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Effects of Cashew Kernels Cake on the Nutritional and Sensory Quality of Hen Eggs

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Abstract: Cashew kernels provide fats, proteins, minerals and amino acids like soybeans. They are characterized by their richness in linoleic and oleic acids which respectively contribute up to 20% and 60% of the fat. The aim of the present study is to assess the impact of the diets of laying hens, based on of cashew nut kernels cakes, on the nutritional and sensory quality of eggs. To carry out the experiment, 20 weeks old, 96 hens of the LOHMAN-Brown strain and with an average weight of 1600 g, were used over a period of 10 weeks. Laying hens were fed four diets Rt, R10, R15 and R20 at incorporation rates of 0%, 10%, 15% and 20% cashew kernel cake, respectively. The results indicate that the R10, R15 and R20 diets, after two weeks of testing, were associated with a reduction of up to 34.50% in egg yolk cholesterol content, compared to the Rt control diet. In sensory analysis tests, panelists accepted eggs from different diets without distinction. In short, far from degrading the quality of eggs, the dietary the lipids in cashew kernel cake can contribute to the development of poultry production by providing the consumer the fatty acids recommended by the medical profession.

Keywords: Cashew Kernel, Cake, Laying, Egg Yolk, Cholesterol

1. Introduction

The hen's egg is a reserve of nutrients and a mine of essential molecules for various biological activities [1]. It contains vitamins, minerals (shell), proteins and lipids (yolk), necessary for the development of the embryo.

Eggs are also a staple food that is widely consumed throughout the world. It has a high nutritional value due to the balance of its easily assimilable amino acids [2, 3]. The quality characteristics of the egg determine the acceptability and marketability of eggs for consumption [4]. However, variations in the composition of its constituents are observed. These variations are related to the hen itself, to its genetic origin and age, but also to its diet.

For a long time, the poultry industry has subsisted on the conventional feed ingredients such as corn and soy. However, the availability of these ingredients for poultry is hampered by low production on the one hand, and by the competitive use of these ingredients in other sectors and their cost of production on the other. Consequently, some authors have suggested the partial or total replacement of conventional feed ingredients with less expensive non-conventional alternatives [5]. However, the use of non-conventional feed can compromise the quality of the feed, and deteriorate the quality of the egg [6]. The question that arises is therefore whether the use of alternative ingredients in laying hen diets has an impact on the nutritional and sensory quality of eggs.

This study therefore aims to investigate the consequences

of incorporating cashew kernel meal in poultry diets on the nutritional and sensory quality of laying hen eggs.

2. Material and Methods

2.1. Experimental Device and Animals

Ninety-six (96) 20-week-old LOHMAN-Brown hens with an average weight of 1638.31 ± 36.7 g were used in this study. They were selected at the experimental farm of the School of Specialization in Livestock and Meat Trades of Bingerville (ESEMV-B, Côte d'Ivoire) and distributed totally randomly in an experimental design based on four diets named Rt, R10, R15 and R20. These diets provided 0%, 10%, 15% and 20% cashew kernel cake respectively. Cashew kernel cake was produced using an artisanal press "cassava press" [7]. All four diets are iso-protein (17.28%) and provided the same amount of metabolizable energy (2756 Kcal/Kg) (Table 1).

Hens were housed in batches of four in a compartmentalized chamber house (1 m x 1.35 m or 1.35 m^2), on a floor covered with litter. Each experimental regime was repeated on six (6) groups of hens. The experiment lasted ten (10) weeks divided into two phases: an initial adaptation period of two (2) weeks and the real experiment conducted over eight (8) weeks [8].

2.2. Measurements of Study Parameters

Every two weeks, six eggs were randomly selected per group of hens and broken to collect the yolk. At the end of the eight weeks of experimentation, one hundred (100) eggs of which twenty-five (25) per diet were collected and submitted for sensory analysis.

