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Impact of Incorporating Argan Cake (*Argania spinosa* L.) and Desalted Anchovy Waste (*Engraulis encrasicolus*) on the Productive Performance of Broiler Chickens (*Gallus gallus*)

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ABSTRACT

Desalted anchovy bones (*Engraulis encrasicolus*) and argan cake are important sources of minerals and animal proteins. The objective of this study was to analyze the respective consequences of their addition to the diet of broiler chickens (*Gallus gallus*). Four groups, each containing 15 chickens, were organized according to the following factorial scheme: four feed treatments (including a control group) x five chickens per treatment x three repetitions (4x5x3). The groups were fed four different feed rations containing varying proportions of desalted anchovy bones (DAB) and argan cake (AC): T (0%DAB/0%AC), L01 (1%DAB/1%AC), L02 (2%DAB/2%AC), and L03 (3%DAB/3%AC). Results of the study revealed a significant difference (p>0.05) in weight gain during the start and end of the study for L02 (2144.46g), which was higher compared to the control T (2140.56g). Regarding the feed conversion ratio, L02 (1.54) was lower than the control T (1.65). Conversely, the other feed combinations, including 1% (L01) and 3% (L03), negatively affected weight gain and feed conversion ratio due to the addition of DAB and AC. From the results of the study, it can be concluded that at a low rate of 2% (L02: 2%DAB/2%AC), both desalted anchovy bones and argan cake appear to be effective substitutes for other fish meals and soybean cake in the diet of broiler chickens.

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1 Introduction

Poultry production has grown significantly globally, increasing from 101 million tonnes in 2014 to 133 million tonnes by 2021 (FAO 2021). The broiler poultry sector provides more than 98,000 direct and 225,000 indirect jobs (Abdelmajid et al. 2021). Poultry meat production has experienced an annual growth rate of more than 4% in recent years (Govoni et al. 2021). Poultry is one of the most consumed animal products in the world and plays a crucial role in guaranteeing food security and nutrition (Mottet and Tempio 2017). Current estimates suggest that by 2025, poultry meat production and consumption will surpass that of beef, pork, and mutton (Belkhanchi et al. 2023). Global poultry meat production is projected to reach 331 million tons by 2028 (Oladokun and Adewole 2020). The growing consumption of poultry can be attributed to its affordability and accessibility as a protein source (Belkhanchi et al. 2023). The poultry sector remains crucial as a provider of high-quality proteins, vitamins, and micronutrients essential for human consumption (Oladokun and Adewole 2020). The increased production of white meat demands a significant quantity of feed (Govoni et al. 2021).

Animal feed manufacturing has undergone numerous advancements, transitioning from simple manual formulations to computerized formulations (Alhotan 2021). Animal feed formulations are evidence to trace quality or address consumer claims (Bouchand et al. 2020). Plant by-products are increasingly considered nutrient-rich sources with useful compounds, offering cost-effectiveness and versatility (Taarji et al. 2018). Argan cake (*Argania spinosa* L.) is commonly used in the agri-food sector (Mirpoor et al. 2022). In Morocco, argan cake is indispensable to meet the protein requirements of livestock (Lakram et al. 2019). The argan forest in Morocco covers approximately 800,000 hectares and contains over 20 million trees (Sinsin et al. 2020). Meanwhile, argan oil production volume reached 5,640 tons in 2019 (MAMFRDWF 2020), with exports experiencing a nearly 55% increase from 871 tons in 2012 to 1,348 tons in 2019 (MAMFRDWF 2020). Traditionally, argan cake is used by the Berber community to feed and warm livestock (Mechqoq et al. 2022), including lambs (Moutik et al. 2021). Due to its nutritional properties, the argan tree is highly valued (Koufan et al. 2020) but rarely used in poultry feed. It is proposed that incorporating argan cake could improve the quality of chicken meat while reducing production costs (Boumendil et al. 2023). Therefore, it will be used as an ingredient in our broiler chicken formulation.

