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EVALUATION OF BAKER'S YEAST (Saccharomyces cerevisiae) SUPPLEMENTATION ON THE FEEDING VALUE OF HYDROPONIC BARLEY SPROUTS FOR GROWING RABBITS

F. M. K. Abouelezz[1] and A. M. A. Hussein[2]

[1]Dep. of Poul. Prod., Fac. of Agric., Assiut Uni., Assiut 71526, Egypt. [2]Dep.of Anim. Prod., Fac. of Agric., Assiut Uni., Assiut, Egypt.

Corresponding author: F. M. K. Abouelezz Email: abollez@aun.edu.eg

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ABSTRACT: This study is consisted of two experiments and aimed to determine the nutrient composition and feeding value of the hydroponic barley fodder (HBF) and that HBF irrigated with bakers' yeast (HBFY) for the growing Californean (CAL) and White New Zealandean (NZW) rabbits. The first experiment included 36-weaned rabbit males, 18 rabbit males from each of CAL and NZW breeds, which were housed in 18 paired cages. The nine replicates (2 rabbits in each replicate) of each breed were then allotted randomly to three feeding treatment groups: Control. Basal diet, T1. Basal diet + HBF, and T2. Basal diet + HBFY. The rabbits were adapted to the tested fodders for one week, and the data collection continued for six weeks. The second experiment followed the same design, but using female rabbits instead of males.

The fresh-8-day HBF and HBFY contained 17.30% and 16.84% dry matter, 17.75% and 16.68% crude protein, 15.90% and 15.67% crude fiber, respectively. The one kg of barley grains yielded 6.12 kg of fresh HBF, versus 6.02 kg of fresh HBFY/ kg grains. The results of Exp. 1 showed that the male rabbits provided with fresh HBF recorded the highest body weight, body weight gain and carcass weight, while the HBFY males had the worst ($P<0.01$) feed conversion ratio. In Exp. 2, the HBFY females had the lowest BW and BWG and the worst FCR value. In both trials, the male and female rabbits which were provided with fresh HBF had a cheaper feed cost per gain than those of the control group, while the HBFY rabbits had the most expensive value. Besides, the tested treatments showed inconsistent impacts on the feed and fodder intake values, while they did not show any sifgnificant effect on the dressing percentage, carcass cuts, body muscles, or internal organ weights.

Conculsively, the results therefore revealed that feeding the growing male or female rabbits with the HBF displayed considerable nutritional benefits, while the HBFY is not recommended.

Keywords: Hydroponic fodder; feed alternatives; baker's yeast; weaned rabbits; forage intake.

INTRODUCTION

In animal production enterprises, the feed is considered as the most imperative and expensive element. Consequently, there is a usual need to evaluate all potential sustainable feed resources for livestock production; including agricultural by-products, foliages, and weeds (Safwat et al., 2014). Recently, the hydroponic fodder industry has been advertised extensively worldwide, which renewed the interest of livestock producers and scientists as well (Bruke, 2014). The barley grains have been considered as the most adequate grains for hydroponic fodder production; mainly for its availability with low prices (Morales et al., 2009). The most important aspect of hydoponic fodder production is that the hydroponic sprouting of one kg of barley grains can yield from 7 to 10 kg of green fodder within 8-15 days regardless of season (Gebremedhin, 2015). Such fodder has been reported to have various nutritional aspects; in terms of protein content and quality (Dung et al., 2010), essential fatty acids, carbohydrates, enzymes (Fazaeli et al., 2012), vitamins and mineral availability (Shipard, 2005).

Hydroponic green forage is defined as highly palatable sprouts, of heights ranging from 15 to 20 cm, produced by soil-less germination of cereal grains (barley, soybean, maize, etc) and using water with a mineral nutrient solution (FAO, 2001). In a recent study, Mohsen et al. (2015) have used the urea, animal faces, and poultry droppings as N-source fertilizers. They added that the true hydroponic method of growing plants in a water and nutrient solution is rarely used. Furthermore, the process usually requires a specific control of water amount and nutrient solutions (Atlas Global Crop. LTD., 2004) to avoid the increasing costs of the commercial nutrient solutions, which can reduce the anticipated profits. Besides, Naik et al. (2015) suggested that the hydroponic fodders can be sprouted successfully with tap water only without any nutrient supplements. But, their nutrient content is likely affected. Besides, Nitrogen is a macro-mineral needed for the leafy and green production of a plant, which can be derived from the atmosphere by plant roots or through the stoma in the leaves and stems (Yang et al., 2014). Besides, additional sources of nitrogen can be obtained from fertilizers such as Ammonium nitrates (Sophie and Touraine, 2004).