Table 1. *Chemical composition of different diets.*

Experimental diets				
Ingredients (Kg)	**Rt**	**R10**	**R15**	**R20**
Corn	0.6455	0.5100	0.4434	0.3655
Wheat bran	0.0000	0.0300	0.0600	0.0700
Rice flour	0.0000	0.0500	0.0700	0.1100
Soybean meal 44	0.2060	0.1296	0.0605	0.0503
Cashew kernel cake	0.0000	0.1000	0.1500	0.2000
Cotton cake	0.004	0.0279	0.0500	0.0500
Fish meal	0.0400	0.0400	0.0537	0.0417
Oyster shell	0.0880	0.0880	0.0880	0.0880
TNH Eggs 1.25%	0.0125	0.0125	0.0125	0.0125
Salt (NaCl)	0.0020	0.0020	0.0020	0.0020
Sepiolite	0.0020	0.0100	0.0100	0.0100
TOTAL (Kg)	1	1	1	1
Calculated values				
Metabolizable energy (kcal / kg)	2 756	2 756	2 756	2 756
Crude Protein (%)	17.28	17.25	17.28	17.28
Fat (%)	3.05	5.05	6.13	7.13
Crude cellulose (%)	2.79	3.95	4.53	5.30
Calcium (%)	3.35	3.37	3.46	3.41
Phosphorus (%)	0.17	0.22	0.29	0.29

Rations Rt, R10, R15 and R20: incorporation rates of 0%, 10%, 15% and 20% of cashew kernel cake respectively.

2.3. Nutritional Characteristics of the Egg

The nutritional quality of eggs was determined by the lipid and cholesterol content of the egg yolk. The protocol for the extraction of fat from egg yolks was that of Folch [9].

$$\text{Fat content (\%)} = \frac{P2-P1}{P0}\ X\ 100$$

P0: Weight in g of the sample, P1: Weight in g of flask, P2: Weight in g of flask and lipids.

The total cholesterol content of egg yolks was determined according to the method of Pasin [10].

$$\text{Total cholesterol content} = \frac{\text{ODSc - ODB}}{\text{ODS - ODB}}\ \text{X ES}$$

ODSc: Optical density of the sample, ODB: Optical density of the blank, ODS: Optical density of the standard et CS: Concentration of the standard in g/l.

The coloration of the yolk was estimated by the DSM Yolk Color Fan, which presents a 15-branch spectrum of different colorations ranging from pale to dark yellow.

2.4. Sensory Analysis of Eggs

The eggs were stored at room temperature for 48 h before evaluation. The eggs were evaluated in two forms: raw and in the shell (cooked). For raw eggs, the judges broke the sample themselves on a plate and assessed the shell color, yolk color and odor. For cooked eggs, the eggs were presented to the judges immediately after cooking. Hard-boiled eggs were obtained in 10 min over low heat in water. The eggs were cooled at room temperature in the preparation room to 50°C before being served. The eggs were shelled, cut

longitudinally, and placed in separate containers [11]. Judges evaluated the color, odor, taste, aftertaste of the yolk of the cooked eggs. Scores ranging from 5 (extremely pleasant) to 1 (extremely unpleasant) were assigned to the different descriptors [12].

2.4.1. Acceptability Test

The panel consisted of 42 untrained individuals (young girls and boys, adult women and men), recruited on the basis of their availability. Egg samples coded with three digits were presented monadically (one after the other) to each panelist in a randomized order. Each panelist's perceived pleasure was scored on a hedonic scale.

2.4.2. Quantitative Descriptive Analysis

The method consists of evaluating and quantifying the appropriate descriptors, such as color, odor, taste and aftertaste, using a category scale that reveals their intensity [13]. The eggs of the hens that had consumed the cashew kernel cake diets, as well as the eggs of those that had not, were presented to a panel of 25 people who were recruited and trained in the methodology of analyzing and evaluating the selected qualitative traits [14]. This panel was composed of adult men and women who were recruited on the basis of their knowledge and acceptance of egg products. Their availability, their sensitivity (sight, touch, taste, color) to the stimulus, and their oral and written knowledge of French were also criteria that contributed to recruitment.

The collected eggs were presented two to three days later as fresh eggs with shells and then as cooked eggs for food preparation. For each batch, 100 eggs were randomly selected from those collected during the last two weeks of the trial. The boiled eggs were transported in coolers to the sensory analysis room, which was prepared for the occasion. During the actual evaluation, four samples from each batch of eggs were coded in randomized order and presented simultaneously to each panelist. Perceived sensation after observing and/or tasting the sample was collected. Between items, panelists were asked to wash and dry their fingers and rinse their mouths with water. A sensory profile of each batch was thus established from the four samples.