On the other hand, desalted anchovy bones present a significant mineral source that can also be repurposed as another ingredient in innovative broiler chicken formulations (Boumendil et al. 2023). National fishery production recorded a volume increase of more than 10% compared to 2021 (Driouichi 2023), with anchovy being one of the most frequently caught species worldwide (Fernandez et al. 2018). In-depth studies on the use of salted fish meal in poultry have not yet been conducted (Hasan et al. 2019). These local resources used in broiler chicken formulations are tested on three groups with 1%, 2%, and 3% ratios.

The composition of poultry feed is determined by several factors, including the nutritional needs of birds at different stages of their lives, available ingredients, costs, and production goals (Belkhanchi et al. 2023). The success of quality feed formulation heavily depends on a good understanding of the physicochemical characteristics of raw materials (Hertrampf and Piedad-Pascual 2012). It is necessary to know the chemical composition, physical characteristics, and digestibility of ingredients used in animal feed. However, the raw materials used for feed formulation depend on the country or region and their potential (Brah et al. 2015). It is recommended that each formulator build their database based on available local or natural feed resources (Burel et al. 2000). The number of nutrients to be considered for formulation varies. Still, the most commonly used for formulation are metabolizable energy, crude protein (Brah et al. 2015), amino acids (Sterling et al. 2005), fatty acids, calcium, and phosphorus (Burel et al. 2000). The maximum and minimum limits of each ingredient must be known to avoid toxicity (Brah et al. 2015). Determining nutrient requirements, including metabolizable energy, crude protein, amino acids, calcium, and phosphorus of poultry feed, is essential for its successful formulation (Belkhanchi et al. 2023). Further, poorly adjusted feed formulation can negate the profit margin of chicken production. It is thus necessary to optimize the feed contents of each essential amino acid (methionine, lysine, threonine, tryptophan) (Alagawany et al. 2021). This step involves calculations to determine the combination of different ingredients that cover the recommended needs for poultry.

Previously, formulation techniques such as empirical and manual methods (Chiba 2009; Omidiora et al. 2013) were employed. Mathematical programming techniques such as linear, nonlinear, multiobjective, and quadratic programming are also employed (Peña et al. 2009; Heydari 2014; Brah et al. 2015). The objective of this study was to meet the nutritional needs of broilers (*Gallus gallus*) and improve production performance using local and natural resources: desalted anchovy bones (*E. encrasicolus*) and argan cake, following a profitable, practical, and less expensive formulation.

2 Materials and Methods

The study was conducted on a certified farm located in the Tnine Chtouka region, El Jadida province, Morocco (N°295 23/VV/09/EL/POU/Ch). Sixty (ROSS 308) broiler chickens (n = 60) were randomly divided into 4 groups according to a factorial design: 4 dietary treatments (including a control group), 5 chickens per treatment, and 3 repetitions (4x5x3). The chickens, selected from a hatchery at one day old with an initial weight of approximately 40 grams, were fed with starter and grower feed.

The feed used as the control (T) was a commercial feed produced by OMNIA INTAJ, which specializes in manufacturing compound feed for poultry. The poultry houses had ventilation and lighting systems provided by mesh-covered wall openings placed 60 cm above the ground. Temperature and humidity were regularly monitored to ensure an optimal environment for the chickens. Nipple drinkers, brooders, and feeders were installed to provide the chickens with ad libitum feeding and continuous access to drinking water. Unconsumed feed was collected and weighed at regular intervals.

The formulation of the diets was developed using the ALLIX[3] software in collaboration with the CCPA GROUP, a French company specializing in animal nutrition and health. The experimental diets included standard components such as corn and soybean meal, different levels of desalted anchovy bone waste (DAB) and argan cake (AC). The feed rations prepared for the experiment were control T (0% DAB/0% AC), L01 (1% DAB/1% AC), L02 (2% DAB/2% AC), and L03 (3% DAB/3% AC). The chemical compositions of the DAB, AC, and the experimental diets calculated in this study are presented in Tables 1 and 2.

Statistical analysis was performed using IBM SPSS.21 software. Analysis of variance (ANOVA) was conducted to assess zootechnical performance, and differences were considered significant at $p < 0.05$.