Yeasts are a rich source of vitamins and natural antioxidants (Gazi et al., 2001 and Amprayn et al., 2012), which have been used successfully as a growth promoter for animals (Shehu et al., 2016). Besides, they recently gained a great interest as a plant fertilizer showing plant growth promotion abilities (Botha, 2011 and Amprayn et al., 2012). They are unicellular fungi that proliferate and grow rapidly on simple carbohydrates, often through fermentative, as well as, respiratory pathways (Botha, 2011). Microorganisms can promote plant growth mainly through the whole uptake of bacteria and yeast cells by root cells to use them as nutrient sources after digestion of those microbes (Paungfoo-Lonhienne et al., 2010). Therefore, the effect of yeast supplementation on nutrient composition and feeding value of hydroponic barley sprouts for growing rabbits is of interest in this study.

Rabbits, among the other herbivores involved in meat production, can give a saleable product in a short time (Iyeghe-Erakpotobor, 2007), healthy meat with low cholesterol levels, and with low prices (Lebas and Laplace,1982 and Iraq, 2003). Certainly, because they have a renowned ability to utilize inexpensive fodders (Aduku and Olukosi, 1990). Evaluating the HBF seems to be adequate with rabbits, whereas they require a specific high level of fibers to maintain the stability of their digestive system (Gidenne and Nehl, 2000 and Chao and Li, 2008).

Therefore, the objective of this study was to evaluate the nutrient composition and the nutritional impacts of HBF supplemented or non-supplemented with baker's yeast on the growth performance, economical value, carcass cuts, and internal organs of two rabbit breeds.

MATERIALS AND METHODS

Experiment site

This study was carried out at the Poultry Research Farm, Poultry Production Department, Faculty of Agriculture, Assiut University, Assiut, Egypt.

Animals, housing, diet and experiment design

This study is consisted of two experiments, which aimed to determine the feeding value of the hydroponic barley fodder (HBF) and the HBF supplemented with bakers' yeast (HBFY) in irrigating water for growing rabbits. In the first experiment, thirty-six weaned six-week-old rabbit males belonging to California (CAL) and White New Zealand (NZW) breeds were used. The experiment followed a factorial (2 breeds x 3 treatment groups), which comprised two breeds and three dietary treatment groups with three replications in paired battery cages (64x62x48 cm). The nine replicate paired cages of each breed (18 rabbits) were allotted randomly to three feeding regimens including (6 rabbits in each group): Control. Commercial pelleted feed concentrate (Fulfilled the the recommendations of NRC, 1977) ; T1. Feed concentrate + HBF, and T2. Feed concentrate+ HBFY. Each treatment group was devided into three replicates (2 rabbits in each replicate). The rabbits were acclimatized to the tested fodders for one week, and then the data collection continued for six weeks. The second experiment was initiated one week later than the first one, and it was carried out following the same numbers and design, but using females instead of males.

The feed concentrate used in this study is a registered commercial product (No. 1/8397 Egyptian Ministry of Agriculture) based on yellow corn, sunflower meal (28%), alfalfa (17% CP), soybean meal (46% CP), Di-Ca-Phosphate (1781), $CaCo_3$, mineral and vitamin premix (3779). The chemical composition of the experimental diet and yield of hydroponic barley fodder are shown in Table 1.

yeast in irrigating water. [3]NFE: Nitrogen free extract. [4]: Calculated value

Sprouting procedure of hydroponic barley

Green fodder barley was produced in a hydroponic sprouting unit (10.0 x 6.0 x 3.5 meters as length x width x height, respectively), which had an adequate slope to remove the excessive water. The sprouting unit had four metal stands (4.0 x 0.5 x 2.3 m) of five shelves each (40 cm height each), with a capacity of up to 40 hydroponic plastic trays (30 x 70 cm). Semi-automated irrigating sprayers were used, while the irrigations including the nitrates and yeast supplements were done manually. The sprouting room was controlled to maintain a range of 22 – 25 ºC, and 70-80% of relative humidity.