2.5. Statistical Analysis

The results obtained in this study were analyzed using Statistica Version 7.1 software. The mean values per diet from the study criteria were subjected to an analysis of variance (ANOVA), followed by a comparison of means according to the Newman-Keuls test at the 5% significance level. Numerical calculations and graph construction were performed with Excel software.

3. Resultats

3.1. Dry Matter Content of Egg Yolk

The average yolk dry matter content of eggs from hens fed the Rt control diet was 48.44 ± 0.60%, compared with 50.72 ± 1.55%, 50.23 ± 0.89%, and 47.38 ± 3.69%, respectively, for egg products from animals fed the R10, R15, and R20 diets. However, statistical analysis did not reveal any significant difference ($p \geq 0.05$) between the yolk dry matter contents of hens on the different diets.

3.2. Lipid Content of Egg Yolk

The lipid content of the egg yolk was recorded every two weeks. The values obtained varied from 26.16 ± 1.86 to 32.16 ± 4.57%, 24.33 ± 4.92 to 27.16 ± 1.83%, 25.24 ± 1.92 to 29.49 ± 1.56% and 24.78 ± 2.81 to 28.16 ± 2.16%, respectively for weeks 2, 4, 6 and 8, without however reaching significantly different values according to the rate of incorporation of cashew kernel cake in the birds' diet (Table 2).

Table 2. *Evolution of lipid levels as a function of time.*

Characteristics	Weeks	Experimental diets			
		RT	R10	R15	R20
Lipid rate (%)	2	30.16 ± 3.06 [a]	26.16 ± 1.86 [a]	28.66 ± 1.83 [a]	32.16 ± 4.57 [a]
	4	27.16 ± 1.83 [a]	24.33 ± 4.92 [a]	26.83 ± 0.75 [a]	26.83 ± 1.94 [a]
	6	28.66 ± 2.01 [a]	25.24 ± 1.92 [a]	27.74 ± 2.3 [a]	29.49 ± 1.56 [a]
	8	27.91 ± 1.87 [a]	24.78 ± 2.81 [a]	27.28 ± 0.89 [a]	28.16 ± 2.16 [a]

[a,] There is no significant difference ($p \geq 0.05$) between two means ± standard deviation (on the same line). Rations Rt, R10, R15 and R20: 0%, 10%, 15% and 20% cashew kernel cake incorporation rates, respectively.

3.3. Cholesterol Content of Egg Yolk

After two weeks of experimentation, the yolk cholesterol content of eggs produced by hens on the Rt control diet was 25.37 ± 0.86 mg/g, compared to 20.99 ± 1.99 mg/g, 19.32 ± 2.61 mg/g and 17.01 ± 2.18 mg/g in those on the R10, R15 and R20 diets, respectively.

Egg yolk cholesterol levels recorded at weeks 4, 6, and 8 varied from 26.08 ± 3.18 mg/g to 17.08 ± 1.81 mg/g, 26.08 ± 3.18 to 17.08 ±1.81 mg/g and 25.90 ±1.90 to 17.06 ±2.05 mg/g, respectively. The R10, R15 and R20 diets, after two weeks of testing, induced a 17.20 to 17.36%, 23.84 to 25.69% and 32.95 to 34.50% reduction in the yolk cholesterol content of the hens compared to the control diet, respectively. After two weeks of experimentation, the yolk cholesterol contents of the R10, R15 and R20 diets decreased, highly significantly ($p < 0.05$) compared to that of the Rt control batch (Table 3).

Table 3. *Evolution of Cholesterol Concentration as a Function of Time.*

Characteristics	Weeks	Experimental diets			
		Rt	R10	R15	R20
Cholesterol concentration (mg/g)	2	25.37±0.86 [a]	20.99±1.99 [b]	19.32±2.61 [c]	17.01±2.18 [d]
	4	26.08 ± 3.18 [a]	21.55±2.53 [b]	19.38±1.91 [c]	17.08±1.81 [d]
	6	25.72 ±2.06 [a]	21.27 ±2.40 [b]	19.35 ±2.00 [c]	17.04 ±1.90 [d]
	8	25.90 ±1.90 [a]	21.41 ±2.20 [b]	19.36 ±2.02 [c]	17.06 ±2.05 [d]
Taux de baisse du cholestérol	2		17.20% [e]	23.84% [f]	32.95% [h]
	4		17.36% [e]	25.69% [f]	34.50% [h]
	6		17.30% [e]	24.76% [f]	33.74% [h]
	8		17.33% [e]	25.25% [f]	34.13% [h]

[a, b, c, d, e, f, h] There is no significant difference (p≥0.05) between two means ± standard deviation (on the same line). Rations Rt, R10, R15 and R20: 0%, 10%, 15% and 20% cashew kernel cake incorporation rates, respectively.

