of chia seeds or oil to the diet, and this increase was statistically significant in the groups supplemented with 1% chia seeds and 0.5 and 1.0 g/kg chia oil (P<0.01). There is a correlation among body temperature, metabolic rate, and blood glucose concentration in poultry. In other words, body temperature and metabolic rate are high in birds, so blood glucose concentration is higher than in some other species. Nitrayova et al. (2014) and Kulczynski et al. (2019) stated that the leucine, one of the branched-chain amino acids, found at the level of 1.37-1.43 g/100 g in chia, is effective in regulating blood sugar.

Compared to the control group, the serum HDL concentrations of the birds in the groups fed with diet supplemented 1% chia seeds and 0.5 or 1.0 g/kg chia oil were found to be considerably higher (P<0.05). However, Alagawany et al. (2020) noted that the addition of chia oil to the diet at levels of 0.4 to 1.6 g/kg did not affect serum HDL level of growing quails.

Table 4. Effects of dietary chia seeds and oil levels on serum biochemical constituents in layer quails

Tablo 4. Rasyon chia tohumu ve yağı seviyesinin yumurtlayan bıldırcınlarda biyokimyasal bileşenlerine etkisi

Parameters	Control	Chia seeds, %		Chia oil, g/kg		SEM	P-value
		1	2	0.5	1.0		
Glucose, mg/dL	319^{C}	339^{AB}	329^{BC}	336^{AB}	344^{A}	4.3	0.007
Cholesterol, mg/dL	145	157	170	154	150	10.2	0.543
HDL, mg/dL	42.18^{b}	50.00^{a}	48.62^{ab}	53.54^{a}	50.55^{a}	2.18	0.048
AST, U/L	202	201	240	251	240	16.0	0.111
ALT, U/L	2.40	2.40	2.60	2.50	2.20	0.152	0.813
Total protein, g/dL	4.34	4.06	3.92	4.32	4.00	0.176	0.538
Albumin, g/dL	1.64	1.50	1.52	1.57	1.47	0.075	0.589
Globulin, g/dL	2.70	2.56	2.40	2.75	2.53	0.151	0.516
Urea, mg/dL	5.36	4.94	5.66	6.25	5.12	0.596	0.601
Creatinine, mg/dL	0.320	0.318	0.303	0.312	0.303	0.0051	0.173
Calcium, mg/dL	21.64^{A}	21.92^{A}	17.50^{B}	19.75^{AB}	18.23^{B}	0.854	0.004
Phosphorus, mg/dL	4.50	5.32	5.92	5.07	4.60	0.370	0.093

Within row, the different capital letters show statistical difference at P<0.01, while the different small letters show statistical difference at P<0.05. HDL: High density lipoprotein, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase. SEM: Standard error mean

The serum calcium concentration was significantly lower in the 2% chia seeds and 1.0 g/kg chia oil supplemented groups compared to the control group and the 1% chia seeds supplemented group (P<0.01). In the previous section, it was indicated that the reason for the increase of eggshell breaking strength was quercetin, which is known to improve eggshell quality and is found in high amounts in chia seeds. It is evaluated together with the serum calcium concentration; it can be said that chia seeds and oil improve the eggshell breaking strength by decreasing the blood calcium level and increasing it's in the eggshell or increase the effect of quercetin in the same way.

Conclusions

The feature that distinguished the current research from previous studies examined the effects of chia in the literature was that it was used as a feed additive, not as a component of the diet, and it was a study in which the seeds and oil are compared. As a result of the current research, it can be said that the addition of 1% chia seeds or 0.5 g/kg chia oil to the diet improved the eggshell breaking strength without affecting the performance parameters. In addition, further studies are needed to examine the effects of chia seeds and oil on blood parameters and some performance parameters especially egg external quality, in poultry.

References

Alagawany, M., Nasr, M., Al-Abdullatif, A., Alhotan, R.A., Azzam, M.M., Reda, F.M., 2020. Impact of dietary cold-pressed chia oil on growth, blood chemistry, haematology, immunity and antioxidant status of growing Japanese quail. Italian Journal of Animal

Science. 19(1): 896-904. doi: 10.1080/1828051X.2020.1807420.

Amevor, F.K., Cui, Z., Ning, Z., Du, X., Jin, N., Shu, G., Deng, X., Zhu, Q., Tian, Y., Li, D., Wang, Y., Zhang, Z., Zhao, X., 2021. Synergistic effects of quercetin and vitamin E on egg production, egg quality, and immunity in aging breeder hens. Poultry Science. 100(12):101481. doi: 10.1016/j.psj.2021.101481.

Antruejo, A., Azcona, J.O., Garcia, P.T., Gallinger, C., Rosmini, M., Ayerza, R., Coates, W., Perez, C.D.,2011. Omega-3 enriched egg production: the effect of a-linolenic x-3 fatty acid sources on laying hen performance and yolk lipid content and fatty acid composition. British Poultry Science. 52(6):750–760. doi: 10.1080/00071668.2011.638621.

Ayerza, R., Coates, W., 2000. Dietary levels of chia: Influence on yolk cholesterol, lipid content and fatty acid composition for two strains of hens. Poultry Science. 79(5):724-739. doi: 10.1093/ps/79.5.724.

