The use of sprouted grains as dietary feed ingredients for broilers - a brief overview

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Abstract

The presences of anti-nutritive compounds in seeds or cereal grains have been accounted to the poor nutritive values and digestibility. Some methods may be carried out to improve the nutritional characteristics and digestibility of cereal feed grains for broilers. Among the methods, germination is a simple method to improve the nutritional and functional characteristics, which therefore increase the consumption and utilization of the grains by chickens. Germinated grains can be used as the alternative to the conventional energy- or protein-rich feed ingredients in broiler diets. The germinated feed grains can also be used to promote the intake and growth performance of broilers. Also, germinated grains may be used to improve the antioxidative status and health condition of broilers. The current review aimed to elucidate the sprouting or germination method to improve the nutritional and functional properties of feed grains for broiler chickens. The application of sprouted or germinated grains in broiler diets is also elaborated in this review.

Key words: *broilers, germination, growth, health, seeds, sprouts*

Introduction

Cereal grains are the major components of broiler diets, and contribute largely to carbohydrates and proteins. Maize, rye, oats, wheat, barley and sorghum are among the most common feed grains for broiler chickens (Dei 2017). Though it is the preferred grains for poultry feeding, the presences of anti-nutritive components such as non-starch polysaccharides (NSPs), arabinoxylans (pentosans) and β-glucans may account to the poor nutritive characteristics of the cereal grains (Annison and Choct 1991). Likewise, the content of tannins, lectins, saponins and trypsin inhibitors in cereal grains may be attributed to the depressed chicken growth as they can limit the acceptability and utilization by the chickens (Peiretti 2018). The cereal grains are also often contaminated with several toxins including deoxynivalenol (DON) and mycotoxins (Escriva et al 2015), which can exert lethal effect on broiler chickens.

Various methods have been conducted to improve the nutritional values of cereal grains for poultry. Medugu et al (2012) and Linh et al (2020) revealed that physical strategies could be implemented to improve the nutritional properties of grains, including cooking, soaking, sprouting (germination), dehulling, autoclaving and roasting or toasting. The chemical methods could also be applied, including the use of alkaline substances, addition of tallow (fat), application of tannin biding agents (such as polyvinylpolypyrrolidone, activated charcoal and compound polyethylene glycol), enzyme administration, fermentation and urea treatment (Medugu et al 2012; Nkhata et al 2018). With regard particularly to germination, such physical strategy can be defined as a series of events that occur when the grains or dry grains are still absorbing water resulting in increased metabolic activity and initiation of seeding from the embryo. In order for germination to begin, the following criteria must be met, including that the seed must first be viable (the embryo is alive and capable of germinating), suitable environmental conditions such as available water, the right temperature, oxygen, and, in some cases, light must be provided as well as primary dormancy in grains must be overcome (Arteca 1996). Medugu et al (2012) suggested that there are some changes in the grains during the germination process, including the breakdown of particular components of the grains, mineral transport from one part of the grain to another, in particular from the endosperm to the embryo or from the cotyledons to the rising sections of the grain and synthesizing new products from the breakdown product.

The present review aimed to elucidate the sprouting or germination method to improve the nutritional and functional characteristics of feed grains for broiler chickens. The application of sprouted or germinated grains in broiler diets is also elaborated in this review.