3.4. Sensory Characteristics of the Egg

3.4.1. Acceptability Test

At the end of the acceptability test, the average rank assigned by the panelists is calculated for the eggs of a given diet. For the cooked (in the shell) eggs, it is 3.82 ± 0.13 for the control diet Rt while the diets R10, R15 and R20 had rank averages of 3.70 ± 0.14, 3.92 ± 0.14 and 3.94 ± 0.14 respectively.

As for the mean rank of raw eggs, the values of 3.88 ± 0.13, 3.86 ± 0.13, 3.86 ± 0.15 and 3.84 ± 0.15 were recorded for the Rt, R10, R15 and R20 diets respectively (Table 4). These descriptor means reflect that the eggs are accepted. Statistically there was no significant difference (P ≥ 0.05) between the egg rank means for either the raw or cooked egg.

Table 4. *Comparison of the overall acceptability averages of cooked and raw eggs in different diets.*

Batch of oggs	Rt	R10	R15	R20
Cooked eggs	3,82 ± 0,13 [a]	3,70 ± 0,14 [a]	3,92 ± 0,14 [a]	3,94 ± 0,14 [a]
Raw eggs	3,88 ± 0,13 [a]	3,86 ± 0,13 [a]	3,86 ± 0,15 [a]	3,84 ± 0,15 [a]

1: extremely unpleasant, 2: unpleasant, 3: neither pleasant nor unpleasant, 4: pleasant, 5: extremely pleasant

[a], There is no significant difference (p≥0.05) between two means ± standard deviation (on the same line). Rations Rt, R10, R15 and R20: 0%, 10%, 15% and 20% cashew kernel cake incorporation rates, respectively.

3.4.2. Quantitative Descriptive Analysis

The descriptors selected for the sensory evaluation of the eggs were yolk color, egg odor, egg taste, and egg aftertaste for the product in its cooked version and then shell color, yolk color, and egg odor for the raw egg. The descriptor means for the cooked egg ranged from 2.76 ± 0.17 to 3.14± 0.15, 3.50 ± 0.15 to 3.88 ± 0.14, 3.66 ± 0.12 to 3.84 ± 0.14 for yolk color, egg odor, egg taste, and egg aftertaste respectively. These descriptor means for cooked eggs correspond to neither dark nor pale yolk, pleasant odor, pleasant taste and aftertaste. The descriptor means for the shell egg (raw) ranged from 3.05 ± 0.14 to 3.74 ± 0.19, 3.26 ± 0.17 to 3.72 ± 0.17, 3.45 ± 0.15 for shell color, yolk color and egg odor. These descriptor means for raw eggs are equivalent to egg shells that are neither dark nor light, yolk color that is neither dark nor light, and odor that is rather neither pleasant nor unpleasant (Figures 1 and 2).

During the descriptive analysis test, the analysis of variance of the organoleptic data for cooked and raw eggs showed no significant difference (P ≥ 0.05) between the means of each descriptor for the four egg samples Rt, R10, R15, and R20 submitted to the taste panel.