3 Results and Discussion

3.1 Composition of the Ingredients Used in This Study

The argan tree, *Argania spinosa* (L.) Skeels, is an endemic forest species in Morocco, widely cultivated for the significant nutritional qualities of its oil (Chakhchar et al. 2022). However, argan cake, a by-product of oil extraction, remains underutilized by farmers despite its nutrient richness. The biochemical composition of argan cake, rich in protein, essential amino acids, and other nutritional elements, makes it a valuable feed ingredient in poultry diets (Lakram et al. 2019).

Broiler chicken farming has experienced significant growth, which affects the birds' skeletal development and leads to leg disorders, resulting in economic losses. Calcium and phosphorus are essential components of chicken bones, and their presence in the diet is crucial, with recommended amounts of 6 to 6.5 g/kg for calcium and 2 to 3.5 g/kg for phosphate (Matuszewski et al. 2020). Anchovy bones are considered an excellent source of organic minerals, particularly calcium at 7.07% and phosphorus at 3.65% (Table 1). Therefore, introducing anchovy bones into broiler chicken diets could improve skeletal health and reduce economic losses related to leg disorders (Savitri et al. 2021).

To evaluate their effectiveness as poultry feed, it is imperative to conduct rigorous experimental studies to determine their impact on poultry growth. The results of these studies will provide precise recommendations regarding the optimal proportions of argan cake

Table 1 Chemical Composition of Various Ingredients Used in the Diets

Compositions	Nutrients	DAB	AC
Chemical (%)	Crude protein (%)	34.50	39.50
	Dry matter (%)	90.90	89.90
	Total phosphorus (%)	03.65	00.65
	Fat (%)	16.10	17.00
	Ash (%)	24.80	04.00
	Crude fiber (%)	00.00	17.20
Mineral (%)	Potassium(%)	01.20	01.00
	Phosphorus(%)	03.65	00.65
	Calcium (%)	07.07	00.50
	Sodium chloride (%)	04.70	00.30
Amino acid (%)	Digestible isoleucine (%)	01.33	00.98
	Digestible lysine (%)	02.37	01.26
	Digestible threonine (%)	01.30	01.04
	Digestible valine (%)	01.56	01.49

DAB: Desalted Anchovy Bones, AC: Argan cake

(AC) and desalted anchovy bones (DAB) to include in broiler chicken diets. The chemical compositions of AC and DAB used in this study are presented in Table 1.

3.2 Formulation and Composition of the Experimental Diets

Formulation software is crucial to optimize the use of raw materials and ensure better incorporation of new ingredients. In this study, a linear program was deemed essential to formulate balanced diets regarding essential nutrients, aiming to improve zootechnical performance and reduce economic losses (Mallick et al. 2020). The design of the feed formulas was carried out using the ALLIX 3 software, developed in collaboration with the CCPA GROUP, a French company specializing in animal nutrition and health.

The formulation results highlighted the variations between the different prepared diets, ensuring that these diets were isocaloric, thereby emphasizing the importance of maintaining consistent energy while optimizing ingredient combinations. Table 2 details the different feed compositions for each phase of broiler chicken production (*Gallus gallus*).

This research indicates that the protein concentration increases from 17.5% in the control group to 17.80% for L01, 19.32% for L02, and 20.52% for L03. In the starter phase, the protein concentration is 20.8% in the control group, while it is 21.2%, 23%, and 23% for groups L01, L02, and L03, respectively. The increase in AC concentration in the diets can also raise the levels of essential minerals, such as calcium, from 0.57% in the control group to 0.62% in the three groups. Potassium levels, however, are 0.817% for L01, 0.806% for L02, and 0.726% for L03, remaining lower than the control group in the growth phase at 0.823%.

In summary, increasing the AC concentration appears to positively impact protein concentration, while calcium levels increase and potassium levels slightly decrease. Based on these observations, it is possible that increasing the AC concentration has distinct effects on the various nutrients present in the diets.