Germination as a method to improve the nutritional properties of grains

Various literatures have confirmed that germination can be an easy method to improve the nutritional qualities of seeds and cereal grains. Chinma et al (2017) revealed that germination process can increase protein and mineral and reduce crude fiber contents in *Moringa oliefera* seeds. Other investigation by Martínez et al (2018) confirmed that germinated soybean (*Glycine max*) had higher nutritional quality, especially with regard to total protein content, in comparison with the non-germinated one and, thereby is more digestible and usable by the chickens. Also, Fouad and Rehab (2015) reported that germination increased the protein content, amino acids and protein solubility of legume seeds. Likewise, Lien et al (2017) showed that germination resulted in increased protein level, but decreased fat content of soybean seeds. In line with the latter study, Rico et al (2020) showed that germination reduced fat as well as carbohydrates contents of barley seeds. In sorghum grains, Tizazu et al (2011) observed that germination increased the content of phosphorus, (total and non-phytate phosphorus), iron, zinc and calcium. Beltrán-Orozco et al (2020) also reported that germination increased protein and tryptophan contents of chia seeds. In general, respiration is an important process during seed germination. This process uses carbohydrates and thereby diminish such organic matter content in the seeds (Nkhata et al 2018). The loss of carbohydrates during seed germination may therefore implicate in the relative increase of other organic compounds including protein in the seeds or grains (Gómez-Favela et al 2017; Nkhata et al 2018). Apart from the relative increase, the protein content may also absolutely increase in germinated seeds due to the synthesis of some amino acids (such as lysine, methionine and tryptophan) during the germination process (Nkhata et al 2018). The decreased fat content in the sprouted grains seems to be associated with the diminution of stored fat which is involved in the catabolic action of seed needed for protein synthesis in growing plants (Onimawo et al 2004). With regard to fibre, Malama et al (2020) confirmed that germination process can improve the crude fiber fraction in grains so that they are easier to be digested. In accordance, Rico et al (2020) showed that sprouting decreased the content of fiber and β-glucan in barley grains. The latter investigator suggested that the decreased fiber content in the germinated seed was attributed to the activation of hydrolyitic enzymes during germination, which is responsible for the degradation of cell wall polysaccharides. In respect particularly to β-glucan, Narsih et al (2012) and Rico et al (2020) suggested that germination can increase the activity of β-glucanases that eventually degrade β-glucan, which is the major components of endosperm cell walls of grains.

Sprouting has also been associated with the reduced anti-nutritional substances such as tannins and phytic acid so that grains can be more optimally digested and utilized by livestock (Tizazu et al 2011; Malama et al 2020). In agreement, Lien et al (2017) showed that sprouting decreased anti-nutritional factors including phytic acid and trypsin inhibitor in soybean seeds. Moreover, Sokrap et al (2012) pointed out that germination reduced the content of phytic acid in corn. They also suggested that germination increases phytase activity, which therefore reduce the level of phytic acid in grains. In addition to germination, soaking (prior to germination) may also be attributed to the leaching the phytic acid out into soaking water under the concentration gradient. In general, the availability of minerals in cereal grains is poor due to the presences of tannin, phytic acid as well as fiber. In this respect, the decreased such anti-nutritional factors and dietary fiber due to germination may therefore could be attributed to the increased mineral content in the sprouted seeds (Luo et al 2014). The presence of phytic acid has generally been attributed to the poor bioavailability of minerals as phytic acid binds to minerals. In this respect, the decreased phytic acid content due to germination could be associated with the enhanced content and bioavailability of minerals in grains (Nkhata et al 2018).

Germination as a method to improve the functional properties of grains

Besides improving the nutritional quality, germination is also reported to increase the functional values of cereal grains. Tarasevičienė et al (2019) reported that germination can trigger the accumulation or increase of bioactive components such as vitamins, γ-aminobutyric acid (GABA), polyphenols and trace elements that function as antioxidants. In agreement, Beltrán-Orozco et al (2020) noticed that germination increased total phenolic, flavonoid and vitamin C in chia seeds. Falcinelli et al (2020) also reported an increase in total phenols and antioxidant activity in citrus seeds due to the germination process. In line with this, Fouad and Rehab (2015) and Niroula et al (2019) noted that germination can increase the polyphenol content and antioxidant capacity of grains and cereals. Also, Kim et al (2018) revealed that germination increased the content of phenolic acids (gallic acid, 4-hydroxybenzoic acid, vanillic acid, caffeic acid, syringic acid, ferulic acid, and p-coumaric acid) and GABA as compared to those in non-germinated wheat grains. In other study, Lien et al (2017) reported that sprouting resulted in increased total phenolic compounds, total flavonoid content, vitamin C and α-tocopherol contents in soybean seeds. In barley seed, Rico et al (2020) also found that germination elevated the levels of vitamins B_1, B_2 and C. The sprouting process also enhanced total phenolic components, GABA and antioxidant properties of barley seeds as reported by Rico et al (2020). Other investigators further revealed that sprouting process increased the contents of phenolic acids (caffeic acid, ferulic acid and *p*-coumaric acid), flavonoids, total antioxidant activity as well as vitamin C in flax sprouts as compared to those in flaxseeds (Wang et al 2015). Moreover, Tajoddin et al (2014) found the increase in total polyphenol concentration in mung bean.