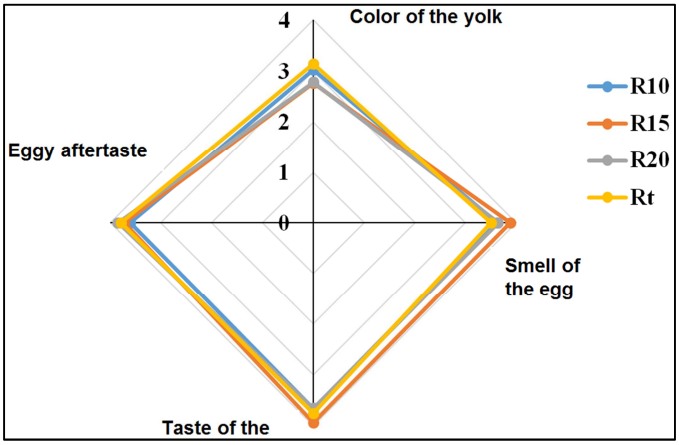

Figure 1. *Sensory profile of cooked eggs.*

Yolk color: Very pale, Pale, Neither dark nor pale, Dark, Very dark
Smell of egg: Very unpleasant, Unpleasant, Neither pleasant nor unpleasant, Pleasant, Very pleasant.
Taste of egg: Very unpleasant, Unpleasant, Neither pleasant nor unpleasant, Pleasant, Very pleasant.
Egg aftertaste: Very unpleasant, Unpleasant, Neither pleasant nor unpleasant, Pleasant, Very pleasant.
Rations Rt, R10, R15 and R20: incorporation rate of 0%, 10%, 15% and 20% of cashew nut meal respectively.

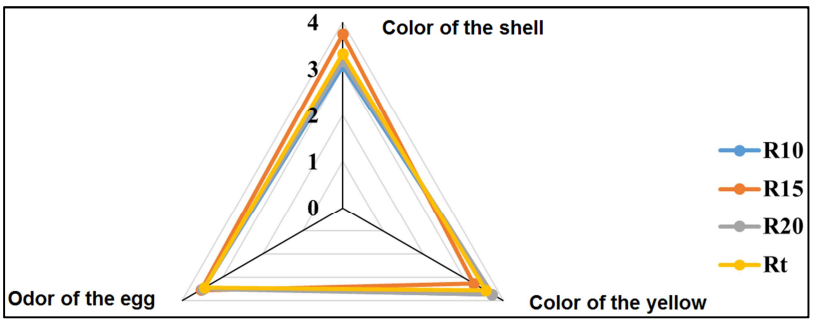

Figure 2. *Sensory profile of raw eggs.*

Shell color: Very light, Light, Neither dark nor light, Dark, Very dark
Yolk color: Very pale, Pale, Not dark-not pale, Dark, Very dark
Egg odor: Very unpleasant, Unpleasant, Not pleasant-not unpleasant, Pleasant, Very pleasant
Rt: Control diet; R10: Diet with 10% cashew nut cake, R15: Diet with 15% cashew nut cake, R20: Diet with 20% cashew nut cake

4. Discussion

The high cholesterol level being an obstacle to the free consumption of eggs, the present study aims at proposing diets able to improve the quality of the egg yolk. The analysis of the studied parameters revealed no significant difference in the moisture and total dry matter content of the egg yolk in relation to the addition of cashew kernel cake. This result is consistent with those reported by other authors who found no difference in egg yolk dry matter when incorporating up to 20% coconut cake [15, 16]. There is evidence that total solid levels of yolk increase with the age of the birds and the strain of the birds [17]. Similarly, egg storage conditions may alter the relative proportion of these yolk characteristics.

The lack of effect of the diets tested on the total lipid content in the yolk composition would be explained by the fact that the enzymes of lipogenesis are not affected by the nature of the diet [18]. Identical results were observed when 15% flaxseed was included in the diet for laying hens [19].

The R20 diet induced a reduction of up to 34% in the total cholesterol content of the egg yolk. Such a variation was also observed after supplementing the feed with chia (*Silva hispanica L.*) and euphorbia seeds (*Euphorbia heterophylla L.*) [20, 21].

These authors found an 18% reduction in chicken yolk cholesterol by incorporating 15% *Euphorbia heterophylla* seeds in the diet of laying hens. Monogastrics, including chicken, show a strong positive correlation between the nature of the fat ingested and the fat deposited in the carcass [22], especially for Polyunsaturated fatty acids (PUFAs), which are known to have beneficial effects on human health. The addition of oils in animal nutrition improves the growth performance and quality of the products obtained by providing essential fatty acids [23].

However, these results are different from those obtained by some authors who found no significant difference in the cholesterol content of egg yolks following the incorporation of fish and flaxseed oils in the diets of laying hens [24, 25].

The positive impact of the introduction of cashew kernel cake is undeniable. The reduction in cholesterol content of egg yolks in diets containing cashew kernel cake could be a result of the increased content of oleic acid and α-linoleic acid provided by cashew kernel cake since Monounsaturated Fatty Acids (MUFA) and Polyunsaturated Fatty Acids (PUFA) can lead to a reduction in cholesterol levels during lipid metabolism in birds [26].