Table 2 Chemical composition of the diets

Period	Composition	Startup Composition	T	L01	L02	L03
Startup	Chemical (%)	Crude protein (%)	20.80	21.20	23.00	23.00
		Total phosphorus (%)	0.636	0.602	0.599	0.562
		Crude fat (%)	3.00	3.231	3.562	2.944
		Ash (%)	5.981	5.806	6.149	6,061
		Crude fiber (%)	4.829	3.063	3.238	2.573
	Mineral (%)	Calcium (%)	0.970	0.970	0.970	0.970
		Sodium chloride (%)	0.150	0.150	0.150	0.150
	Aminoacid (%)	Digestible lysine (%)	1.060	1.100	1.100	1.207
		Digestiblemethionine(%)	0.483	0.508	2.400	30.826
		Digestible valine (%)	0.868	0.902	0.969	0.978
Growth	Chemicals (%)	Crude protein (%)	17.50	17.801	19.321	20.527
		Total phosphorus (%)	0.509	0.468	0.474	0.500
		Crude fat (%)	3.044	2.773	3.385	2.593
		Ash (%)	4.522	4.294	4.561	4.172
		Crude fiber (%)	4.299	3.437	3.861	2.451
	Minerals (%)	Calcium (%)	0.570	0.620	0.620	0.620
		Potassium (%)	0.823	0.817	0.806	0.726
		Sodium chloride (%)	0.162	0.140	0.140	0.140
	Amino acids (%)	Digestible lysine (%)	0.910	0.910	0.968	0.910
		Digestible methionine (%)	0.408	0.401	0.385	0.382
		Digestible valine (%)	0.717	0.735	0.814	0.840

T: 0% DAB/0% AC, L01:1% DAB/1% AC, L02: 2% DAB/2%AC, L03: 3% DAB3%AC

3.3 Analysis of Broiler Chicken (*Gallus gallus*) Zootechnical Performance

Broiler chickens were monitored for 35 days. Figures 1 (initial stage of broilers) and 2 (growth stage of broilers) show the progression of parameters (weight, weight gain, feed consumption, and feed conversion ratio). The results of this study, illustrated by Figure 1, show that the initial average weight of L03 (926.06 g) is almost identical to that of the control group T (926.70 g), unlike L01 (925.70 g), which is slightly lower. However, the average weight of L02 (929.78 g) exceeds the standard value of T (926.70 g). On the 35th day (Figure 2), it was observed that the average weight of chickens in L01 (2137.58 g) and L03 (2137.23 g) was lower than that of chickens in T (2140.56 g). In contrast, the average weight of chickens in L02 at the end of the experiment was higher (2144.46 g) than that of chickens in T (2140.56 g). These results indicate that incorporating DAB and AC into broiler chicken diets in a proportion of L02 (2% DAB/2% AC) can increase chicken weight.

The results of this study show that the total feed consumption during the starter phase varies from 1215.07 g to 1242.44 g. Feed consumption ranges from 3386.05 g to 3443.97 g during the growth phase. Chickens fed with L01 (3386.05 g) and L03 (3443.97 g) had the highest consumption compared to L02 (3304.43 g), which was lower than the control group T (3333.30 g). These results suggest that chickens fed with the L02 diet can grow normally compared to control chickens (T).

Regarding the feed conversion ratio of the three studied groups, L02 (1.54) has the lowest conversion ratio compared to L01 (1.58) and L03 (1.61) and is close to the standard T (1.56). These results are positive, as the weight of L02 is higher than that of the control group T, with a lower feed conversion ratio than the other two diets (L01 and L03).

The obtained results showed that a balanced diet with proteins, essential amino acids, and minerals has a greater advantage in achieving better results than diets with amounts below or above the standards. This can be explained by further research conducted by Aftab et al. (2006), showing that protein percentage is always closely related to the composition of essential amino acids. The same observation was made by Garcia Neto et al. (2000), who found that a diet with 17% protein instead of 24% over 21 days led to a decline in zootechnical performance. This observation is consistent with the composition of our diets, as L02 has the best protein percentage in the starter phase at 23% compared to the control group at 20.8% and L01 at 21.2%. Similarly, in the growth phase, L02's protein percentage (19.32%) is higher than that of the control group and L01, which have 17.05% and 17.8% protein percentages, respectively. Following the recommendations of the producers of the strain used in this investigation(ROSS308 2022), L02 remains within the acceptable protein percentage range, as they recommend 22% in the starter phase and 19-20% in the growth phase (ROSS308 2022).