Some explanations regarding the elevated antioxidant activity of seeds during the germination process have been extensively elaborated. Germination leads to the increase in the phenolic compounds as a consequences of the production or transformation of other compounds in the seeds into phenolic components (Tarasevičienė et al 2019). This inference is supported by Nkhata et al (2018) revealing that germination can hydrolyse the binding of phenolic components resulting in the increased free phenolic compounds. The *de novo* production of phenols in the embryonic axis of the germinated seeds (sprouts) may also be attributed to the increased phenolic components in the sprouts (Nkhata et al 2018). In term of phenols alteration, duration and temperature during germination greatly affect the levels of such functional ingredients in the sprouts. In this case, Rico et al (2020) noticed that total phenols and antioxidant activity in barley seeds increased between 2-fold and 4-fold during germination, and the increase was more pronounced at higher temperatures and longer sprouting times. In agreement, Kim et al (2018) also reported the greater phenolic compounds and antioxidant activity in wheat with longer germination times. The increased vitamin contents in sprouts has been associated with the synthesis of vitamins during the germination process (Nkhata et al 2018). With regard particularly to vitamin C in sprouts, Lien et al (2017) suggested that the increased activity of enzyme (L-Galactono-γ-lactone dehydrogenase) involved in the oxidation of L-galactono-1, 4-lactone to ascorbic acid seems to be attributed to the accumulation of vitamin C in the germinated grains. Likewise, the enhanced activity of lipoxygenase enzyme during the germination process may account to the increased level of α-tocopherol in sprouts (Lien et al 2017).

The use of sprouted grains as the substitute for energy- or protein-rich feed ingredients in broiler diets

Cereal grains are the primary components of broiler rations, and contribute largely to energy and proteins. One of the aims in incorporating the unconventional sprouted seeds or grains in broiler rations is to reduce or substitute the use of conventional energy-rich grains such as maize and barley or protein-rich feed ingredient such as soybean meal (Table 1). This strategy seems to be more economical (Lasisi et al 2018) as the price of maize and soybean meal is increasing over the years. On the other hand, the unconventional or alternative feed grains such as sorghum (Jain and Gautam, 2016), wheat (Afsharmanesh et al 2012), buckwheat (Chowdhury and Koh, 2018), roselle (Ashom et al 2016), pearl millet (Afsharmanesh et al 2016) and *Senna obtusifolia* (Clement et al 2017) are abundantly available and has not been widely used, which make these alternative grains possess relatively low price. Besides the economic consequences, other argument may be proposed on using of sprouted grains as the substitute for energy- or protein-rich feed ingredients in broiler diets. From the environmental point of view, dietary inclusion of germinated buckwheat could improve the utilization of phosphorus by the chickens (Chowdhury et al 2017). This condition may consequently reduce the phosphorus use in broiler diets, which is favourable for environment. In line with the above authors, Chowdhury and Koh (2018) suggested that germinated buckwheat can be exploited as an alternative phytase source, which can improve the digestibility and utilization of phosphorus by chickens.

The use of alternative feed ingredients is generally encouraged only when the replacement implies no detrimental effect on the performance of broilers. Table 1 shows the substitution of energy- or protein-rich feed ingredients in broiler diets using sprouts, which resulted in no deteriorated effect on the growth performance of broiler chickens. Indeed, the replacement could improve the growth rate of broilers (Bakoshi et al 2014; Jain and Gautam, 2016; Clement et al 2017).

Effect of sprouted grains on feed intake and growth performances of broilers

Adequate feed intake is crucial to ensure the sufficient nutrient supply for animals. Feeding the alternative feed ingredients has usually been concerned regarding the presences of anti-nutritional factors and dietary fiber that may reduce the intake of broilers (Sugiharto et al 2018). Indeed, the improved nutritional characteristics in seeds or grains due to germination, such as the reduced level of anti-nutritional components and fiber content in seeds, has been attributed to the increased feed consumption in broilers (Singh et al 2013; Ashom et al 2016; Maidala et al 2019). Table 1 shows the studies reporting feed intake of broilers provided with sprouted seeds or grains. However, the data on feed consumption of broilers fed sprouted seeds are inconsistent as some studies reported that feeding germinated seeds increased, had no effect or reduced the intake of broilers. In the case that dietary sprouts reduced feed intake, Sharif et al (2013) suggested that bitter taste and bad smell as the consequences of sprouting process may reduce the palatability and hence reduced feed intake of broilers. In agreement, Kasprowicz-Potocka et al (2013) noticed that germination of lupin reduces feed palatability and feed intake of broilers. The increase in the content of tannins with the period of germination (Tajoddin et al 2014) may also be responsible for the decrease in palatability and thus feed intake of broilers (Sharif et al 2013). Apart from the reduced palatability, the increased levels of germinated seeds or grains in diets seemed to be more responsible for the reduced feed consumption of broilers (Sharif et al 2013). In line with this, Lasisi et al (2018) revealed that up to 5% in diets malted sorghum sprouts had no influence on feed intake of broilers, but when the inclusion exceeded 5% it reduced feed intake of broilers.

