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Early nutrition programming - an approach for improving production performance of Indonesian Native Chicken – Kampung Chicken

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Abstract. Indonesia is considered as one the major chicken domestication centers in the world due to distinctive characteristics of chickens in this country compared to those in Asia and other countries in the world. Based on molecular studies, Red Junglefowl (*Gallus gallus*) is strongly presumed as the ancestor of the of Indonesian native chicken (INC). Through domestication processes, now, there are at least 30 different clumps of INC, which can be grouped into identifiable clumps with specific characteristics (colour, sound, etc, such as Pelung, Kedu, etc), and the non-identifiable clump with no specific characteristic, and usually called Kampung chicken. Kampung chicken clump represent the highest population among local chickens, and most of them are raised under an extensive traditional system. They are having very high genetic variation and diverse physical appearances (body size, colour, sound), and the most of them has not been modified genetically. Compared with exotic commercial breed, both broiler or layer, Kampung chicken has lower in production and reproduction, very slower growth rate and poorer feed efficiency. However, from market point of view, Kampung chicken products have better prices and consumer preferences. This market condition is certainly an opportunity to fill and to develop market of Kampung chicken. Additionally, this condition also motivates the farmers improving Kampung chicken production as their livelihood. As an approach, Early Nutrition Programming (ENP) may be a complementary of various previous efforts carried out to improve the performance of Kampung chicken. The program is a mean to provide specific additional nutrients earlier to the developing embryo in the incubation period (*in ovo* feeding – IOF program), which then continued after hatching (Post-hatch feeding - PHF program) with neonate nutrition in the perinatal period (a week before to a week after hatching). In the modern broiler industry, the application of ENP has been widely implemented and reported that the program resulted in achieving market weight quicker than before. However, information about application of ENP in Kampung chicken is still scarce. The early nutrition programming (ENP) can be implemented for improving the performance of INC – Kampung chicken with some considerations. From scientific point of view, ENP can be fully conducted. The ENP has much potential to yield several advantages, among them reduced post-hatch mortality and morbidity; greater efficiency of feed nutrient utilization at an early age; improved immune response to enteric antigens, and



increasing production performance as a whole. From technical point of view, consideration should be done during embryonal period, particularly for the treatment of IOF (injected solution : diluted nutrient, osmotic pressure, time, site); During perinatal period, earlier acces to external feed will help the new hatched chicken to improve the overall performance of Kampung chicken.

1. Introduction

Visually, the general understanding of native chickens is the name given to all local chickens, without any characteristics and specific location, and used as meat, egg producers, and for saving (multi-purposes). In line with this understanding, revealed that Indonesian local chickens [1] have a lot of diversity with different morphological characteristics, and so far at least 30 clumps have been identified. Furthermore, the results, of collaborative research between the Indonesia Institute of Sciences (LIPI) and the International Livestock Research Institute (ILRI) in Nairobi concluded that this diversity seems to be related to the fact that Indonesia is one of centers of chicken domestication in the world [2].

Besides as meat or egg producers, local chickens are also used for their beauty of crowing sounds (such as Pelung chicken – West Java, Ayam Ketawa – South Sulawesi, Bekisar chicken – Madura, Gaok chicken – Madura), for offering in traditional events (such as chickens from Temanggung – Kedu Cemani – Kedu Hitam chicken and Kedu Putih chicken, for ornamental chickens because of the beauty of their color (a such as pearl chicken), and fighting chickens -Bali.

The above description provides a clue attributing with the presence of genetic diversity in these local chickens, and it should be seen as a wealth of germ-plasma that needs to be maintained; so any efforts to increase the productivity of local chicken, do not avoid conserve efforts.

The development understanding of the community about knowledge of nutrition (nutrition literacy), the purchasing power of nutrition (capable of nutrition) and awareness of nutrition (nutrition awareness), local chicken has the potential economic value that cannot be ignored. At a lower productivity level compared to exotic breed, small-medium scale of local chicken farming continues to grow. This matter certainly reflects the gap between market needs and production supplies. However, even though the supply of exotic chicken breed products (meat and eggs) on the market is abundant, it does not mean that the preference level of the community for the products of the exotic breed is higher than local chickens; This can be seen form higher price appreciation than the price of the products of the exotic breed chicken. This situation, on the other hand, is an opportunity to increase the market prospects for the local chicken products, and at the same time become a common challenge for all stakeholders of local chicken farms to develop it in the future.

