POULTRY PRODUCTION IN SPAIN: NEW ADVANCES IN FEEDING AND NUTRITION PRACTICE

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1.- Introduction

Spain produces approximately 600 M broiler chickens per year and has a current laying hen census of 35 M birds. Production of other poultry species, such as turkeys and ducks, is quite limited. The number of birds slaughtered has remained quite flat for the last 10 years although final body weight (BW) has increased in this period by almost 200 g per bird. The number of laying hens has decreased markedly (e.g. circa 50 M in 2010) and the proportion of brown-egg layers has increased from less than 10% in 1990 to more than 90% in 2013. In addition to egg color, brown eggs are preferred by the consumers because of bigger size and better shell quality.

Broiler production corresponds primarily (70:30) to heavy birds slaughtered with more than 2.7-2.8 kg BW and medium size birds slaughtered at 2.4-2.5 kg BW. The interest in one or other type of bird depends primarily on geographical location. A small percentage of birds are destined to the grill market and slaughtered at lower weight (below 2.0 kg). Details on the characteristics of the diets and expected productive performance of commercial broilers are showed in Table 1. Most of the carcasses produced in Spain (> 70%) correspond to white broilers with no corn used in the finisher phase diets and less than 10-15% in the starter diets. Consequently, commercial diets are based primarily on wheat, barley, and soybean meal, with limited amounts of sunflower meal, rapeseed meal, and animal and vegetable fats. High amounts of barley (e.g., 40-50%), sunflower meal (e.g., 10-15%), and vegetable oil soapstocks (> 2-4%) are frequently included in the laying hen diets.

Table 1.- Broiler production in Spain

	Heavy birds	Medium size birds
Nutrient content		
AMEn, Mcal/kg	2.95 up to 3.17	3.00 up to 3.16
CP, %	23.0 down to 17.4	23.0-18.5
Dig. Lys, %	1.28 down to 0.93	1.28 down to 0.96
Productive performance		
Slaughter BW, kg	2.78-2.85	2.45-2.50
BW gain, g/d	64-66	60-62
FCR	1.75-1.85	1.72-1.75
Days to slaughter	42-45	40-42
Mortality, %	4.5-5.0	4.0-4.5

2.- Main factors impacting poultry production

As in most European Union (EU-27) countries, food safety, animal welfare, and sustainability issues, are key driver of animal production with high impact in nutritional decisions. For example, most diets will use phytases and monocalcium phosphate (rather than dicalcium or tricalcium phosphate) many times irrespective of cost. Also, the crude protein (CP) content of the diets is decreasing and the utilization of crystalline amino acids (including Lys, TSAA, Thr, and even Val) increasing. Moreover, numerous additives such as organic acids, probiotics, and prebiotics are used in substitution of growth promoters of antibiotic origin. The control of the incidence of footpad dermatitis, bone fractures, and feather pecking are taking into account in the nutritional programs, not only because of economic considerations, but also to meet legislation and consumer demands. In Table 2, we present data on production systems in key countries of the EU-27 related to hen welfare. Cages are still prevalent in South Europe while alternative systems, such as floor production and “freedom park” systems are gaining interest in North Europe.

Table 2.- Hen production systems in key European Union-27 countries, %

	Cages	Floor	Freedom[1]	Ecology
Germany				
2007	39	30	24	7
2011	17	62	14	8
UK				
2008	58	4	32	3
2012	49	4	45	3
Spain				
2012	96	2.3	1.6	0.1

[1]Open parks

3.- Nutritional practices

At present time, nutritional practices focus on the improvement in feed efficiency while maintaining carcass quality and fulfilling "social" requirements (food safety, animal welfare, and sustainability) of the consumers. Although possible, further increases in BW gain might not be as desirable in the near future, as it is now because of animal welfare legislation and consumer perception. In this respect, the industry is paying attention to 1) feed form of the diet and particle size of the ingredients, 2) carcass quality, integrity of the skeleton and the skin, and incidence of footpad dermatitis at slaughter, 3) judicious use of long-time existing (coccidiostats, enzymes, pigments, organic acids) and new (proteases, phytases, probiotics, prebiotics, herbs) additives, 4) control of microflora growth and microbial profile to improve gastrointestinal tract (GIT) health, and 5) feed and food safety for both chickens and humans. In this respect, high microbial counts or presence of *Salmonella* spp in the feed, or contamination by mycotoxins, heavy metals, dioxins, or chemical products of ingredients is no longer acceptable. Moreover, the use of "in feed antibiotics" as preventives and of meat and bone meal a dietary ingredient, are banned. In fact, many integrators will not use any ingredient of animal origin (such as lard or tallow) in their feeds.