Several studies have reported the growth-promoting effect of sprouted grains on broiler chickens as presented in Table 1. In line with that in broiler strains, Linh et al (2020) reported in local crossbred chickens that dietary inclusion of sprouted rough rice (0, 2.5, 5.0 and 7.5% of diets) linearly increased daily weight gain and improved FCR. In the case of growth improvement, germination has been reported to improve feed digestibility (Malomo et al 2013), biological value of proteins (Nkhata et al 2018), availability of amino acids, vitamin and trace minerals (Rao et al 2018a) and mineral retention/utilization (Chowdhury et al 2017), and thereby increased nutrient supply for the growth of chickens. Indeed, the reduced anti-nutritional components (Malama et al 2020) as well as fiber content (Chinma et al 2017) in sprouted seeds may also contribute to the increased nutrient utilization by the chickens. Other investigator further suggested that the improvement in intestinal ecology and morphology could improve digestion and absorption of nutrients, which eventually improve the growth capacity of chickens. In such case, Afsharmanesh et al (2012) reported that the use of sprouted wheat in the diet increased ileal villus height as compared to control. The same authors also showed that the depth of intestinal crypt was decreased due to germinated barley inclusion in diets. In agreement, Afsharmanesh et al (2016) reported that dietary sprouted pearl millet improved the development of intestinal villi. These conditions thereby increase nutrient absorption capacity of chickens. In addition to this, feeding sprouted seeds improved the intestinal microbial balance of chickens and hence improve the intestinal function of chickens (Afsharmanesh et al 2012; Linh et al 2020). With regard to the improved digestibility, the increased availability and activity of enzymes (such as phytase) and decreased fiber content in grains due to germination may decrease digesta viscosity and therefore improve digestibility and nutrient absorption of broilers (Sharif et al 2013; Rao et al 2018a). The increase in feed intake may also contribute to the increased weight gain in broilers fed sprouted grains (Madzimure et al 2017). However, the increased feed intake is not always evident with feeding sprouted grains, as the increased levels of sprouts may also reduce the feed consumption and thereby compromise growth performance of broilers (Sharif et al 2013; Lasisi et al 2018). Besides the reduced feed intake, the activated anti-nutritional factors due to the extended period of germination may also be accounted to the compromised growth performance in broilers fed sprouted seeds (Sharif et al 2013).