Based on the description above and some results of the study, local chicken as Indonesia's original genetic resources needs to be preserved, sustained and developed to realize the independence of the provision of food sources of national animal protein that has been aspired, and following PP, number 68 of 2012 concerning the importance of independence provision of food based on local resources.

Many efforts has been done by experts from universities, government, and private research institutes and practioners and breeders to increase the productivity of native chicken, including though selection and crossing, biosecurity, feed, and management approaches. The results of these studies generally have a positive impact on improving the productivity of native chickens.

As an alternative approach discussed on this occasion, titled: Early Nutrition Programing, an approach to improve the performance of Indonsian Native Chicken (INC) - Kampung chicken.

2. Indonesian Native Chicken (INC)

Indonesia is considered as of of the major chicken domestication centers in the world due to distintive characteristics of chickens in this country compared to those in Asia and other countries in the world [3,4] There are so many varieties of native chicken or Local chicken and named as 'Ayam Buras' or Ayam Bukan Ras. The term 'Ayam Buras' is given to differentiate from the exotic commercial breed resulted from a systematically crossbreeding program. In general, there are 2 groups of the local

chicken clump, namely identifiable and non-identifiable (Directorate General of Livestock Services 2003) The identifiable clump is to describe chicken which usually having the specific characteristic (primarily specific plumage color, sound, etc while non-identifiable clump is local chickens with no specific phenotypical characteristics [3,5], such as Kampung chicken. The Kampung chicken clump is believed to be the most common and represents the highest population among local chickens [5,6]. In the contrary, describe chicken such as Pelung chicken is considered local to a certain area and their population is low [6].

Two theories are explaining the origins of Indonesian native chicken. The first explains that native chicken originated from one ancestor (monophyletic origin) of red jungle fowl. The second explains that Indonesia native chicken comes from several ancestors (polyphyletic origin) [7] Historically, it is indicated that Indonesia native chicken is the result of domestication of four wild chicken species: green wild chicken (*Gallus varius*), red wild chicken (*Gallus gallus*), Indian grey wild chicken (*Gallus Sonetratti*) and Ceylon orange wild chicken (*Galus lavayetti*) [6]. It is also claimed that Indonesia is one of the main centers of chicken domestication in the world [8]

At the beginning of the poultry industry in Indonesia until the end of 1970, there was no exotic commercial breed of poultry entering the country. Therefore, local chicken is the main source of poultry meat and egg, which then dominated the market. However, since 1979 the government start importing some exotic commercial breeds of broiler and layer for accelerating and fulfilling the requirement of human nutrition, as local chicken has a very lower ability to produce meat and egg compared to that of the exotic breed.

In 2019, the estimated total population of local chicken was about 312 million, an increased 9.3 % of 2015, which were mostly (80%) raised under extensive of traditional systems. Several of them genetically improved for the commercial commodity [9]. According to Livestock and Animal Health Statistic [10] local chicken has been contributing to national poultry meat production for about 7,51% or about 298,08 tons, and it was only about 11.7% meat produced by exotic breed.

This situation certainly reflects a gap between market needs and the supply of its products. Additionally, even though the supply of exotic chicken products (meat and eggs) on the market is abundant to meet the needs of the community, it does not mean that the preference level of the community on exotic breed products is higher than local chickens. This matter can be seen from the appreciation of the consumers on the price per unit of the product, which is higher than the exotic chicken product. This situation is certainly an opportunity to fill and to develop the market of the local chicken product, and at the same time, there is a common challenge for all local chicken farm holders to develop in the incoming days.

In general, local chicken are having very high genetic variation and diverse physical appearances such as color, size, sound, production, and reproduction ability. Most of the local chickens have not been modified genetically. They are raised under an extensive- traditional system, in where they are free to scavenge for their feed around farmer's house during the day. Almost all of the local chicken clump is very low in production and reproduction. They grow very slowly and have a poor feed efficiency. For instance, the egg production under an extensive traditional system is only 45 eggs/bird/year or equivalent to 12.5% per day. By improving the management of semi-intensive systems, egg production is around 18.4% hen day and with the intensive system on battery cage, egg production could reach 34.8% hen day. This is too far away compared with a genetically modified strain like Isa Brown which has hen day production above 80%. They usually laid 10-20 eggs per period with the interval between egg productions approximately around 14-30 days.