The color of the yolk is important to consumers. Pale yolks are perceived as a sick hen while well colored yolks indicate a healthy hen. This impression is wrong because yolk coloration is directly dependent on the hen's carotenoid intake. The degradation of the yolk coloration would be related to the amount of carotenoids consumed by the hen because the animals cannot synthesize carotenoids. Therefore, it is only their diet that determines the yolk color of the eggs [27, 6]. Cashew kernel cakes would therefore be poor in carotenoids.

During the descriptive analysis test, the analysis of variance of the organoleptic data of the cooked and raw eggs shows no significant difference between the means of each descriptor for the four egg samples (Rt, R10, R15, and R20) submitted to the taste panel. These data imply that eggs produced from the cashew kernel meal feed have similar organoleptic qualities to eggs produced from the control (commercial) feed. These results are comparable to those obtained by some authors, who did not observe any effect on the sensory analysis of boiled eggs incorporating different food sources rich in n-3 fatty acids [28].

The present results corroborate those establishing similarity between the organoleptic qualities of soy milk and cashew almond milk for the mean sensory scores of soy milk and cashew milk [29]. Indeed a similarity was found in mouthfeel due to the similar fat contents present in both milk samples, as fat is well known to be associated with better mouthfeel.

Also, color is another important attribute used by consumers to judge the acceptability of food products [30]. The sense of taste of a food enables its ingestion and absorption into the body. Flavor is the primary criterion for liking or disliking a product. The sensations of taste and smell are flavor functions that are a complex of sensations [31]. Thus, eggs from diets containing cashew kernel meal

have organoleptic characteristics that allow them to be well liked by consumers on par with eggs from the control diet.

5. Conclusion

The results of this study indicate that the incorporation of cashew kernel cake in the diets of laying hens is likely to reduce egg cholesterol levels. This is a definite advantage, especially since the presence of anti-nutritional factors in cashew kernel cake has no significant effect on the parameters considered, even at 20% of the ration. In conclusion, far from degrading the quality of hens' eggs, the dietary lipids in cashew kernel cake can contribute to the optimization of poultry production by providing the consumer with the fatty acids recommended by the medical profession. The processing industry could thus formulate products based on eggs from farms supplemented with cashew kernel cake, without major problems of functional or sensory properties.

Abbreviations

ESEMV-B: School of Specialization in Breeding and Meat Trades of Bingerville
INP-HB: National Polytechnic Institute Houphouët Boigny
PUFA: Polyunsaturated Fatty Acids
MUFA: Monounsaturated Fatty Acids
ANOVA: analysis of variance
ODSc: Optical density of the sample
ODB: Optical density of the blank
ODS: Optical density of the standard
CS: Concentration of the standard
P0: Weight in g of the sample
P1: Weight in g of flask
P2: Weight in g of flask and lipids.
TNH Eggs 1.25: Mineral and vitamin supplement

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References

[1] Réhault S., Anton M., Nau F., Gautron J. and Nys Y. (2007). The biological activities of the egg. INRA Prod. Anim., 20, 337-348 https://doi.org/10.20870/productions-animales.2007.20.4.3470.

[2] Nys Y. and Sauveur B., (2004). Nutritional value of eggs. *INRA Animal Production*, 17 (5): 385-393, https://doi.org/10.20870/productions-animales.2004.17.5.3611.

[3] Seuss-Baum I., (2007). Nutritional evaluation of egg compounds. In: Bioactive egg compounds. Huopalahti R., Lopez-fandino R., Anton M., Schade R. (Eds), *Springer-verlag*, Allemagne, pp 117-144, http://dx.doi.org/10.1007/978-3-540-37885-3_18.

[4] Oluyemi, J. A and Roberts, F. A. (1979). Poultry production in warm wet climates. Revised edition. Spectrum House Ibadan Macmillian, Press Ltd., Londres, p. 197., https://agris.fao.org/agris-search/search.do?recordID=US201300583542.

[5] Garba S., Faruk, M. U. Jibir, M., Lescoat, P. and Tukur, H. M. (2010). Performance of Laying Hens Fed Millet-Based Diet with Different Energy Levels. In Proceedings of the XIIIth European Poultry Conference, Tours, France, 23-27th August, 2010.