4.- Digestive physiology and GIT health

The incidence of subclinical coccidiosis and the presence of *Clostridium* spp is of a major concern for most integrators. The ban of use of many coccidiostats, including nicarbazine, and “in feed antibiotics” as growth promoters has increased the incidence of litter problems. Many efforts in management and nutritional practices try to modulate GIT function, control microbiota growth, and improve the consistency of the excreta. In any case, the incidence and severity of wet litter problems is of limited relevance under practical conditions because of improvements in chick quality and hygiene and management conditions of the farms, as well as subtle changes in composition and nutritional specifications of the feeds. Practices used in this respect include a) coarse grinding of ingredients, b) use of mash diets rather than pellet diets, c) moderate reductions in CP content while maintaining the amino acids (AA) profile, d) moderate increases in dietary fiber, e) inclusion of whole wheat, and f) utilization of certain additives. Many of these practices aim to improve gizzard development and GIT function with better tuning of the anatomy and physiology of the digestive tract and of the microbial profile (Mateos et al., 2002, 2012).

a.- Feed form and particle size

Pelleting is a common practice used to maximize growth performance and reduce feed wastage in commercial broiler operations (Abdollahi et al., 2011; Serrano et al., 2013). Heat, moisture, and pressure applied during the pelleting process modify protein structure and increase AA digestibility of the diet. Broilers eat more with pellets or crumbles than with mash diets (Serrano et al., 2012). Serrano et al. (2012) compared growth performance of broilers fed mash, crumbles, or pellets from 1 to 21 d followed by a common pelleted diet from 21 to 42 d of age and observed a 7.4 and 5.8% increase in BWG with crumbles or pellets as compared with mash feeding. Also, FCR was 3% better for chicks fed pellets than for chicks fed mash, with chicks fed crumbles being intermediate (Table 3). The benefits of pellet feeding as compared with mash feeding on broiler growth diminished with age. Moreover, the incidence of wet litter, *Escherichia coli* counts, and *Salmonella spp* contamination of carcasses is higher with pellets than with mash (Engberg et al., 2002; Huang et al., 2006).

Table 3.- Effects of feed form on growth performance of broilers[1] (Serrano et al., 2012)

	BWG (g/d)	ADFI (g)	FCR
Day 1-21			
Mash	34.6[b]	57.0[ab]	1.65[a]
Crumbles	42.4[a]	58.8[a]	1.39[b]
Pellets	43.4[a]	56.3[b]	1.30[c]
P	***	*	***
Day 21-42			
Mash	89.1	154.0[b]	1.73[b]
Crumbles	90.6	166.1[a]	1.83[a]
Pellets	87.8	161.0[a]	1.84[a]
P	0.11	***	***

[1]Four replicates of 65 birds each per treatment

Pelleting requires fine grinding of the ingredients to improve the cohesion of feed particles. Consequently, the digest passage rate through the GIT is faster with pellets than with mash. As a result, birds will be satiated faster and will eat less of a coarse mash diet than of a pellet diet (Amerah et al., 2007) and consequently, growth rate will improve when the feed is pelleted. On the other hand, gizzard function and GIT development will improve with coarse grinding of the diet as compared with fine ground pelleted diets and consequently, nutrient digestibility might be reduced with pelleting (Svihus, 2011). Recent research (Svihus and Hetland, 2001; Abdollahi et al., 2010; Serrano et al., 2013) has shown that pelleting reduced nutrient digestibility an effect that might be more noticeable with wheat than with coin diets and when high temperatures are used. The existing data suggest that during the last part of the fattening, a period in which broilers are growing over 100 g/d, pelleting of the feed might improve BW gain but not necessarily feed efficiency. Moreover, a slight reduction in feed intake in this period might benefit feed efficiency of the chickens.

b.- Whole grain inclusion

The inclusion of whole wheat and other cereals in the diet results usually in an improvement in litter quality without any negative impact on growth or feed efficiency (Hetland et al., 2002; Plavnik et al., 2002; Svihus et al., 2004). Usually, whole wheat added at the expenses of the whole diet, improves nutrient digestibility and reduces feeding cost (Svihus et al., 2001). Whole wheat feeding led to changes of the upper part of the digestive tract with an increase in gizzard and pancreas development (Gabriel et al., 2008). The improvement in litter quality observed is often associated with changes in the microbial profile of the GIT with a reduction in *Clostridium spp* count (Bjerrum et al., 2006) and better control of subclinical coccidiosis (Gabriel et al., 2003a,b). However, the use of high proportion of whole wheat reduces carcass yield, and when fed early in life, might reduce feed intake. Probably, birds will need to learn and adapt to whole wheat feeding as early as possible.

c.- Dietary fiber

Traditionally, fiber has been considered as a diluent and an antinutritional factor in broiler diets with negative effects on feed intake, nutrient digestibility, microbial profile, and growth. However, recent research (Gonzalez-Alvarado et al., 2007, 2008, 2010; Svihus, 2011; Mateos et al., 2012) have shown that this might not be the case and that will depend on the ingredient composition of the diet, age of the birds, and type and level of fiber source used (Tables 4 and 5).