Starting from a simple think that livestock production is the result of interaction between its genetic potential and the environment, with respective contributions presumed of 30 and 70%. In relation to the title of this article, it is beginning with the fertile egg – embryo development – up to post-hatch performance (producer of egg or meat), are directly and indirectly interacting with their micro and macro environments.

A lot of investigation on various aspects have been conducted to improve the productivity of Kampung chicken involving many experts from universities, government, and private research

institutes and practitioners, and poultry breeders through selection and cross-breeding programs, biosecurity, feed, and management approaches. In general, the results indicated a positive impact on improving the productivity of local chicken. Moreover, results of intensive selection and cross-breeding program indicated that some local chickens have been genetically improved their performances and commercially developed for meat and egg producers. Some of them are known as KUB, Sentul, and IPB-D1 chicken [11].

Cross-breeding programs have been used for improving the productivity of local chickens. This approach has produced significantly higher productivity, but has resulted in a loss or dilution of the local indigenous chicken characteristics and instinct for broodiness.

In commercial chicken breeds, genetic selection programs has been conducted for almost a century by poultry breeders, and have been very successful in producing specialized egg-laying and fast-growing breeds that far exceed the production of their wild ancestors [12]. Moreover, higher body weight achieved in a shorter time, in addition to less feed consumed per kg of body weight gain. These intense genetic selection programs resulted in an increase the performance of the important production trait of broiler.

However, the selection of production traits in broilers has been accompanied by negative consequences on some physiological aspects. These negative consequences are mainly due to the faster growth rate, and the tremendous increase in body mass without parallel improvements in the internal organs, vascular system, and skeleton to support such a rapidly growing and large body mass. A number of adverse complications are including ascites, fatness, leg deformity, skeletal abnormalities, immune-suppression, metabolic disorders, reproduction problems, immune-suppression, metabolic disorders, reproduction problems, and increased susceptibility to infectious diseases.

Even though the production performance of Kampung chickens as meat or egg producers has not been able yet to compete with the performance of commercial breeds, there are several advantages of specific attributes of Kampung chickens, such as resistance to disease, consumer preferences on meat and egg of Kampung chicken, less body fat, the ability to live on a traditional farming system. These advantages are the basic reasons for the efforts to improve the production performance of Kampung chicken, in addition to maintain Kampung chicken as one of Indonesia germplasm.

3. Early nutrition programing

Early nutrition programing is a mean to provide specific additional nutrients earlier to the developing embryo in the incubation period (*in ovo* feeding – IOF), which then continued after hatching with neonate nutrition in the perinatal period. The perinatal period (a week before to a week after hatching) is a transitional time in which the chicks undergo metabolic and physiological shifts from the utilization of egg nutrients to exogenous feed. Apparently, the embryonal and perinatal period are critical times to achieve the first objectives of the program which is to maximize the genetic potentials carried in the genome of the chicken through the mechanism of epigenetic.

Our knowledge about early nutrition programing is mostly attributed to the effect of nutrition on gene expression and it has been proved animal models; many examples of which can be found in the overview of the mechanism by which nutrients interact with the molecular target to modify gene expression. In poultry, nutrients deposited into the egg by the hen are the only source of nutrients available to the embryo, and this may be the last direct means by which the hen may transfer an epigenetic message to its offspring. A means to manipulate the nutrients deposited in the egg, beyond those which can be changed through maternal nutrition, is to inject nutrients into the egg at an appropriate time when the embryo is at the most sensitive time to epigenetic regulation. This timing could not be fully elucidated yet and may differ for a different system or target.

In chickens, there is an indication that conditioning in early-life imparts long-term effects. Although little is known about the underlying molecular mechanisms, there is evidence that feed stress may alter gene expression, in part through epigenetic regulation [13] Epigenetics can explain how gene expression might be changed and stably maintained without affecting the sequence of DNA or

genome. Moreover, epigenetic marks could be transmitted to subsequent generations and influence offspring traits that occur either via epigenetic changes acquired during embryonic development or through the inheritance of epigenetic marks via the gametes.