Table 1. The use of sprouts in broiler diets

Sprouted grains	Levels in diets	Impact on broilers	References
Sprouted mung bean (*Vigna radiata*)	10 g/bird/day	Protected broilers against coccidiosis induced changes on growth rate, haematological and parasitological parameters	Singh et al (2013)
Sprouted roselle (*Hibiscus sabdariffa* L.)	Replaced 16.5% of full-fat soybean in finisher diet	Had no effect on growth performance of broilers	Ashom et al (2014)
Sprouted red sorghum	Replaced full proportion of maize in diet	Produced greater slaughter weight than that of fed maize-based diet	Bakoshi et al (2014)
Germinated barley	Replaced barley at proportions of 33%, 66% and 100% in barley-based diets	Replacement at 33% produced higher growth performance in broilers	Dastar et al (2014)
Sprouted pearl millet	Replacement full portion of maize in diets	Decreased feed consumption without affecting growth performance of broilers	Afsharmanesh et al (2016)
Sprouted roselle (*Hibiscus sabdariffa* L.)	Replaced up to 50% of soybeans in diets	Increased feed intake and had no effect on growth, nutrient absorption and health of broilers	Ashom et al (2016)
Germinated sorghum	Added as 25, 50, 75 and 100% of the total maize portion in diets	Substitution at 50 and 75% improved the growth rate and feed efficiency of broilers	Jain and Gautam (2016)
Sprouted *Senna obtusifolia*	Replaced 20% of soya bean meal in diets	Improved feed intake weight gain and feed conversion ratio (FCR) in broilers compared to that of fed raw *Senna obtusifolia* seed	Clement et al (2017)
Sprouted buckwheat (*Fagopyrum esculentum*)	Replaced 10% of maize in diets	Increased phosphorus utilization, maintained performance and tibia characteristics of broilers in low phosphorus diets	Chowdhury et al (2017)
Sprouted-roasted guar bean (*Cyamopsis tetragonoloba*)	Included at 0, 50, 100 and 150 g/kg diets	Inclusion up to 50 g/kg had no detrimental effect on growth and FCR of broilers	Madzimure et al (2017)
Sprouted buckwheat	Replaced maize proportion in diets as for 10, 15 and 20%	Restored the growth rate, bone quality and phosphorus retention impaired by phosphorus deficiency in broilers	Chowdhury and Koh (2018)
Germinated soya bean	Replaced as 30% of raw soya bean	Increased retention of nitrogen and organic matter in broilers	Martínez et al (2018)
Sprouted pulses	Included at 5% in diets	Improved FCR of broilers at 21 days of age compared to control	Rao et al (2018b)
Germinated sprouts of millets	Included at 5% in diets	Had no effect on body weight gain and FCR at 42 days of age	Rao et al (2018a)
Sprouted soy bean	Replaced as 36.04% of raw full fat soy bean in rations	Increased daily feed intake, final body weight and daily weight gain of broilers	Maidala et al (2019)

Effect of sprouted grains on health status of broilers

The presences of some bioactive components (Kim et al 2018; Tarasevičienė et al 2019; Beltrán-Orozco et al 2020) have encouraged poultry nutritionist to use sprouted grains as the functional feed ingredients in broiler rations. Recently, Rao et al (2018b) reported that the use of sprouted pulses at 5% in diets decreased lipid peroxidation and enhanced glutathione peroxidase, glutathione reductase and superoxide dismutase activities in liver and spleen of broilers reared in tropical summer condition. In agreement with this, Rao et al (2018a) revealed that dietary germinated sprouts of millets at 5% ameliorated the oxidative stress in modern broiler chickens reared in opened-sided broiler house during summer, as indicated by the reduced lipid peroxidation as compared to control. Such improvement in the antioxidative status may consequently improve the health status of broiler chickens. However, the treatment had no substantial effect on the immune response of broilers as seen on the titre of Newcastle disease and cell-mediated immune response at days 21 and 42 of ages. In accordance with this, Ashom et al (2016) showed that feeding sprouted roselle seed meal increased the number of leukocytes of broiler at finisher phase. This improvement in health status seemed therefore to reduce the mortality rate of broilers. The latter condition could be observed in the study of Lasisi et al (2018) at which dietary supplementation of malted sorghum sprouts significantly reduce the mortality rate of broiler as compared to control. In agreement, Singh et al (2013) demonstrated that sprouted mung was able to alleviate coccidial infection and improve immune competences of broiler chickens. It is most likely that the synergy among various compounds in the sprouts including polyphenols, polyunsaturated fatty acids (PUFAs), lignans, isoflavones and vitamin C (Kim et al 2018; Beltrán-Orozco et al 2020, Rico et al 2020) could improve the physiological conditions, antioxidative status, immune competences, gut microflora and thereby health status and survivability of broiler chickens. Different from the above-mentioned studies, Rao et al (2018a) reported that feeding germinated sprouts of millets did not have impact on the immune responses of broilers, as indicated by antibody titres against Newcastle disease vaccine, cell-mediated immune response against phytohemagglutinin (PHA-P). There is no definite explanation for the divergent results above, but it seems that the differences in the nature of seeds or grains, time of germinations, dietary levels of sprouts, dietary compositions, broiler conditions and experimental conditions may be attributed to the different responses of broilers to the dietary sprouts.

Conclusions

- Germination is a simple method to improve the nutritional and functional properties of seeds or cereal grains.
- From the economical point of view, sprouts of the unconventional seeds can be used to substitute the conventional energy- or protein-rich feed ingredients in broiler diets.
- The germinated grains can also be used to promote the intake and growth performance of broilers. Also, sprouts may be used to improve the antioxidative status and health condition of broilers.
- Overall, the nature of seeds or grains, germination conditions and the levels of in diets may determine the effect of sprouts on broiler production and health.

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