Effects of Natural Products Mixtures Based on Marl, Mild Paprika, Turmeric, Ginger and Garlic on the Performance of Laying Hens

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Abstract

The effects of adding 3% of natural preparations based on marl and mild paprika mixed with garlic (MPGar), ginger (MPGin) and/or turmeric (MPT) on the laying performance and egg qualities were studied in laying hens from 48 to 53 weeks. One hundred and twenty-eight H&N strain laying hens were randomly allocated to 4 treatments (8 replicates and 4 hens per replicate). Hens were fed the following diets for six weeks, respectively: 1) basal diet (control group without any addition); 2) the basal diet added with 30 g/kg of MPGar complex; 3) the basal diet added with 30 g/kg of MPGin complex; 4) the basal diet added with 30 g/kg of MPT complex. Laying performance (number, egg weight, egg mass, feed conversion ratio), egg qualities (albumen and yolk weight, Haugh units, yolk colour) and the eggshell strength were evaluated weekly. The results of this study showed that mixtures of natural preparations significantly improve the laying percentage, the egg mass and feed conversion ratio ($P<0.05$). Moreover, compared to the control group, the yolk (%), the Haugh units and the yolk colour were impacted significantly in hens receiving the experimental diets ($P<0.05$). On the other hand, although not significant, the mixtures (MPGar) and (MPGin) seem to improve the shell thickness (+2.4% and +1.7%, respectively). Results of this experiment highlight the value of marl and spices mixture to improve the laying performances and egg qualities.

Keywords: Condiments, egg production, eggshell, marl, yolk colour

Introduction

To meet the expectations of government, scientists and consumers looking for healthy and natural animal products, a wide spectrum of natural additives based on phytobiotics and clays were recommended in poultry feed. Thereby, many medicinal and aromatic plants, spices and their extracts have recently received considerable attention as natural feed supply. Indeed, natural additives are generally believed to be safer, healthier and mitigate the risk of residues from antibiotic use in animals and humans. Likewise, phytobiotics exert antimicrobial and antioxidant activities, increases enzymatic secretions, maintain the integrity of the digestive tract and improve immune status (Fascina *et al*., 2012), enhances feed efficiency, performance and animal welfare (Sugiharto and Lauridsen, 2016). Moreover, clays are natural products that can be economically used to achieve a healthy

digestive tract, to optimize performances and poultry welfare (Ouachem *et al*., 2015). Besides, clays are naturally abundant, cheap and so widely voluntarily used by the free-range hens or through ingestion of earthworms and insects of soil fauna. Soil ingestion may have some therapeutic value. In fact, there is a hypothesis established by Engel (2002) which states that soil ingestion by hens is akin to self-medication. The spontaneous consumption of clay has been shown in other situations, especially in cases of digestive disorders or for reducing a state of unrest (Andrews and Horn, 2006). The Marl is a clay type available in Algeria, results of positive responses observed in both broilers and layers have been published in recent years (Ouachem *et al*., 2015; Lombarkia and Ouachem, 2019). The available results are generally obtained in tests that used these natural additives alone. However, comparative studies and scientific reports describing the effects of a natural preparation based on mixtures of clays and condiments on laying performances and egg qualities are not sufficiently documented. Based on these considerations, we became interested to compare the effectiveness of three natural preparations based on marl and mild paprika (MP) mixed with garlic (MPGar), ginger (MPGin), and/or turmeric (MPT) on the laying productive performances and egg qualities.

Materials and methods

Experimental design, diets and clay

The experiment was carried out at the poultry research unit of the Agronomic and Veterinary Sciences Institute of Batna 1 University (Algeria) on a total of 128 (48-weeks-old) H&N laying hens (Super Nick strain), weighing on average 1760g. Prior and throughout the experimental period, the hens did not receive any vaccination or prophylactic program, they were randomly distributed among four dietary treatments groups of 32 hens each (control and three experimental groups) into 8 standard cages with four hens each. Through a 6-weeks trial period, birds of a control group (C) received a basal diet without additives; those of the experimental groups were fed some diets supplemented with 3% of preparation based on marl and mild paprika mixed with garlic (MPGar), ginger (MPGin) and/or turmeric (MPT). Diets were prepared according to the nutritional recommendations of the breeding guide of H&N international laying strain. Diets ensure the needs for essential amino acids and minerals of laying hens and consist mainly of corn and soybean-meal 48, all feeding programs were isocaloric and isonitrogenous, the nutritional characteristics of diets were: 2750 kcal/kg ME, 16.6% CP, 0.80% of lysine, 0.40% of methionine, 0.73% of meth-cyst, 0.17% of tryptophan, 3.9% of calcium and 0.4% available phosphorus. Marl was ground, sieved (1.5 mm) and then mixed with spices studied. The marl matrix basically contains 68% of clay, 13 % of sand, low rate of organic matter (0.6%) and its physicochemical composition (in milliequivalent/100 g of soil) is: (Ca^{2+} = 4.6), (Mg^{2+} = 2.87), (Na^{+} = 0.33), (K^{+} = 0.1), (Cation Exchange Capacity = 20.5). A pre-experimental period (adaptation) of two weeks was carried out. According to the management guide H&N, the birds received 16 h of light/d throughout the experimental period, food was adjusted to 105 g/hen/day, the refusals were weighed weekly and hens had free access to water supplied by nipple drinkers system.