The second objective is on the establishment and development of a healthy and mature GIT and its microbiome. It has been recognized for its critical role in the overall health and growth performance of chicken, and understanding of its development may lead to interventions to improve chicken nutrition, disease resistance, and welfare.

The development of the GIT occurs throughout incubation. Morphological, cellular and molecular changes occur in the small intestine towards the end of incubation. During the last days of incubation, intestinal weight relative to embryonic weight increases from 1.4% at 17 days of incubation to 3.4% at hatch [14]. At the time of hatch, the GI tract of the chick is typically sterile and the establishment of the bacterial populations occurs post-hatch, the number as well as diversity of these bacteria increase with age and remain relatively stable thereafter [15].

3.1. *In ovo feeding (IOF) program – concepts and constraints*

What is the importance of this program?, Prenatal nutrition is crucial for embryonic development and neonatal growth, and has the potential to be a main determinant of life-long health and performance. It may be a complementary approach to the numerous approaches as mentioned previously.

Application of IOF technique is to feed developing embryos with certain nutrient to overall improved growth performance including muscle cell proliferation before hatching. Among several advantages of application IOF are reduced post-hatch mortality and morbidity, greater efficiency of feed-nutrient utilization at an early age, improved immune response to enteric antigens, reduced incidence of developmental skeletal disorders, and increased muscle development and breast meat yield [16]. The use of the in ovo feeding technique in poultry was firstly reported several decades ago for vaccination against Marek's disease; Currently, this technique has shown major developments.

This technique has owned its advantages, shortcoming, and constraints. For example, having earlier immunity against disease with minimal interference from maternally-derived antibodies. By in ovo inoculation, the chick has the best possible start when hatches, and better disease resistance from the first day. However, there still exist some limitations to this technique. Economically, IOF is suitable only for large-volume and poultry industries. For this technique, it hard to make sure the exact site of injection, and due to the variable size of each embryo in eggs, it enhanced the damaged possibility when using in ovo injection machine. If operation by manual, it is also difficult to control the time, environment, and other conditions. The most essential points is there are no consistent results on the ideal time, site, and volume of in ovo injection. Different injection materials may have a specific optimal injection procedure. So, it is critical to evaluate the best IOF as regular procedures. Accordingly, there are several technical questions that need to be answered for the application of IOF technique, namely:

- 1) What kind of chicken expected produced by doing IOF?
- 2) What nutrients, and how much volume can be in ovo fed without increasing metabolic load or causing toxicity to the embryo?
- 3) What is the best time to inject (embryo age or stage of development)?
- 4) Where IOF-nutrient solution will be injected?
- 5) What is the best osmolality of the solution, so it will not harm for embryo balance?

These questions attributed to the physical constraints of egg and metabolic constraints of the embryo must be answered.

Many potential nutrients have been used as bioactive substances (carbohydrates, fatty acids, amino acids, minerals, vitamins, nanoparticles, prebiotics, probiotics or synbiotic, hormone) either for a specific or several functions in the in ovo solution. Some of these substances have been proved enhancing growth and post-hatch performance, reducing post-hatch mortality and morbidity; efficiency of feed-nutrient utilization – digestibility [17] increased immune system development and function [18–20]. Some approved vaccines for the in ovo technique are those for Marek's disease,

Newcastle disease, fowl pox, infectious bursal disease and coccidiosis [21]. Isotonic NaCl is commonly used to dilute the nutrient, in addition, sodium and chloride ions (Na^+ , Cl^-) play a major role in the activity of apical and basolateral transporters in the absorption of glucose and amino acids [22]. In embryonic development, all amino acids are essential: the absence of any of them causes protein synthesis impairment and a disturbance of the homeostasis of the embryo, which in turn results in impaired growth and development of the young growing animals.

There are five possible sites of in ovo injection: the air cell, the amniotic fluid, the allantoic membrane, the yolk sac, and albumen. However, the omniotic is considered as the most affective site for injection and directly influencing the developing embryo [23].

Through the mechanism of epigenetic regulation, in ovo feeding stimulates intestinal development by enhancing villi, increasing intestinal capacity to digest and absorb nutrients, and provides a basis for muscle growth. Immediate post-hatch access to feed is to initiate growth processes after first ingestion [24]. The enhanced growth caused by early feeding stimulates yolk utilization, increase intestinal development, and has longterm metabolic effects.