Barley grains (Hordium vulgari L.) were purchased from the Barley Research Department, Agricultural Research Institute, Egypt. The grains were first washed sufficiently and soaked for 24 hours using tap water. The soaking water included 0.1% hypochlorite to avoid fungal contamination (Morgan et al., 1992). After which, they were moved to a plastic container, and covered with a wet towel for another 24 hours for germination. Then, they were spread out in the trays at a rate of 750 grams with a thickness of 1.5- 2 cm. The biomass production of barley hydroponic fodder was recorded, and the sprouting method was performed according to Gebremedhin (2015).

Tap water was used to irrigate barley grains three times daily, at 8.00 am, 12.00 am, and 4.00 pm. In the fourth and fifth days of sprouting period, all barley trays were irrigated with water included 1% of Ammonium-Nitrate fertilizer (1g/ Litre). In addition, one-half of the trays were irrigated with an additional amount of yeast containing water (0.5 gm/ liter) at the last irrigation time (6 pm) of the second, third, and sixth day of the sprouting period. The ammonium-nitrate fertilizer was used as a source of nitrogen (Product of Egyptian Ministry of Agriculture). Besides, the wet baker's yeast (Saccharomyces cerevisiae) was used, which was pre-fermented aerobically by incubating the required amount of yeast in a water bath (25º C) for six hours before mixing it with the irrigating water (FAO, 1998).

Sampling procedure

Before offering to the rabbits, both fodders were kept at the room temperature without irrigation for approximately 21 hours (between 12:00 pm and 9:00 am), to reduce their water content. In each replicate of HBF and HBFY groups, 900 g of fresh fodder was offered daily in a separate feeder attached to the cage at 9:00 hrs daily; the refusals weight of the previous day was also, recorded.

The dietary treatments were continued for seven weeks, between the seventh and thirteenth weeks of age, in which the first week was used as an adaptation period. The initial and final body weights (BW) were measured for the individual animals. The daily feed intake (FI) was calculated as the difference between the offered feed and refusals per cage. The dry matter (DM) intake from the tested fodders was calculated as the difference between the added and refused DM (Abou-Elezz et al. 2012). The total feed intake (TFI) was calculated as the sum of dry fodder intake plus the concentrate FI (CFI). The feed conversion ratio (Feed: gain) (FCR) was obtained by dividing the TFI by the rabbit weight gain (BWG). Digestive problems did not occur during this study. During the different weeks of experiment two, three NZW animals, one from each treatment, were dead for unknown reasons.

Carcass and organs evaluation

The dressing percentage, internal organs and muscle weights were evaluated in rabbit males only (Exp 1). At the end of the first experiment, all males were slaughtered for carcass and internal organ evaluation. The animals were fasted from the feed, but allowed access to water over a 12 hour period, re-weighed to get the slaughter weight, and then slaughtered by bleeding from the jugular vein. The tail close to the base was first removed, and then the head, feet, and pelt. During evisceration, the internal organs were separated and weighed. Carcasses were then cooled at 4 °C for 24 h and re-weighed to obtain the chilled weights. After which, the carcass cuts and muscles were separated and weighed. The weight of chilled carcass plus the edible organs were used to calculate the dressing percentage.

Chemical analyses

The tested fodders and experimental diets were analyzed in duplicates according to the methods of AOAC (2000). DM was determined by drying the samples at 60ºC in a forced-air oven for 48 h. The Nitrogen (N) content was determined by the Kjeldahl method and crude protein (CP) was calculated by multiplying N x 6.25. Ash content was measured by igniting of the dried samples in a muffle furnace at 550ºC for 3 h.

Feed cost per gain (FCPG).

In the control group, the FCPG was calculated as follow: the FCR x price of 1 g feed.

In the groups provided with barley fodders.