On the other hand, the desalination method used for DAB allowed the detoxification of argan cake from 4.56 to 0.4 mg/g (reduction

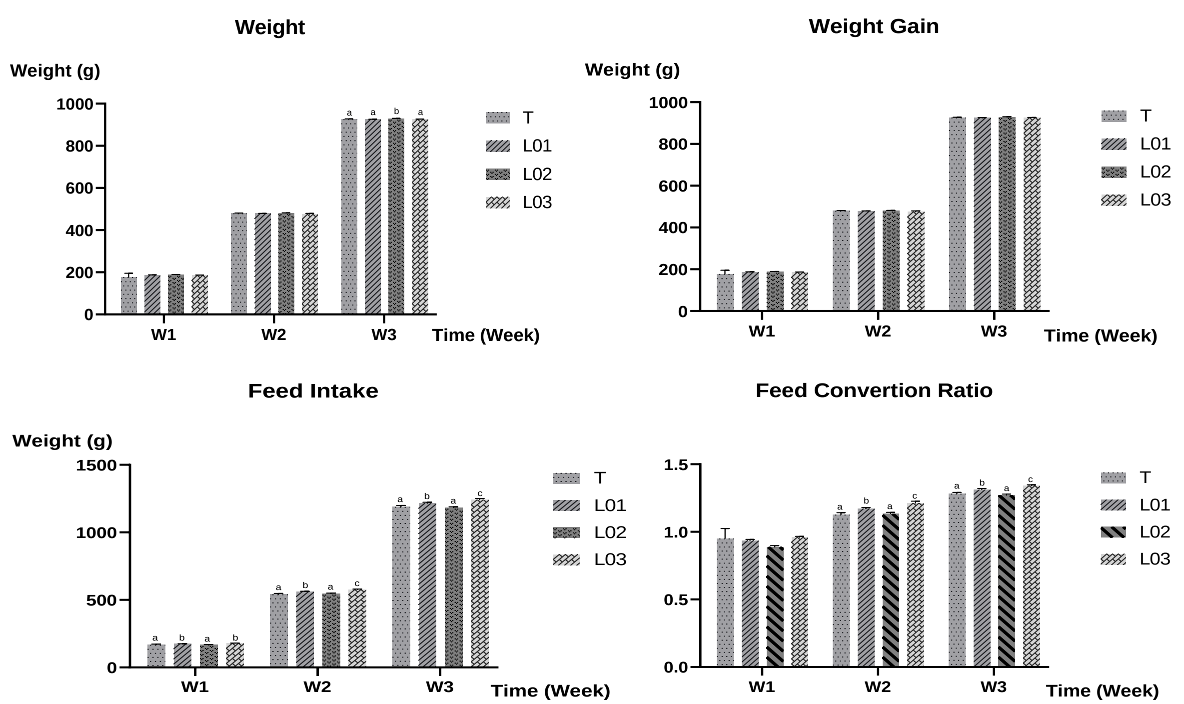

Figure 1 Initial stage of broilers (*G. gallus*)