3.2. The post-hatch feeding program

The development of in ovo feeding technique applicataion has established a new scope of perinatal periode (a week before hatching – a week after hatching) which is a critical period in the development of the chick embryo because of its high caloric demand to fuel hatching process and basal metabolism [25].

Several physiological systems are structurally and functionally in transisition that require maturation during perinatal period, including the gastrointestinal tract (GIT), and immune systems [26]. Coinciding with this physiological transistions, the remaining residual yolk is metabolized and exogenous feed offered as a nutrient source.

3.2.1. Gastro-Intestinal Tract (GIT) and its microbiome. Maturation of the GIT starts during the final stage of incubation, initiated by absorption of the amniotic fluid [27]. Maturation of the GIT in newly hatch chickens has been extensively reviewed [28,29] and is mainly by increased overall length and weight of GIT.

As incubation progresses, embryonic small intestinal weight increases at a much greater rate than body weight increases from approximately 1% on d 17 of incubation to 3.5% at hatch [14]. In the posthatch period, the small intestine continues to increase in weight more rapidly than the rest of body mass. Increases in intestinal weight and length are not identical in the duodenum, jejunum, and ileum. Instestinal development after hatch is also rapid with respect tp enzymatic and absorptive [30]. The small intestine of the newly hatched chick is immature and undergoes morphological, biochemical, and molecular changes during the 2 wk posthatch, although the most dramatic changes occur within the first 24 h posthatch.

During the first week of life, the changes are mainly due to villi development to increase the absorptive area of the GIT. Villi development is measured by greater villi length and increased villi density, resulting in a larger surface area available for absorption of nutrients provided through feed. The surface area of a single villi develops faster in the duodenum than in the jejunum and ileum [31]. During the first day after hatch, enterocytes, enterocctes within these villi slightly change their function, from absorption of macromolecules during incubation become absorption of dietary nutrients during the first day after hatch and thereafter [32]. This change function of enterocytes is already initiated during the final incubation stage, as demonstrated in turkey embryos [33]. By studying gene expressin patterns involved with enterocytes brush border enzyme and nutrient transporters activity, it was found that the digestive capacity at hatch is limited to relatively simple molecules, such as small peptides and mono – and disaccharides.

A further developing of small intestine by means of increasing its length, villi number and size may be associated with increasing nutrient absorption because of an increased absorption surface and a longer transit time [34]. The rapid development of the GIT relative to other organ systems in the first

week of life suggests that a large portion of the retained energy and protein at this age is allocated for intestinal development.

3.2.2. Microbiome. The gastrointestinal tract (GIT) of chickens is home for a complex and dynamic of microbial communities or microbiomes, which are crucial and essential for the gut homeostasis and maintaining the health of the host by modulating several physiological function, including digestion, absorption and metabolism, and interact with the gut-associated immune system, detoxification [35–37]. The microbial communities within the intestinal tract play a significant role in the overall health and digestion in avian species. Evidence indicates that bacteria may increase the digestibility of the diet, which may increase dietary bioavailability to the host and could lead to better skeletal-muscular accretion. Additionally, the stability of the microbiome can impact the immune response as well as be exploited by some pathogens.

At the time of hatch, the GI tract of the chick is typically sterile and the establishment of the microbial populations occurs post-hatch, the number as well as diversity of the population increase with age and remain relatively stable thereafter [15]. In early life, the chicken GIT microbiome is most susceptible to interventions and it refers to the observation that pathogens are less successful in colonizing the chicken GIT when their native microbiomes are more diverse, later in life.

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The GIT microbiome is a mixture of bacteria, fungi, protozoa, yeasts, and viruses, but bacteria are the predominant microorganisms [38–40]. Dynamic ecosystems exist within the different segments of the gut, each one having distinct luminal and mucosal niches, which are affected by the flow of nutrients from the diet, secretions from the host and the systemic responses of the host (animal) dictated by its immune, endocrine and nervous systems [41–43]. Briefly, all microbiota in the GI tract interact with each other as well as with the host, influencing many physiological functions within the host.