A. The DM contribution (%) of barley fodder to the total FI was calculated as follows: [HBF DM intake / (HBF DM intake + concentrate FI)] x 100.

B. The DM contribution (%) from the concentrated feed = 100 – A .

C. Feed cost per gain was calculated as follows: [(FCR x price of g HBF x A)/100 + (FCR x price of g feed concentrate x B) / 100].

D. Therefore, the change (+/-) in feed cost per gain was obtained by comparing the resulting values in treatment groups with that of the control group.

Statistical analysis

The current study was designed as 2×3 (with two breeds and three feeding treatments) factorial experiment conducted in Randomized Complete Block Design (RCBD), and the statistical analysis model was as follow:

$$Y_{ijk} = \mu + A_i + B_j + (A\,B)_{ij} + B_k + \varepsilon_{ijk}$$

Where Y_{ijk} = the observation, μ= overall mean, A_i= effect of the ith level of factor A (feeding treatments), B_j= effect of the jth level of factor B (breed), $(A\,B)_{ij}$= effect of interaction between ith level of factor A and jth level of factor B, B_k= effect of kth block, ε_{ijk}= the effect of the error related to individual observation.

The statistical analysis was generated using SAS software (2002). Prior to analysis, data were tested for normality and transformations were performed when necessary. Comparisons between the different breeds and feeding treatments were done using the Duncan Multiple Range Test (Duncan, 1955), while the interactions were tested using Lsmeans with PIDFF procedure.

RESULTS

Nutrient composition of HBF and HBFY

The proximate analyses and production data of HBF and HBFY are shown in Table 1. The two fodders contained 17.3% and 16.84% DM, 17.75 and 16.68 % CP, 15.90 and 15.67% CF, plus 4.05% and 4.12% EE, respectively. One kg of barley grains yielded 6.12 kg of fresh fodder and 1.06 kg of HBF DM vs. 6.02 kg of fresh and 1.02 kg DM of HBFY. The HBFY sprouts had a lower height (19.94 cm vs. 20.50 cm), and higher root-to-shoot proportions than that of HBF; where the root layer was found to measure 4.92 vs. 3.83 cm and the green shoot layer measured 15.02 cm vs. 16.67 cm in the two fodders, respectively. During the sprouting process, a high fungal mold was observed in the HBFY, particularly in the root layer.

Body weight and body weight gain

The BW and BWG results of rabbit males and females are shown in Table 2. In males (Exp. 1), the HBF group had a higher BW (P<0.05) than those of the control and HBFY rabbits, which estimated 2389.5; 2164.8, and 2138.0; respectively. Similarly, the BWG of HBF males was higher than the corresponding values of control and HBFY rabbits; which amounted to 1305.1; 1119.4 and 1061.5 g; respectively. In females, the HBF rabbits had similar BW and BWG values to that of control, while the HBFY had lower values (P< 0.05). The two breeds, regardless of treatment, did not show significant differences in their BW or BWG values. Besides, there was a significant breed x treatment interaction in the final BW (P<0.01) and BWG (P<0.05) of both males and females.

Feed intake, barley fodder intake and feed conversion ratio in male rabbits

The results of rabbit males' FI, barley intake and FCR are shown in Table 3. There were no significant differences in males' concentrate FI and TFI among the tested treatments. The fodder intake of HBF males was higher than that of HBFY group (30.1 versus 22.7 g DM/d). The FCR of HBF males was relatively improved versus control and significantly (P<0.01) than HBFY groups (6.2, 6.8 and 8.7, respectively). With respect to the breed effect, there were no significant differences between the NZ and CAL males in FI, BI, total FI and FCR values. Besides, there was a significant breed x treatment interaction in HBFI (P<0.05) and FC ratio (P<0.01).

Feed intake, barley intake and feed conversion ratio of female rabbits

The results of rabbit females' FI, BI, and FCR are shown in Table 4. Comparing the effect of treatments, the animals fed HBF and HBFY had lower (P<0.01) concentrate FI versus control females (111.9 and 127.0 vs. 157.6 g /d). There was no significant effect on HBFI and total FI due to the treatments. The FCR (feed: gain) in HBF females was relatively better than that of the control group (5.3 vs. 5.7), while HBFY group had the worst (P<0.01) value (7.9). Similar to the results obtained with males, there were no significant differences between NZW and CAL rabbit females' FI, HBFI, total FI and FCR values. Besides, the results showed a breed x treatment interaction in FI, HBFI, TFI and FCR.