Methods and analysis

The laying productive performances (egg number, egg weight, feed conversion ratio and egg mass), the egg qualities (albumen and yolk percentage, Haugh units, yolk colour) and shell thickness were evaluated weekly.

The eggs weight was recorded using a precision scale (Sartorius 0.01g sensitivity), Feed conversion ratio was calculated by dividing the total feed intake (g) by the total egg weight produced (g) in the same week. The weight of egg yolk, albumen and eggshell was measured weekly. To measure these components, all eggs produced on a given day of the week were collected, weighed individually, then broken and the albumen and the yolk were separated before weighing. The eggshells were carefully washed and dried for 12 h in a drying oven at 70°C and then weighed, shell thickness was measured using an electronic caliper. The egg mass was determined from the formula:

$$\text{Egg Mass (g)} = \frac{\text{Egg Number X Egg weight}}{\text{Hen number}}.$$

Albumen height was measured by using a tripod after spreading a broken egg on a flat area and then the Haugh unit was determined by applying the formula described by Sauveur (1988):

$$\text{Haugh Units} = 100 \log (\text{albumen height} - 1.7 \text{ Egg weight}^{(0.37)} + 7.57).$$

The yolk colour or Roch Yolk Colour Fan value (RYCF) was estimated using the colour spectrum of the Roch scale (DSM nutritional Co), based on 15 shades, ranging from yellow to orange and bearing numbers 1 to 15.

Statistical analysis

Statistical analysis of data obtained were carried out in accordance with a completely randomized design of one-way variance analysis (ANOVA) using excel stat version 22. Differences were found significant at $P<0.05$.

Results

The results of the effects of experimental diets on laying productive performances, egg quality, eggshell strength, are shown in Table 1.

Overall, mixtures of natural preparations studied in this experiment were accompanied by significant responses both on the productive performance as well as the egg qualities. In fact, experimental diets improve the laying percentage, egg mass and feed conversion ratio ($P<0.05$). Parallel, compared to the control group, natural preparations studied, statistically ($P<0.05$) improved the percentage of yolk (+3.5% for MPGar and +3.4% for MPT), the Haughs units (+4.8% for MPGin group and +3.5% for MPT group) and significantly enhanced the yolk score which appreciably goes from 5.56 to scores above 12 ($P<0.05$). However, although it is not significant, compared to the control group, the hens receiving the mixtures of a natural preparation (MPGar and MPGin) have thicker eggsshells (+2.4% and +1.7%, respectively).

Discussions

Laying productive performances

The results of this study have clearly shown that mixture supply positively improves ($P<0.05$) all productive performances, excepted the egg weight. This was in agreement with the recent positive results observed in laying hens receiving natural clay-based preparations (kaolin and marl) mixed with olive leaves, mild paprika and turmeric (Lombarkia and Ouachem, 2019). In addition, the impact of the use of a commercial mixture composed of sepiolite and plant extracts based on thymol, eugenol and carvacrol was tested by Mathiaud *et al.* (2011) on zootechnical performance and the litter state in chicken and turkey. The results of this experiment showed improved feed efficiency in both contexts, but with a greater amplitude for the turkey (-8%) than in chickens (-2.9%). Likewise, according to the same reference, experimental diet also had a

positive effect on the droppings state and reduces interventions to renew degraded litter as well as repelling costs.

Furthermore, recently, under experimental conditions using mixtures of natural substances, Rahman *et al.* (2021) reported that the incorporation of 1.5% of plant powder mixture (plantain, ivy-gourd, garlic and spearmint) bossed to significant improvement in egg number (+10.1%), egg weight (+5.1%), egg mass (+15.7%), laying percentage (+10.2%) and feed conversion ratio (-8.4%) compared to control group, which agrees with this study.

Moreover, Abou-Elkhair*et al*. (2018) reported that the inclusion of fennel and hot red pepper seed improved the laying hen performance including egg weight, egg mass, hen day egg production and feed conversion ratio. This same trend was observed by Etha *et al*. (2017) in broiler production with a mixture of turmeric (1.25%) and red ginger (1.75%). According to the authors, the inclusion of the mixture mainly induces an improvement in weight gain (+4.8%) and feed efficiency (-9%), with a significant decrease in the rate of abdominal fat (-31%).