An individual chicken may be composed by 200 to 350 different bacterial species [44] while around 640 bacterial species from more than 100 bacterial genera have so far been identified in the chicken gastrointestinal tract [37]. Studies on broiler chicken indicated that results regardless of age or section of the intestinal tract, the most abundant phylum in chicken, namely Firmicutes is the most predominant (70%), followed by Bacteroidetes (12.3%), Proteobacteria (9.3%) [45].

Despite their differences in digestive function, there appears to be little difference in microbiome composition between the three small intestinal compartments, although the density of the microbiota is lower in the proximal small intestine compared to the ileum [46].

3.2.3. Immune system. Basically, chickens have two types of immune system to counter infectious agents, namely, innate (non-specific) immunity and adaptive immunity (specific immunity). The first immunological defence of newly hatch chicken mainly depend on their innate immune system of the maternal antibodies deposited by the hen into the egg [47,48].

Non-specific immunity comprises of cellular components (macrophages, dendritic cells, heterophils, etc), and the physical and chemical barriers as an alternative complement pathway to prevent invasion, by means of developing a sufficient mucus layer and developing epithelial cell of morphologically mature intestinal tract [49].

Although the innate immune system is functional at the time of hatch, its development continues during the first days after hatch. Goblet cells within the GIT begin to produce mucin during the final stage (> 18 d) of incubation [14]), functioning as a protective layer against pathogens within the intestine. Within two days after hatch, the intestinal tract is populated by matured heterophils, protecting the intestinal tract through secretion of antibacterial B-defensins [47].

Specific immunity is made up of two parts, namely humoral immunity and cellular immunity; Humoral immunity is characterized by an adaptive function of the immune system, which produces antibodies in response to an antigen. Cellular immunity involves mechanisms mediated by cells infected with foreign agents such as viruses are destroyed directly by an effector in contact with the target cell. The cellular components of specific immunity are lymphocytes. Chicken lymphocytes consist of B cells, which develop in the bursa of Fabricius, and the T cells in the thymus. Both, the B and T cell and T cell has a homogenous set of antigen receptors specific for a given antigen [50]. These both lymphoid organs are considered as the primary lymphoid organ, and functional immune cells leave the primary lymphoid organs to fill the secondary lymphoid organs [51].

The Bursa of Fabricius (a site of B-lymphocyte development and differentiation) and the thymus (a site of T-lymphocyte development and differentiation) are considered to be primary lymphoid organs of functional immune cells leave the primary lymphoid organs and populate secondary lymphoid organs.

The secondary lymphoid organs, characterized by aggregates of lymphocytes and antigen-presenting cells, are scattered throughout the body. Spleen, bone marrow, bronchial-associated (BALT), and gut-associated (GALT) lymphoid tissues, lymph nodules and lymph nodes along with the lymphatic circulatory system that transport lymph fluid throughout the body are the examples of secondary lymphoid organs. In chickens, GALT includes the bursa of Fabricius, cecal tonsils, Peyer's patches and lymphoid aggregates in the urodeum and proctodeum [52,53].

Approximately 70% of the body's immune system is found in the digestive tract of chickens, the gut associated lymphoid tissue (GALT). One of the key stimulators of intestinal development in the chick is physical exposure to feed, while feed deprivation delays the onset of gut development [31,53].

Within two days after hatch, the GIT is populated by matured heterophils, protecting the intestinal tract through secretion of antibacterial B-defensins [47]. This excretion compensates a lack of secretion of defensins from enterocytes within the gut epithelium at that age. The immune system in GALT initiates its function after the first two weeks of life: firstly by cellular responses followed by humoral responses [54]. Additionally, B-cells, part of the acquired immune response and responsible for antibody production, start to colonize the small intestine from 4 d of age onwards, but they only become functional at approximately 2 weeks of age [54].

A study on the broiler chicken indicated that as a compensation for this immature immunological development during the first two weeks of age, chicken has to depend on maternal antibody protection, which is primarily of IgY, and in limited amounts of IgM and IgA [48]. These maternal antibodies will disappear within 2-3 weeks of age [55,56].

The time period during which maternal immune-globulins decline and the owned immune system is still developing may cause a potential gap in immune protectiveness that puts young chickens at risk.