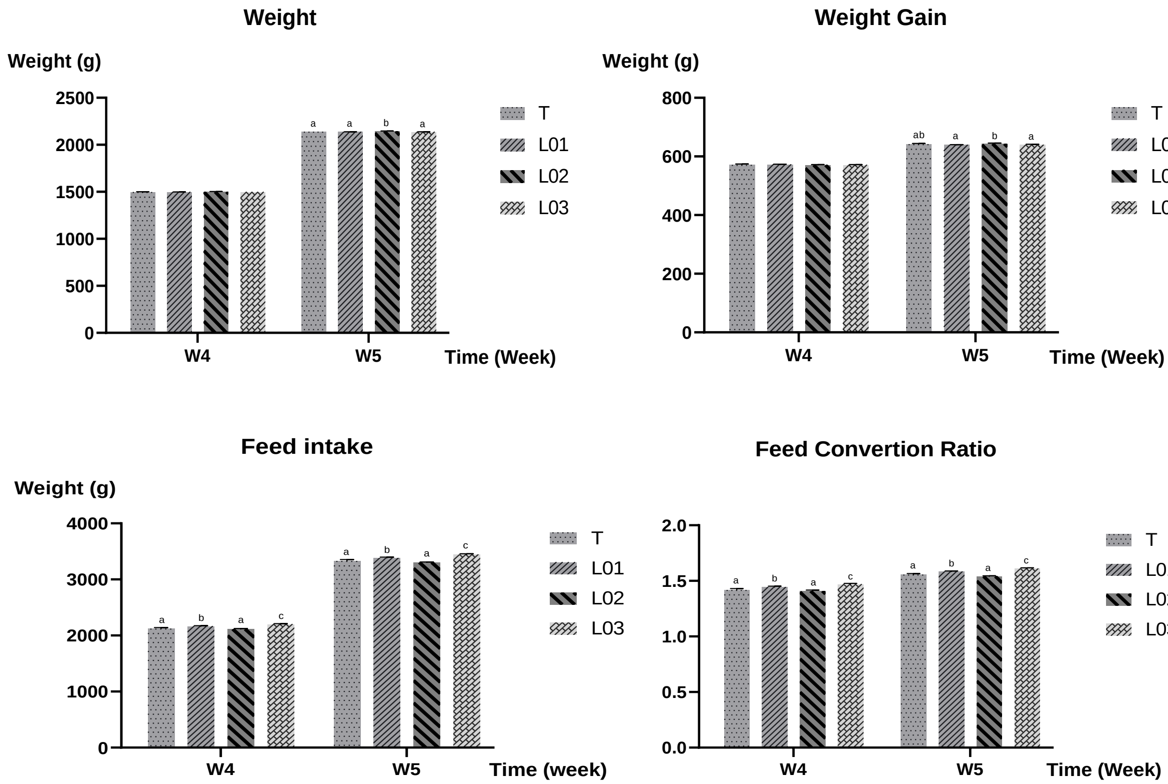

Figure 2 Growth stage of broilers (*G. gallus*)

of antinutritional substances such as saponins)(Lakram et al. 2019). The study of the physicochemical parameters of the by-products and the method of preserving semi-finished fish bones also show that our product meets the poultry needs according to the studied parameters (Boumendil et al. 2019). Indeed, the analyses conducted have demonstrated that our product meets the essential nutritional criteria for poultry growth and health.

Conclusion

The results of this study show that chickens fed diets enriched with AC and DAB at 1% (L01), 2% (L02), and 3% (L03) achieved notable outcomes. The 1% (L01) and 3% (L03) ratios, however, were negatively affected by the addition of DAB and AC, with the average weights of L01 (2137.58 g) and L03 (2137.23 g) being lower than that of the control group T (2140.56 g). In contrast, L02 showed two positive outcomes: an average weight of 2144.46 g, higher than T (2140.56 g), and a lower feed conversion ratio of 1.54 compared to the control group's ratio of 1.56. These results suggest that L02 chickens have better feed conversion efficiency, indicating improved utilization of the nutrients in their diet. Based on these findings, continuing studies exploring the effects of different proportions of DAB and AC in broiler chicken diets would be valuable. Further research could also focus on assessing the nutritional quality of the produced meat.

Reference

Abdelmajid, S., Mukhtar, A., Baig, M. B., & Reed, M. R. (2021). Climate change, agricultural policy and food security in Morocco. In: M. Behnassi, M. Barjees Baig, , M. El Haiba, M.R. Reed (Eds) *Emerging Challenges to Food Production and Security in Asia, Middle East, and Africa: Climate Risks and Resource Scarcity* (pp. 171-196). Springer, Cham. https://doi.org/10.1007/978-3-030-72987-5_7

Aftab, U., Ashraf, M., & Jiang, Z. (2006). Low protein diets for broilers. *World's Poultry Science Journal, 62*, 688-701.

Alagawany, M., Elnesr, S. S., Farag, M. R., Tiwari, R., Yatoo, M. I., Karthik, K., Michalak, I., & Dhama, K. (2021). Nutritional significance of amino acids, vitamins and minerals as nutraceuticals in poultry production and health - a comprehensive review. *The veterinary quarterly*, *41*(1), 1–29. https://doi.org/10.1080/01652176.2020.1857887

Alhotan, R. (2021). Commercial poultry feed formulation: Current status, challenges, and future expectations. *World's Poultry Science Journal, 77*, 279-299.