Table 1. Effects of MPGar, MPGin and MPT feed preparations on laying productive performances, egg quality, and eggshell thickness of laying hens.

Variables	Control	MPGar	MPGin	MPT	SEM	P value
	Laying Productive performance					
Egg number/week	198.17^{b}	218.50^{a}	219.5^{a}	220^{a}	2.09	P<0.05
Egg Weight (g)	59.96	61.01	61.69	60.62	0.415	P=0.542
Egg Mass (g)	53.02^{b}	59.50^{a}	60.45^{a}	59.54^{a}	0.726	P<0.05
FCR	2.08^{a}	1.83^{b}	1.81^{b}	1.83^{b}	0.026	P<0.05
% Lay	88.47^{b}	97.54^{a}	97.99^{a}	98.21^{a}	0.936	P<0.05
	Egg quality					
Albumen (%)	64.21	61.41	63.87	63.49	0.472	P=0.14
Yolk (%)	25.93^{b}	26.82^{a}	26.37^{ab}	26.80^{a}	0.146	P<0.05
Yolk colour	5.56^{b}	12.54^{a}	12.06^{a}	12.61^{a}	0.774	P<0.05
Haugh units	86.27^{b}	87.37^{ab}	90.45^{a}	89.33^{ab}	0.656	P<0.05
Shell thickness (µm)	398.35	407.90	405.23	393.13	5.38	P=0.8

$^{(a,b)}$Means with different letters in the same line are statistically different; **MPGar**: a diet based on marl-paprika-Garlic; **MPGin**: a diet based on marl-paprika-Ginger; **MPT**: a diet based on marl- paprika-Turmeric; **FCR**: feed conversion ratio.

Similar effects observed in the broiler with a mixture of clay (attapulgite) and oregano powder have been attributed to the antimicrobial efficacy of clay and bioactive molecules of oregano against total coliforms of the ileum and cecum as well as by the significant proliferation of lactobacilli (Skoufos *et al*., 2016). Further, Tzora *et al*. (2017) explained the significant effect of a mixture of clay, oregano, benzoic acid on the performance and the scarcity of jejunal enterobacteria through the antioxidant and antimicrobial activity of phenols. Indeed, phytobiotics and natural spices possess phytochemicals and bioactive compounds providing antioxidant, antimicrobial and pro-

digestive activities challenging the enzymatic activity and intestinal functions, involved in the control and stability of the intestinal flora and the absorption of nutrients (Abou-Elkhair *et al*., 2018; Rahman *et al*., 2021).

Furthermore, natural substances such as clays and phytobiotics have often been used alone and not mixed, however, with positive responses on performance and quality. Indeed, as an indication, the addition of 2% clinoptilolite improves the egg weight (Rizzi *et al*., 2003). Whereas, 1.5% of sepiolite, significantly enhances feed conversion ratio and slightly increases egg number and egg mass (Mizrak *et al*., 2014). Furthermore, in breeding Campbell ducks, Fatouh *et al*. (2012) showed a particular effect of sodium bentonite on egg number, feed consumption ratio, egg mass, fertility and hatchability.

Note that the effects observed with condiments used in this study (paprika, garlic, ginger and turmeric) also exist through other citations. In fact, according to Riasi *et al*. (2012), 2% of turmeric statistically impacts the feed conversion ratio (2.25 vs. 2.54) and the egg mass (43.7 vs. 40.8 g; either + 7.1%). Similarly, Asrat *et al*. (2018) found that the addition of garlic powder at 1, 2 and 3% in the laying hen diet lead to improve the hen day egg production and egg quality.

It is well known that clays such as bedelix, smecta and others are considered like a digestive dressing, usually used in human medicine, promoting physical protection of the mucous membranes of the stomach and intestine. As a result, it was observed that the villi of the jejunum and the duodenal crypts of broilers fed a diet supplemented with marl appear significantly more developed (Ouachem *et al*., 2017). Likewise, according to Xia *et al*. (2004), the montmorillonite protects the small intestine epithelium and promotes higher villi. Still, copper treated montmorillonite, improves the villi height and the ratio: villi height /depth crypts, report these authors.

The clay responses can also be attributed to their antimicrobial effect and improved immune status. In fact, the addition of clay promotes a hygienic digestive tract by adsorption of aflatoxins (Prvulovič *et al*., 2007) and improves immunity by an increase (10%) of the relative weight of bursal Fabricius (Prvulovič *et al*., 2008). According to Rizzi *et al*. (2003), clay addition helps to protect the liver against the negative mycotoxins effects, improves the yolk pigmentation and laying performances. So, some clay types were recommended for their pro digestive properties to increase feed efficiency and healthy digestive tract as well as for antitoxic capacity to many gut undesirable substances such as biogenic amines, mycotoxins and endotoxins (Andrews and Horn, 2006).