4. Applying early nutrition programming on INC

Information about the application of early nutrition programming on Kampung chicken is still scarce. For INC, early nutrition programming is apparently an alternative approach of providing the required nutrients for both the developing embryo (in ovo feeding), which then continued immediately after hatch in the perinatal period. As mentioned previously, the first objective of the program is to maximize the genetic potentials carried in the genome of kampung chicken through the mechanism of epigenetic, and the second is to establish and to develop a healthy and mature GIT and its microbiome structurally and functionally. This is considered because of its critical role in the overall health and growth performance of Kampung chicken, and understanding of its development may lead on improving nutrition based on local resources, disease resistance, and welfare.

In ovo feeding appears to be an earlier feeding of developing embryos to improve nutritional status of newly hatched chicks in the perinatal period. Several advantages of IOF are including improvements of total digestive tract capacity, increased body weight, growth rate, and feed

efficiency; reduction of post-hatch mortality and morbidity; improvements in the immune system and the response to enteric antigen, and increase in muscle development and breast meat yield [57].

The perinatal period beginning from few days before hatching to few days post-hatching is an important period for the development of the gastrointestinal tract (GIT) and the immune system. Perinatal period is also very critical as the chicks must adjust to the nature of the changing nutrition mostly from yolk-based lipid diet to carbohydrate-based solid feed. It has been observed that chicks are more efficient in utilizing lipid after hatching and then gradually obtaining the capacity to absorb more hexoses and amino acids [58,59]. This is transition between utilization of the reserve nutrient of the embryo and the external feed provided. This also great relevance and complements the results of in-ovo feeding.

Early post-hatch feeding is essential not only for faster growth and development of the digestive system, including pancreatic enzyme secretion (trypsin, chymotrypsin, amylase and lipase) than those the rest parts of the body, but also for maintaining homeostasis. Early feeding of chicks should easily provide available energy to assist restoring hepatic glycogen stores and maintain high body temperature during initial post-hatch days [60]. Feeding chicks immediately after hatch have an effect on their performance throughout the entire performance. This is also great relevance and complements the results of in-ovo feeding. In general, it is considered that chicks are able to survive on yolk sac reserve for up to 72 hours after hatch [61]. However, whilst the yolk sac reserves may guarantee survival, the absence of feeding during the first hours (or days) of life negatively affects the growth and productive performance of chickens. For broiler, pre-starter diet is designed with high nutrient and energy values using digestible protein sources by means of supplementation of various additives.

The following are various studies in broiler chickens about the effect of feed composition during the first week of life on short and long term growth and development of each ingredient: individual ingredients, protein levels and sources [28,62], minerals [63,64], cellulose [65], and macro nutrient ratios [63]. Although some studies have looked into the effect of increasing dietary fat levels in the pre starter diet, however, in young broiler chickens the effects are considered undesirable due to their low digestibility compared to starch [60,65]. Additionally, there is an increase of feeding prebiotics, probiotics and symbiotic to both the embryo (in ovo feeding) [64,66], and newly hatched chicken [67,68]

Substantial attention has been given to the importance of protein level and quality in relation to intestinal development [28]. In general, deficiencies of essential amino acids or imbalances of the amino acid profile may result in impaired intestinal development from 0 to 7 d of age, by means of reduced villi height and overall intestinal weight. On the contrary, an increase of the overall amino acid inclusion levels in feed provided from 0 to 14 d of age resulted in an increased duodenum weight at approximately 7 d of age [69]. There are various potential high digestible protein used and supplemented in the pre-starter diet, including casein and gluten [70], egg powder [71].

5. Conclusion

Briefly, it can be concluded that the early nutrition programming (ENP) for improving production performance of INC – Kampung chicken can be applied with some considerations. From scientific point of view, ENP can be fully conducted. The ENP has much potential to yield several advantages, among them reduced post-hatch mortality and morbidity; greater efficiency of feed nutrient utilization at an early age; improved immune response to enteric antigens, and increasing production performance as a whole. From technical point of view, consideration should be done during embryonal period, particularly for the treatment of IOF (injected solution: diluted nutrient, osmotic pressure, time, site); During perinatal period, earlier access to external feed will help the new hatched chicken to improve overall performance, including modulation intestinal development, stimulation of immune system, faster weight gain and final body weight.

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