Belkhanchi, H., Ziat, Y., Hammi, M., & Ifguis, O. (2023). Formulation, optimization of a poultry feed and analysis of spectrometry, biochemical composition and energy facts. *South African Journal of Chemical Engineering, 44*, 31-41.

Bouchand, C., Nguyen, D., Secretan, P.H., Vidal, F., Guery, R., et al. (2020). Voriconazole topical cream formulation: evidence for stability and antifungal activity. *International Journal of Antimicrobial Agents, 56*, 106083.

Boumendil, I., Baggar, A., Yassif, F. Z., Fechtali, T., & Safi, A. (2019). Physicochemical parameters of moroccan fish salted waste desalting of natural process. In M. Ezziyyani, (Eds), *Advanced Intelligent Systems for Sustainable Development (AI2SD'2019)*: *Advanced Intelligent Systems for Sustainable Development Applied to Environment, Industry and Economy*, *2020* (pp 514-519). Springer, Cham. https://doi.org/10.1007/978-3-030-36671-1_46.

Boumendil, I., Baggar, A., Sisouane, M., El Haimer, Y., Bounouar, N., et al. (2023). Desalting of anchovy residues salted with argan cake for use in poultry feed: use of surface response methodology (RSM). *Chinese Journal of Medical History / Zhong Hua Yi Shi Za Zhi, 53* (4).

Brah, N., Houndonougbo, M., & Issa, S. (2015). Etapes et méthodes de formulation d'aliment de volaille: Une synthèse bibliographique. *International Journal of Biological and Chemical Sciences, 9*, 2924-2931.

Burel, C., Boujard, T., Tulli, F., & Kaushik, S. J. (2000). Digestibility of extruded peas, extruded lupin, and rapeseed meal in rainbow trout (*Oncorhynchus mykiss*) and turbot (*Psetta maxima*). *Aquaculture, 188*, 285-298.

Chakhchar, A., Ben Salah, I., El Kharrassi, Y., Filali-Maltouf, A., El Modafar, C., & Lamaoui, M. (2022). Agro-fruit-forest systems based on argan tree in Morocco: A review of recent results. *Frontiers in Plant Science, 12*, 783615.

Chiba, L. I. (2009). Animal nutrition handbook. *Section, 12*, 316-331.

Driouichi, Z. (2023). Guide D'investissement Dans Le Secteur De La Peche Maritime Et De L'aquaculture Au Maroc. In D. D. L. P. Maritime (ed.) 1 ed.: Ministere De L'agriculture Et De La Peche Maritime.

FAO (2021). Gateway to poultry production and products. 2021 ed. Retrived from https://www.fao.org/poultry-production-products/production/en/: FAO.

Fernandez, G., Cabral, A., Andreoli, M. F., Labarthe, A., M'Kadmi, C., et al. (2018). Evidence Supporting a Role for Constitutive Ghrelin Receptor Signaling in Fasting-Induced Hyperphagia in Male Mice. *Endocrinology*, *159*(2), 1021–1034. https://doi.org/10.1210/en.2017-03101

Garcia Neto, M., Pesti, G. M., & Bakalli, R. I. (2000). Influence of dietary protein level on the broiler chicken's response to methionine and betaine supplements. *Poultry science*, *79*(10), 1478–1484. https://doi.org/10.1093/ps/79.10.1478

Govoni, C., Chiarelli, D. D., Luciano, A., Ottoboni, M., Perpelek, S. N., Pinotti, L., & Rulli, M. C. (2021). Global assessment of natural resources for chicken production. *Advances in Water Resources, 154*, 103987.

Hasan, B., Putra, I., Suharman, I., Iriani, D., & Muchlisin, Z. A. (2019). Growth performance and carcass quality of river catfish Hemibagrus nemurus fed salted trash fish meal. *The Egyptian Journal of Aquatic Research, 45*, 259-264.

Hertrampf, J. W., & Piedad-Pascual, F. (2012). *Handbook on ingredients for aquaculture feeds*, Springer Science & Business Media.

Heydari, S. G. (2014). Effect of linear and random nonlinear programming feed formulating on performance of broilers. *Journal of Novel Applied Sciences, 3*, 1426-1429.