[6] Bouvarel I., Nys Y., Panheleux M. and Lescoat P. (2010). How chicken feed influences egg quality. *Inra Animal Production*, 23: 167-182, https://hal.inrae.fr/hal-02667258/document.

[7] Kouadio K. B., Dougnon M. G. and Kouakou N. D. V. (2016). Effect of supplementing cockerel growth feed (Warren) with detoxified Jatropha curcas meal. *Journal of Animal et Plant Sciences,* 28 (3): 4479-4487, https://m.elewa.org/Journals/wp-content/uploads/2016/05/3.Kouadio.pdf.

[8] Silue F. E., Ouattara H., Méité A., Kouakou N. D. V., Coxam V. and Kati-Coulibaly (2020). Performances zootechniques, économiques et qualité physique des œufs des poules soumises à des régimes alimentaires apportant différentes concentrations de tourteau d'amandes de noix de cajou (Côte d'Ivoire). *European Scientific Journal*, 16 (3): 471-487, DOI: https://doi.org/10.19044/esj.2020.v16n3p472.

[9] Folch J., Lees M. et Sloane-Stanley G. H. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry*, 226: 497-509, DOI: 10.1016/S0021-9258(18)64849-5.

[10] Pasin G., Smith G. M. and O'mahony M., (1998). Rapid determination of total cholesterol in egg yolk using commercial diagnostic cholesterol reagent. *Food Chemistry*, 61: 255, http://dx.doi.org/10.1016/S0308-8146(97)00072-1.

[11] Kouakou N. D. V., Traoré G. C. M., Angbo-Kouakou C. E. M., Jean-François GRONGNET J. F. and Maryline KOUBA M. (2016). Effect of feeding Euphorbia heterophylla seeds on egg production, egg quality, lipid composition and sensory evaluation of eggs. Journal of Animal &Plant Sciences, 31 (2): 5000-5009, http://m.elewa.org/.../1.Ngoran.pdf.

[12] Meilgaard M., Civille G. V. and Carr B. T., (1999). Sensory evaluation techniques. 3rd edition, *CRC Press*, Boca Raton, Floride, 387p, https://doi.org/10.1201/9781003040729.

[13] Lateur M., Planchon V. and Moons E., (2001). Evaluation by sensory analysis of organoleptic qualities of old apple varieties. *Biotechnology, Agronomy, Society and Environment,* 5 (3): 180-188, https://popups.uliege.be/1780-4507/index.php?id=17475&file=1&pid=14842.

[14] Stone H. and Sidel J. L., (1993). Sensory Evaluation Practices. Food Science and Technology. A Serie of Monographs. *Academic Press Inc.* Etats-Unis, 311 p. https://www.elsevier.com/books/sensory-evaluation-practices/stone/978-0-12-672690-9.

[15] Barreto, S. C. S. Zapata J. F. F., Freitas E. R., Fuentes M. F. F., Nascimento R. F., Araújo R. S. R. M., and Amorim A. G. N. (2006). Composição do ovo e dos ácidos graxos da gema de poedeiras comerciais alimentadas com rações contendo farelo de coco. *Pesquisa Agropecuária Brasileira*, 41 (12): 1767-1773, https://doi.org/10.1590/S0100-204X2006001200011.

[16] Vidal T. F., Pereira A. L. F., Abreu V. K. G., Freitas E. R., SoEtats-Unis Neto M. A. and Zapata J. F. F., (2013). Egg quality and yolk lipid composition of laying hens fed diets containing cashew nut meal. *Food Sciences and Technology*, Campinas, 33 (1): 172-179, https://doi.org/10.1590/S0101-20612013005000006.

[17] Ahn D. U., Kim S. M. and Shu H. (1997). Effect of egg size and strain and age of hens on the solids content of chicken eggs. *Poultry Science*, 76 (6): pp 914-919, DOI: 10.1093/ps/76.6.914.

[18] Benatmane F. and Mourot J. (2014). Effect of dietary linolenic acid on the fatty acid composition of neutral and polar lipids in rabbit muscle. *12th French-speaking Days of Nutrition*, Bruxelles, Belgique, 28 (1): 77, HAL Id: hal-01210779 https://hal.science/hal-01210779.