Table 4.- Effects of dietary fiber on growth performance of broilers from 1 to 42 d of age (González-Alvarado et al., 2010)

Fiber source	Control[1]	OH	SBP	SEM
BWG, g/d	55[b]	60[a]	56[b]	0.9
ADFI, g	88[ab]	90[a]	85[b]	1.0
FCR	1.59[a]	1.49[b]	1.53[b]	0.014
Energy efficiency[2]	20.8	20.4	20.5	0.19

[1] Sepiolite was substituted (wt/wt) by 3% OH or SBP
[2] MJ AMEn/kg BW

Table 5.- Effects of fiber inclusion in low fiber diets in broilers from 1 to 21 d of age (González-Alvarado et al., 2007)

	Control[1]	Fiber source[2], 3%			SEM
		Cellulose	OH	SBP	
BWG, g/d	29.3[b]	31.5[ab]	32.3[a]	30.3[ab]	0.57
ADFI, g	40.1	41.9	41.7	39.6	0.90
FCR	1.36[a]	1.33[ab]	1.29[b]	1.30[b]	0.014
N retention, %	61.8[c]	64.3[ab]	67.4[a]	63.9[abc]	0.59
EE dig., %	78.7[b]	84.5[a]	83.6[a]	82.2[a]	0.68
AME_n, Mcal/kg	3.01[c]	3.02[c]	3.19[a]	3.10[b]	0.012

[1] Contained 1.5% CF
[2] Sepiolite in the control diet was substituted (wt/wt) by CEL, OH, or SBP

In general, dietary fiber increased gizzard weight and benefit reverse peristaltism and endogenous enzymes production, resulting in a reduction in gizzard pH and in an improvement in nutrient digestibility (Hetland et al., 2003; Amerah et al., 2009; Jiménez-Moreno et al., 2009c, 2011) (Table 6).

Table 6. Effect of inclusion of oat hulls (OH) and sugar beet pulp (SBP) in the diet on the pH of the digesta of the proventriculus, gizzard and duodenum of broilers at 6 days of age (Jiménez-Moreno et al., 2013b)

	Fiber inclusion (%)	Proventriculus	Gizzard	Duodenum
Control	0	4.51^{a}	4.07^{a}	6.19^{b}
OH	2.5	4.23^{abc}	3.15^{b}	6.21^{b}
OH	5.0	4.27^{abc}	3.09^{b}	6.27^{b}
OH	7.5	4.31^{ab}	2.97^{b}	6.28^{ab}
SBP	2.5	3.99^{c}	3.02^{b}	6.30^{ab}
SBP	5.0	4.07^{bc}	2.92^{b}	6.37^{ab}
SBP	7.5	4.14^{bc}	2.90^{b}	6.40^{a}
S.E.M.[1]		0.099	0.099	0.043
		P-value[2]		
Diet		0.017	<0.001	0.010
OH inclusion				
Linear		0.206	<0.001	0.083
Quadratic		0.111	<0.001	1.000
SBP inclusion				
Linear		0.026	<0.001	<0.001
Quadratic		0.005	<0.001	0.396
Fibre source		0.017	0.139	0.005

[1]Standard error of the mean (*n* = 6 replicates of 12 birds each per treatment).
[2]The interaction source x level of fiber were not significant (P > 0.10).

High quality ingredients are commonly used in diets for young chicks to reduce the incidence of enteric disorders and increase growth performance (Mateos et al., 2002). The amount of fiber contained in these diets is maintained limited to maximize voluntary feed intake and increase nutrient digestibility. However, low fiber diets might compromise GIT function and nutrient utilization (Svihus, 2011; Jiménez-Moreno et al., 2011, and 2013a,b) affecting chick growth (Table 7).

Table 7.- Influence of increasing levels of pea hulls in the diet on broiler performance from 1 to 18 d of age (Jiménez-Moreno et al., 2011)

	Pea hulls[1], %				SEM
	0[2]	2.5	5.0	7.5	
BWG, g/d	30.0[b]	31.2[b]	34.5[a]	31.1[b]	1.01
ADFI, g	41.2	41.2	45.9	39.6	1.15
FCR	1.38[a]	1.32[b]	1.33[b]	1.38[a]	0.014
Energy eff.[3]	54.3[b]	56.1[a]	56.2[a]	55.4[ab]	0.57

[1] The control diet diluted (wt/wt) with 2.5, 5.0 or 7.5% of pea hulls
[2] Contained 3.9% NDF
[3] g BW gain/MJ AME_n intake

Fiber inclusion reduced gizzard pH (Jiménez-Moreno et al., 2009a,b), improved digestive juices secretion, gizzard function, and digesta flow, and might modify microbiota profile in the GIT of the birds (González-Alvarado et al., 2010; Svihus, 2011; Mateos et al., 2012) (Table 8).