Besides, various studies have provided some other explanations on the mechanisms of clay actions. Among the main factors advanced to explain the clay effects it was reported the non-metallic minerals naturally present in some clay types were the most important factor for the antibacterial ability. In fact, copper enriched montmorillonite was more efficient against pathogenic flora and eliminated *Escherichia coli* at a rate of 97% (Xia *et al*., 2004). According to Herrera *et al*. (2000), the treatment of montmorillonite with cetylpyridinium creates a surplus of positive charges on the surface and using scanning electron microscopy, it was found a large amount of *Salmonella enteritidis* accumulated on the cetylpyridinium exchanged montmorillonite surface. Additionally, the magnesium clay richness increases its adsorbent capacity, reduces consequently the pathogenic flora and therefore protects the intestinal mucosa (Melcion, 1995).

Egg quality and shell thickness

As shown in Table 1, the significant increase of the yolk colour, the yolk

percentage and the Haugh units observed in this study supported our recent results in laying hens receiving a natural preparation based on marl, olive leaf, turmeric and mild paprika (Lombarkia and Ouachem, 2019). The addition of marl and phytobiotics (red paprika, ginger, garlic and turmeric) seems to be at the origin of this important change in yolk colour. Indeed, red pepper and turmeric are potentially rich in natural carotenoids, sources of coloring pigments (Sherif, 2016). Otherwise, Asrat *et al.* (2018) found that the addition of 2% garlic powder significantly increased the egg yolk colour that is consistent with the present study. The significant effect of experimental diets on yolk colour is consistent with the positive response observed with clinoptilolite clay type (Rizzi *et al.*, 2003). This finding can be assigned to the probable enhancement of pigment transfer efficiency motivated by the antimicrobial and detoxifying effects of clays (Ouachem *et al.*, 2015). Also, it was reported that clay addition (clinoptilolite) helps to protect the liver against the negative mycotoxins effects, promotes the adsorption of red pigments and improves the yolk pigmentation and egg weight (Rizzi *et al.*, 2003).

Even more, growth and yolk colour are under hepatic control. So, according to Gerber (2006), yolk discoloration may be induced by factors such as mycotoxins which may reduce the activity and normal functioning of the liver. Similarly, according to Zaghini *et al.* (2005), inhibitory factors (mycotoxins) of liver function and lipid metabolism tend to degrade the yolk colour and the yolk weight.

The unexpected lack of an effect of the clay on the shell thickness may be related to a series of factors, in particular, the clay type and its purity (Melcion, 1995), its incorporation rate and rearing period (Prvulovič *et al*., 2007). However, unlike our results, several studies have highlighted the effect of different clay types on shell quality (Rizzi *et al*., 2003; Fatouh *et al*., 2012; Mizrak *et al*., 2014). Among the hypothesis explaining the clay effects on eggshells, it was reported the high affinity of clay to the calcium and its great exchange capacity (Roland, 1988). So, in case of clay zeolite, its exchange capacity towards the calcium would be greater than 7mg/g. The phosphorus excess tends to affect the eggshell (Elliot and Edward, 1991) and the aluminum zeolite contained would be able to make a complex with phosphorus that improves eggshell quality (Elliot and Edward, 1991).

In contrast, it is commonly known that eggs with thick and strong shells usually have a better appeal to consumers. This characteristic is a very important economic sell point because increased shell thickness means reducing the risks of toxic infection and the number of cracked eggs. The improved eggshell thickness among the experimental diets probably indicates that calcium absorption and utilization were enhanced by marl and condiments inclusion. Likewise, these effects appear to be induced by the antimicrobial effect of clays (Rizzi *et al*., 2003; Mizrak *et al*., 2014; Ouachem *et al*., 2015) and the antioxidant activity of phenols and turmeric acid contained in turmeric and paprika. Indeed, according to Riasi *et al*. (2012), the major components of turmeric may improve better uterine synthesis conditions, favourable calcium deposition and consequently increase shell thickness.

Conclusion

The findings in this study have indicated that using marl and spices in combination as feed additives in laying hens diets significantly enhanced ($P<0.05$) laying performance, yolk colour, Haugh unit with however a slight numerical difference in the shell thickness. Furthermore, the natural preparation highlighted the potential of red paprika, turmeric, and possibly garlic and ginger as a source of carotenoids and natural

pigments. So, it is desirable to consider these natural substances as green feed additives in the poultry feed industry. Further other studies in intensive industrial breeding, in less favourable breeding conditions, during the entire laying cycle or even in vitro are however recommended to validate these results.

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