The carcass quality male rabbits

The carcass weight and dressing out percentage, the organ weights, and the muscle weights of male rabbits are shown in Tables 5, 6, and 7, respectively. The feeding treatments did not show any adverse effect on the dressing out percentage; while the HBF group had relatively higher (P>0.05) value versus those of the control and HBFY animals, which estimated 58.1% versus 56.0% and 55.7%, respectively. The HBF group had higher carcass weight (P<0.05), forelegs weight (P<0.01), and hind part (P<0.05) than the values obtained in control and HBFY groups. Besides, the tested treatments did not show any significant effect on the thoracic cage, loin, longissimusdorsi, gluteus medius, vastus laterals, gastrocnemius, triceps, biceps femoris, tibialis anterior or the dissectible fat weight. The HBFY rabbits had higher (P<0.05) perirenal fat weight versus that of control and HBF rabbits. The HBF and HBFY groups had higher (P<0.01) spleen weight versus control (2.0 and 1.5 vs. 0.8 g). Besides, the rabbits of HBF had heavier cecum and kidney weights versus both of control and HBFY rabbits. The HBF group had higher lung weight than that of control (P<0.05), and higher heart weight than the HBFY group (P<0.05).

With respect to the breed effect, regardless of feeding treatment, the CAL rabbits had a higher thoracic cage and lung weights, and a lower testes weight than those of NZ. The CAL and NZW breeds had a similar dressing out percentage (56.9 and 56.2%), and chilled carcass weight (1161.3 and 1136.9 g). Similarly, there were no significant differences between the two breeds in the other parameters of the carcass. The results showed breed x treatment interaction (P<0.05) for the forelegs weight, longissimus dorsi and dissectible fat.

Economical efficieny (%)

1. Feed cost per gain (FCPG)

The results of FCPG in rabbits fed HBF and HBFY are shown in Table 8.

The price of feed concentrate and barley fodder:

The price of one-ton feed concentrate was 5000 LE, i.e. the price of 1 g = 0.50 Egyptian piaster (EP). Based on the market prices, the one ton of fresh HBF and HBFY was estimated to be 900 and 950 LE, respectively. Utilizing the DM percent in HBF (17.32%) and HBFY (16.84%), the price of one kg DM was found to be 5.2 LE (900/173.2) and 5.64 LE (950/168.4), i.e. the price of 1 g DM of HBF and HBFY calculates 0.52 EP and 0.56 EP.

2. Feed cost per gain (FCPG)

Experiment 1 (In males), as a percent of the TFI of HBF rabbits, the dry HBF contributed by 17.09% versus 82.91% of the feed concentrate. The corresponding values in the HBFY group were found to calculate 11.25% and 88.75%, respectively. The FCPG amounted to 3.40, 3.10, and 4.40 EP in the control, HBF, and HBFY groups, respectively. Therefore, the HBF group had 8.83% cheaper FCPG, while the HBFY had 29.41% more expensive value than that of control.

Experiment 2 (In females), the TFI of the rabbits fed HBF was consisted of 24.03% from HBF, plus 75.97% from the CFI. In HBFY group, the corresponding values estimated 22.45% of HBFY and 77.55% of CFI. The FCPG amounted 2.85, 2.69, and 4.04 EP in the control, HBF and HBFY groups, respectively. The HBFY had a 41.75% higher FCPG value, while the HBF had a 5.61% cheaper value than that of control rabbits.