Ayerza, R., Coates, W., 2001. Omega-3 enriched eggs: The influence of dietary α-linolenic fatty acid source combination on egg production and composition. Canadian Journal of Animal Science. 81:355–362. doi: 10.4141/A00-094.

Ayerza, R., Coates, W.,2002. Dietary levels of chia: influence on hen weight, egg production and sensory quality, for two strains of hens. British Poultry Science.43(2):283-290.

Bresson, J.L., Flynn, A., Heinonen, M., Hulshof, K., Korhonen, H., Lagiou, P., Løvik,M., Marchelli, R., Martin,A., Moseley,B., Palou, A.,Przyrembel, H., Salminen, S., Strain, J.J., Strobel, S.,Tetens, I., van den Berg, H., van Loveren, H., Verhagen, H., 2009. Opinion on the safety of 'Chia seeds (*Salvia hispanica L*.) and ground whole Chia seeds' as a food ingredient [1]: Scientific opinion of the panel on dietetic products, nutrition and allergies. EFSA Journal. 996(4):1-26. doi: 10.2903/j.efsa.2009.996.

Capitani, M.I., Spotorno, V., Nolasco, S.M., Tomás, M.C., 2012. Physicochemical and functional characterization of by-products from chia (*Salvia hispanica L*.) seeds of Argentina. LWT-Food Science and Technology. 45(1):94-102. doi: 10.1016/j.lwt.2011.07.012.

Gül, E.T., Olgun, O., Yıldız, A., Tüzün, A.E., Sarmiento-García, A., 2022. Use of maca powder (*Lepidium meyenii*) as feed additive in diets of laying quails at different ages: Its effect on performance, eggshell quality, serum, ileum, and bone properties. Veterinary Sciences. 9: 418. doi: 10.3390/vetsci9080418.

Haugh, R.R., 1937. The Haugh unit for measuring egg quality. US Poultry Magazine. 43:552-573.

Ixtaina, V.Y., Nolasco, S.M., Tomas, M.C., 2008. Physical properties of chia (*Salvia hispanica L*.) seeds. Industrial Crops and Products. 28(3):286-293. doi: 10.1016/j.indcrop.2008.03.009.

Koh, A.S., Pan, A., Wang, R., Odegaard, A.O., Pereira, M.A., Yuan, J-M., Koh, W-P., 2015. The association between dietary omega-3 fatty acids and cardiovascular death: The Singapore Chinese health study. European Journal of Preventive Cardiology. 22(3):364-372. doi: 10.1177/2047487313517576.

Kulczynski, B., Kobus-Cisowska, J., Taczanowski, M., Kmiecik, D., Gramza-Michałowska, A., 2019. The chemical composition and nutritional value of chia seeds-Current state of knowledge. Nutrients. 11(6):1242. doi: 10.3390/nu11061242.

Liu, Y., Li, Y., Liu, H.N., Suo, Y.L., Hu, L.L., Feng, X.A., Zhang, L., Jin, F., 2013. Effect of quercetin on performance and egg quality during the late laying period of hens. British Poultry Science. 54(4):510-514. doi: 10.1080/00071668.2013.799758.

Marcinek, K., Krejpcio, Z., 2017. Chia seeds (*Salvia hispanica*): health promoting properties and therapeutic applications-a review. Annals of the National Institute of Hygiene. 68(2):123-129.

McClements, D.J., Decker, E.A., Park, Y., Weiss, J., 2009. Structural design principles for the delivery of bioactive components in nutraceuticals and functional foods. Critical Reviews in Food Science and Nutrition. 49(6):577-606. doi: 10.1080/10408390902841529.

Mendonça, N.B.D.S.N., Sobrane, F.S.T., de Oliveira, D.H., Lima, E.M.C., Rosa, P.V., Faria, P.B., Naves, L.P., Rodrigues, P.B.,2020. Dietary chia (*Salvia hispanica L.*) improves the nutritional quality of broiler meat. Asian-Australasian Journal of Animal Sciences. 33(8):1310-1322. doi: 10.5713/ajas.19.0608.

Nitrayova, S., Brestensky, M., Heger, J., Patras, P., Rafay, J., Sirotkin, A., 2014. Amino acids and fatty acids profile of chia (*Salvia hispanica L.*) and flax (*Linumusitatissimum L.*) seeds. Potravinarstvo Slovak Journal of Food Sciences. 8(1):72-76.

Oliveira-Alves, S.C., Vendramini-Costa, D.B., Cazarin, C.B.B., Júnior, M.R.M., Ferreira, J.P.B., Silva, A.B., Prado, M.A., Bronze, M.R., 2017. Characterization of phenolic compounds in chia (*Salvia hispanica L.*) seeds, fibre flour and oil. Food Chemistry. 232(33):295-305. doi: 10.1016/j.foodchem.2017.04.002.

Pellegrini, M., Lucas-Gonzalez, R., Sayas-Barberá, E., Fernández-López, J., Pérez-Álvarez, J.A., Viuda-Martos, M., 2018. Bioaccessibility of phenolic compounds and antioxidant capacity of chia (*Salvia hispanica L.*) seeds. Plant Foods for Human Nutrition. 73(1):47-53. doi: 10.1007/s11130-017-0649-7.