Koufan, M., Belkoura, I., Mazri, M. A., Amarraque, A., Essatte, A., Elhorri, H., Zaddoug, F., & Alaoui, T. (2020). Determination of antioxidant activity, total phenolics and fatty acids in essential oils and other extracts from callus culture, seeds and leaves of *Argania spinosa* (L.) Skeels. *Plant Cell, Tissue and Organ Culture, 141*, 217-227.

Lakram, N., Moutik, S., Mercha, I., Maadoudi, E. H. E., Kabbour, R., et al. (2019). Effects of the inclusion of detoxified argan press cake in the diet of dairy goats on milk production and milk quality. *Turkish Journal of Veterinary & Animal Sciences, 43*, 323-333.

Mallick, P., Muduli, K., Biswal, J. N., & Pumwa, J. (2020). Broiler poultry feed cost optimization using linear programming technique. *Journal of Operations and Strategic Planning, 3*, 31-57.

Mamfrdwf (2020). Filière Arganier.

Matuszewski, A., Łukasiewicz, M., & Niemiec, J. (2020). Calcium and phosphorus and their nanoparticle forms in poultry nutrition. *World's Poultry Science Journal, 76*, 328-345.

Mechqoq, H., Hourfane, S., El Yaagoubi, M., El Hamdaoui, A., Da Silva Almeida, J. R. G., Rocha, J. M., & El Aouad, N. (2022). Molecular docking, tyrosinase, collagenase, and elastase inhibition activities of argan by-products. *Cosmetics, 9*, 24.

Mirpoor, S. F., Giosafatto, C. V. L., Mariniello, L., D'agostino, A., D'agostino, M., Cammarota, M., Schiraldi, C., & Porta, R. (2022). Argan (*Argania spinosa* L.) seed oil cake as a potential source of protein-based Film Matrix for Pharmaco-Cosmetic Applications. *International Journal of Molecular Sciences, 23*, 8478.

Mottet, A., & Tempio, G. (2017). Global poultry production: current state and future outlook and challenges. *World's Poultry Science Journal, 73*, 245-256.

Moutik, S., Benali, A., Bendaou, M., Maadoudi, E. H., Kabbour, M. R., El Housni, A., & Es-Safi, N. E. (2021). The effect of using diet supplementation based on argane (*Argania spinosa*) on fattening performance, carcass characteristics and fatty acid composition of lambs. *Heliyon*, *7*(2), e05942. https://doi.org/10.1016/j.heliyon.2021.e05942

Oladokun, S., & Adewole, D. I. (2020). In ovo delivery of bioactive substances: an alternative to the use of antibiotic growth promoters in poultry production—a review. *Journal of Applied Poultry Research*, *29*, 744-763.

Omidiora, E. O., Adegoke, B., & Aderounmu, G. (2013). Review of livestock feed formulation techniques. *Journal of Biology, Agriculture and Healthcare*, *3* (4), 69-76.

Peña, T., Lara, P., & Castrodeza, C. (2009). Multiobjective stochastic programming for feed formulation. *Journal of the Operational Research Society*, *60*, 1738-1748.

ROSS308 (2022). Normes Et Valeurs Nominales Pour Le Poulet De Chair ROSS308 Belgique: AVIAGEN EPI NV.

Savitri, I., Tohata, V., Sormin, R., Lalopua, V., Mailoa, M., & Rieuwpassa, F. (2021) Chemical properties of dried anchovy (*Stolephorus* sp) from Buru Island. *IOP Conference Series: Earth and Environmental Science*, *797*, 012022. doi:10.1088/1755-1315/797/1/012022

Sinsin, T. E., Mounir, F., & El Aboudi, A. (2020). Conservation, valuation and sustainable development issues of the Argan Tree Biosphere Reserve in Morocco. *Environmental & Socio-economic Studies, 8*, 28-35.

Sterling, K., Vedenov, D., Pesti, G., & Bakalli, R. (2005). Economically optimal dietary crude protein and lysine levels for starting broiler chicks. *Poultry Science, 84*, 29-36.

Taarji, N., Da Silva, C. A. R., Khalid, N., Gadhi, C., Hafidi, A., et al. (2018). Formulation and stabilization of oil-in-water nanoemulsions using a saponins-rich extract from argan oil press-cake. *Food Chemistry*, *246*, 457-463.