[19] Augustyn R., Barteczko J. and Smulikowska S. (2006). The effect of feeding regular or low α-linolenic acid linseed on laying performance and total cholesterol content in eggs. *Journal of Animal Feed Sciences*, 15: 103-106, DOI: https://doi.org/10.22358/jafs/70153/2006.

[20] Ayerza R. and Coates W. (2000). Dietary levels of chia: influence on yolk cholesterol, lipid content and fatty acid composition, for two strains of hens. *Poultry Science*, 78: 724-739, DOI: 10.1080/00071660120121517.

[21] Kouakou N. D. V., Traoré G., Angbo-Kouakou C. E. M., Kouamé K. B., Adima A. A., Assidjo N'. E., Grongnet J-F. and Kouba M. (2015). Preliminary trial of egg production of laying hens (ISA Warren) enriched in omega 3 polyunsaturated fatty acids with *Euphorbia heterophylla* L. *International Journal of Biological and Chemical Science,* 9 (4): 1902-1909, https://doi.org/10.4314/ijbcs.v9i4.15.

[22] Smink W., Gerrits W. J. J., Hovenier R., Geelen M. J. H., Verstegen M. W. A., Beynen A. C., (2010). Effect of dietary fat sources on fatty acid deposition and lipid metabolism in broiler chickens. *Poultry Science*, 89 (11): 2432–2440, https://doi.org/10.3382/ps.2010-00665.

[23] Benatmane F. (2012). Impact of feeds enriched with n-3 polyunsaturated fatty acids on the zootechnical performance and nutritional quality of meats. Doctoral thesis, University Mouloud Mammeri of Tizi-ouzou, Algeria, 172 p., https://www.ummto.dz/dspace/handle/ummto/1514.

[24] Ansari R., Azarbayejani A., Ansari S., Asgari S. and Gheisari A. (2006). Production of egg enriched with omega-3 fatty acids in laying hens. *Arya Journal*, 1 (4): 242- 246, https://www.semanticscholar.org/paper/PRODUCTION-OF-EGG-ENRICHED-WITH-OMEGA-3-FATTY-ACIDS-Ansari-Azarbayejani.

[25] Yalcyn H., Unal M. K. and Basmacyoolu H., (2007). The fatty acid and cholesterol composition of enriched egg yolk lipids obtained by modifying hens' diets with fish oil and linseed. *Journal of Medicinal Food*, 58 (4): 372-378, https://doi.org/10.3989/gya.2007.v58.i4.449.

[26] Xu J., Nakamura M. T., Cho H. P. and Clark S. D., (1999). Sterol regulatory element binding protein-1 expression is suppressed by dietary polyunsaturated fatty acids. A mechanism for the coordinate suppression of lipogenic genes by polyunsaturated fats. *The Journal of Biological Chemistry*, 274: 23577-23583, DOI: https://doi.org/10.1074/jbc.274.33.23577.

[27] Nys Y., (2000). Dietary carotenoids and egg yolk coloration. *A review of Archives Gefluegelkd,* 64: 45-54, https://www.cabdirect.org/cabdirect/abstract/20001421098.

[28] Baéza E., Chartrin P., Lessire M., Méteau K., Chesneau G., Guillevic M. and Mourot J. (2014). Effect of different dietary sources of n-3 fatty acids on laying performance and technological, nutritional and sensory quality of eggs. *Clinical Nutrition and Metabolism*, 28 (1): 68-69, Doi: 10.1016/S0985-0562(14)70646-6.

[29] Muhammad F. M., Ahsan M., Rabia S., and Nazir A. (2017). Nutritional and Sensory Properties of Cashew Seed (*Anacardium occidentale*) Milk. *Modern Concept et Developments in Agronomy,* 1 (1): 501; https://crimsonpublishers.com/mcda/pdf/MCDA.000501.pdf.

[30] Ahmad S., Roselina K., Hasanah M. G. and Nyuk L. C. (2013). Textural, Rheological and Sensory Properties and Oxidative Stability of Nut Spreads-A Review. *International Journal of Molecular Sciences – Int. J Mol Sci*., 14: 4223–4241, https://doi.org/10.3390/ijms14024223.

[31] Abu-Salem F. M. and Abou-Arab A. A. (2011). Effect of supplementation of Bambara groundnut (Vigna subterranean L.) flour on the quality of biscuits. *African Journal of Food Science,* 5 (7): 376-383, https://doi.org/10.5897/AJFS.9000103.