DISCUSSION

Fodder yield and nutrient composition

The current study examined the impact of enriching the irrigating water of the hydroponic barley sprouts with baker's yeast on their fodder yield and nutrient composition; in addition to their economic and feeding values for the growing rabbits. The results indicated no beneficial effects of baker's yeast on the barley sprouts nutrient content (Table 1). On the contrary, the HBFY had relatively a lower fresh and dry fodder yield per kg grain, and lower DM, CP, and CF values than those of HBF. The obtained fresh and dry fodder yields per one kg of grains, as 6.12 and 1.06 of HBF and 6.02 and 1.02 kg of HBFY, were comparable to the values reported by Mohsen et al. (2015); where one kg of grain produced 5.80 kg of fresh and 1.02 kg dry fodder. Also, Peer and Leeson (1985) found that the original weight of barley grains increased 5.7 folds after seven sprouting days.

In a recent study, Lonhienne et al. (2014) found that the addition of live or dead yeast (Saccharomyces cerevisiae) as a bio-fertilizer to the soil has increased the nitrogen content of roots and shoots of tomato and young sugar cane plants; it also increased the root-to-shoot ratio in both species. These latter findings are in a partial accordance with ours; where the HBFY had a higher root–to-shoot proportion versus that of HBF, but it did not show beneficial effects on CP content. The baker's yeast has been reported as a successful cheap organic bio-fertilizer, which showed remarkable growth promotion abilities on plants (Amprayn et al., 2012; Botha 2011 and Lonhienne et al., 2014). Therefore, it was anticipated to obtain some beneficial benefits of using bakers' yeast on the hydroponic fodder yield and/or nutrient content. However, the lack of beneficial effects in this study could be attributed to the different planting conditions between soil plantation and soilless hydroponic agriculture. The obtained analysis of barley sprouts in the current study agreed with some previous reports. In this study, the DM percent of HBF as 17.30% and HBFY as 16.84% were relatively higher than the value 15.1% reported by Dung et al. (2010), and lower than the value 19.2% from Fazaeli et al. (2011), and closer to the value 17.65%, which obtained by Mohsen et al. (2015). Besides, the CP contents in HBF (15.75%) and HBFY (14.68%) were comparable to the values 14.44% (Gebremedhin, 2015) and 15.1% (Dung et al., 2010). The CF of the HBF (15.90%) and the HBFY (15.67%) were very close to the reported value 15.5% from Fazaeli et al. (2012), and that of Morales et al. (2009) as 16.3%. The EE content of the HBF (4.05%) and HBFY (4.12%) were within the value 3.31% which was reported by Mohsen et al. (2015), and that value 5.67% obtained by Gebremedhin (2015). Besides, the obtained NFE in the current study in both fodders was similar to the value 61.3% from Peer and Leeson (1985). Also, the ash content in both of HBF and HBFY was similar to the values 3.60% and 3.72% which was reported by Intissar (2004) and Fazaeli et al. (2012).

Growth performance, meat yield, feed cost per gain.

In the current study, providing the rabbit males with the HBFY resulted in adverse effects on their fodder intake, BW, BWG, and FCR versus those of HBF males (Tables 2 and 3). This could be attributed to the presence of fungal molds in HBFY, which possibly contained mycotoxins as well. Moreover, the deteriorated FCR in the HBFY fed rabbits led to higher feed cost per gain than the corresponding values of the control group by 29.41% and 41.75% in males and females.

Indeed, the risk of fungal mold was reported as a common problem in the hydroponic fodder industry, which increases costs and labor, reduces stock performance (Sneath and McIntosh 2003), and sometimes results in animal deaths due to the mycotoxins produced by these fungi (Kellerman et al., 1984). In cattle, the moldy barley sprouts were reported to reduce the live weight performance (Myers 1974). The poor performance was suggested to be associated with the presence of anti-nutritional factors in the offered hydroponic fodders (Oduguwa and Farolu, 2004; Aganga and Adogla – Bessa, 1999), which could explain the deteriorated FCR of the HBFY rabbits versus that of HBF group. In addition, the presence of mold could result in an unpleasant smell or taste and reduce the FI (Oduguwa and Farolu, 2004). This could be associated with the lower feed intake of HBFY males versus that of HBF rabbits (Table 3).

