

nutrient recommendations of the NRC<sup>11</sup> for broiler starter diets. All experimental diets were provided as mash feed and were fed to broiler chickens from 3-21 days of age. The phytase used was *Escherichia coli*-derived phytase, Quantum Blue, ABVista Feed Ingredients, (Marlborough, UK). The standard recommended level of phytase was 100 g tonne<sup>-1</sup> to achieve the activity of 500 FTU kg<sup>-1</sup>. The cellulase used was SQzyme CSP product, 20,000 unit g<sup>-1</sup>, (Suntaq International Limited, Shenzhen, China).

A total of 200 male broiler chicks (strain Lohmann) three days old (initial body weight of 54.6±2.3 g) were randomly placed in 40 cages with 5 birds per cage and 10 cages (50 birds) per treatment. Each cage was equipped with 1 drinker and 1 feeder. Feed and water were offered *ad libitum* throughout the experiment. Cages were illuminated 24 h per day.

**Growth performance:** Body weight (BW) and feed intake (FI) were weighed by cage at 3, 7, 14 and 21 d of age. Average daily gain (ADG) (g b<sup>-1</sup> day<sup>-1</sup>), average daily feed intake (ADFI) (g b<sup>-1</sup> day<sup>-1</sup>) and the gain-to-feed ratio (G:F) (g g<sup>-1</sup>) were determined periodically and cumulatively. Mortality was recorded daily during the experiment. Birds that died were weighed and their BW was included in the calculation of G:F. Feed intake was adjusted for mortality.

**Sample collection and analyses:** At the end of experiment (21 days of age) and after a period of 8 h of feed withdrawal, birds were weighed. One bird from each of ten replicates per treatment was selected based on proximity to average bird weight per cage and was slaughtered by dissecting the jugular vein, and variables measured were Digestive organs weight, length and digestive contents.

After the birds were killed, the body cavity was immediately opened and the GIT with content was removed and the following segments: gizzard, duodenum (from gizzard to pancreo-biliary ducts), jejunum (measured from the end of duodenal loop to Meckel's diverticulum) and ileum (from Meckel's diverticulum to ileocecolic junction) was cut. The pancreas was also removed. The length of the duodenum, jejunum and ileum was measured to the nearest mm. After measuring the length, the content of duodenum, jejunum and ileum was collected, weighed and then mixed together to be analyzed for dry matter (DM) and phosphorus (P) content. The gizzard content was also collected. The weight of empty digestive organs (gizzard, duodenum, jejunum and ileum) including pancreas was expressed relative to 100 g live BW (without digesta) (g/100 g BW), whereas the weight of

digestive content and the length of duodenum, jejunum and ileum was expressed relative to 100 g live BW (g/100 g BW, cm/100 g BW, respectively).

**Dry matter and phosphorus content:** Dry matter digesta (mixed of duodenum, jejunum and ileum content) and feces were analyzed using standard AOAC method<sup>12</sup>, whereas the P-contained in the digesta and feces was analyzed using a colorimetric method. The analyses were performed in a laboratory at the Nutrition and Food Study Center, University of Gadjah Mada, Yogyakarta, Indonesia.

**Statistical analysis:** All treatment data obtained were analyzed statistically using one-way analysis of variance<sup>13</sup>. When F tests were significant, Duncan's multiple range test was applied to examine differences among group means. Statistical significance was accepted at p<0.05.

## RESULTS

**Growth performance:** The results of growth performance are shown in Table 2. From 3-7 days of age, there was no significant difference (p>0.05) found in ADG, ADFI and G:F but from 7-14 and 14-21 days of age, broilers within the RH groups gained more weight than those within the CON group (30.65 vs 27.60 g b<sup>-1</sup> day<sup>-1</sup> from 7-14 days; 51.19 vs 43.32 g b<sup>-1</sup> day<sup>-1</sup> from 14-21 days, p<0.05, respectively). Furthermore, supplementation of phytase reduced (p<0.05) ADG more than phytase and cellulase but had no effect (p>0.05) on ADFI or G:F. Globally, from 3-21 days of age, ADG and G:F within the RH groups were better than those within the CON group (p<0.05). Mortality was 1.0% and was not caused by any dietary treatment (data not shown).

**Weight and length of digestive organs and weight of digestive content:** Diets did not affect (p>0.05) the weight of pancreas, length and relative weight of duodenum, jejunum and ileum, except for the gizzard (Table 3). At 21 days of age, broilers fed the RH treatment tended to have heavier gizzards without content (p = 0.057) than those fed the CON treatment (Table 3). Supplementation of phytase but not supplementation of phytase and cellulase, caused a reduction in the weight of empty gizzard. The inclusion of rice hulls did not affect (p>0.05) the contents of gizzard, duodenum and ileum but increased (p<0.05) the contents of the jejunum (Table 3). The addition of enzymes on the RH reduced the contents of jejunum the same as those in the CON treatment (p<0.05).

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