Table 8.- Effects of dietary fiber on microbiota profile in broilers at 36 d of age (Mateos et al., 2012)

Fiber source	0%[3]	5% OH	5% SBP
Crop			
Lactobacilli	7.9[b]	7.1[b]	8.4[a]
Ceca			
Lactobacilli	9.8	8.6	10.0
Clostridium perfr.	5.9[a]	1.2[b]	6.2[a]
Enterobacterias	8.4[a]	5. 9[b]	8.4[a]

[1] Log10 cfu/g
[2] Reared in floor pens
[3] Contained 3.9% NDF. Diets diluted (wt:wt) with fiber source

In this respect, Gonzalez-Alvarado et al. (2007) reported that the inclusion of an insoluble fiber source at levels of 3% to a rice-fermented soybean meal-fish meal diet with approximately 1.5% CF, improved nutrient digestibility and growth performance of the birds (Table 5).

Not all fiber sources will show similar effects on bird growth. Solubility, water holding capacity, viscosity, bulk, fermentative capability, and other physico-chemical properties of fibrous ingredients affect the development and pH of the GIT and consequently, they may have nutritional implications in poultry (Montagne et al., 2003; Jiménez-Moreno et al., 2009b). In this respect, soluble fibrous fractions such as pectins from sugar beet pulp (SBP), are dispersible in water and might increase viscosity and bulk of the digesta, reducing feed intake (Table 4). Also, an increase in digesta viscosity may reduce the rate of diffusion of digestive enzymes into the digesta, hampering nutrient absorption. On the other hand, insoluble fibrous fractions, such as those present in OH, stimulate gizzard activity, reduce gizzard pH, and favour GIT refluxes which may improve nutrient digestibility (Hetland and Svihus, 2001; Hetland et al., 2003; Jiménez-Moreno et al., 2010, 2013b). Consequently, the inclusion of high levels of SBP in the diet might result in poor growth performance whereas the inclusion of OH might have opposite effects (Table 9).

Table 9. Effect of inclusion of oat hulls (OH) and sugar beet pulp (SBP) in substitution of the whole diet (g:g) on body weight gain of broilers (Jiménez-Moreno et al., 2013a)

	Fibre inclusion (%)	BW (g) 6 d	BW (g) 12 d
Control	0	132[abc]	311
OH	2.5	131[abc]	318
OH	5.0	134[a]	319
OH	7.5	127[bc]	305
SBP	2.5	132[ab]	317
SBP	5.0	129[bc]	307
SBP	7.5	126[c]	297
S.E.M.[a]		1.7	6.3
P-value			
Diet		*	0.16

[a]Standard error of the mean (*n* = 6 replicates of 12 birds each per treatment).

The inclusion of 25 to 75 g/kg of a fibre source in the diet stimulated the development of the organs of the GIT in young broilers (Jiménez-Moreno et al., 2013b). At similar levels of inclusion, OH was more beneficial for the development of the gizzard than SBP inclusion, and therefore, lower levels of OH than of SBP might be required to stimulate gizzard function. The inclusion of 75 g SBP/kg diet, however, had detrimental effects on intestinal mucosa morphology at early ages. Consequently, diets for young broilers should be formulated with a minimum and a maximum level of dietary fibre. The recommended level of dietary fibre in broiler diets will depend on the age of the bird as well as on the physico-chemical characteristics of the fibre source used. To notice that the "old concept" suggesting negative effects of dietary fiber on bird growth is still valid; an excess of fiber (e.g., > 4-5% CF) might have detrimental effects on the structure of the jejune mucosa and reduce nutrient digestibility (Table 7). In particular, an excess of soluble, easily fermented fiber source, might reduce feed intake and broiler growth (Tables 4 and 9). However, a very low level of dietary fiber (e.g., < 2.0% CF), especially in young chicks, might reduce growth performance.

5.- Conclusions

Broiler productivity has increased steadily in Europe for the last 7 years in spite of the ban of use of "in feed" antibiotics as growth promoters. The continuous efforts of the breeding companies involved in the genetic of the birds might maintain these improvements for the next 10 years. However, new regulations on animal welfare might change objectives from increasing body weights to improving feed efficiency. On the other hand, the lower use of "in feed antibiotics" in broiler diets to improve food safety, guarantees the implementation of new feeding strategies to reduce the incidence of wet litter problems. In this respect, in addition to improve chick quality and hygiene and management of the farm, new studies on feed form and particle size, inclusion of whole grains, and level of crude protein and fiber of the diet might facilitate GIT development and function, resulting in an improvement of broiler production.

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