Providing the rabbits with fresh HBF showed various nutritional benefits on the growth performance of rabbits (Tables 2, 3, 4) and feed cost per gain. Besides, the HBF rabbits had a higher chilled carcass yield, forelegs and hind parts weights, and a lower perirenal fat amount versus the obtained values of HBFY groups (Table 5). The increased weight of carcass primal parts and retail cuts improves the profitability of rabbit enterprises (Agunbiade, 2009). Besides, our results were in a partial agreement with those of Morales et al. (2009), which indicated that replacing the commercial feed of growing New Zealand rabbits by 10%, 20%, and 30% with green HBF impaired feed intake and growth performance, but did not affect feed conversion or the dressing-out percentage. The latter authors used a HBF of an extended sprouting period (15 days) versus 8 days in the current study.

The results of Mohsen et al. (2015) indicated that the HBF can replace up to 30% of the concentrated feed of rabbit diets without any adverse effect on growth performance, retail cuts, or carcass yield. Moussa et al. 2014, using different forages with growing rabbits, found that the forage supplementation increased the concentrated FI, improved the FCR, and decreased the mortality; while, it did not change the diet charge or carcass productivity. In growing Californian rabbits, Carmona et al. (2011) found that the basal diet replacement up to 50% with hydroponic green oat forage did not affect the FI, slaughter weight, final body weight or the dressing out percentage.

In this study, the HBF and HBFY contributed with 30.14 and 22.68 g DM/d, which represented 17.09% and 11.25% of the total FI in males (Tables 3 and 8). In females (Tables 4 and 8), the daily DM intake from HBF (35.41 g) and HBFY (35.91) was found to represent 24.03% and 22.45% of the total DM intake. These contribution levels are considered a voluntary intake by rabbits, which could help in deciding adequate substitution levels when planning future studies.

Furthermore, the rabbits provided with HBF had a lower feed cost per gain than that of control by 8.69% in males and by

5.61% in females. In another study, Mohsen et al. (2015) reported higher values than ours; where the rabbit males and females, fed a commercial diet had a higher total feed cost than the rabbits fed HBF diet (70% concentrate plus 30% HBF), and the net revenue was higher for HBF rabbits than those of the control diet by about 16% in the males and 13% in the females.

A high nutritive value was reported for the barley fodder; in terms of high quality proteins (Shewry et al., 1995), and a considerable content of vitamins and minerals (Shipard, 2005 and Dung et al., 2010). Therefore, Sharif et al. (2013) suggested that the barley sprouts should increase the livestock performance unless the feed intake was reduced. This can explain the improved growth parameters of rabbits males fed the HBFin experiment 1.Whilst, the lack of beneficial effects of HBF in the females' BW and BWG could be attributed to the reduced CFI (Table 2 and 4).

The increased cecum weight in HBF rabbits versus those of HBFY and control groups could be attributed to the increased intake of fibrous material. A similar observation was reported by Agunbiade (2009) with full cecum weight. Besides, the tested fodders did not show any beneficial or adverse effects on the different muscle weights of male rabbits (Table 7). Furthermore, the two breeds showed similar muscle weight values. The obtained muscle weights in this study were relatively higher than those reported by Yalçin et al. (2006) with New Zealand rabbits, but they measured their values with rabbits at 11 weeks of age, versus those of the 13 weeks old rabbits in this study.

CONCLUSION

Supplementing the hydroponic barley sprouts with the baker's yeast (Saccharomyces cerevisiae) in the irrigating water had adverse effects on their fresh and dry yield as well as their quality and nutrient contents. Providing the ad libitum fed rabbits with HBFY showed adverse effects on growth performance, carcass yield and feed cost per gain than those provided with HBF. However, the rabbits fed HBF had a lower feed cost per gain than that of the control group by 8.83% in males and by 5.61% in females.

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Table (1): The chemical composition and yield of hydroponic barley fodder

Parameters	Basal diet	HBF[1]	HBFY[2]
Proximate analyses			
Dry matter (%)	89.50	17.32	16.84
Moisture (%)	10.50	82.68	83.16
Crude protein (%)	17.75	15.75	14.68
Crude fiber (%)	11.87	15.90	15.67
Ether extract (%)	2.60	4.05	4.12
Ash (%)	13.62	3.34	3.69
NFE[3] (%)	54.16	60.96	61.84
Digested energy (Kcal/kg)[4]	2600		
Yield per one kg grain:			
Fresh fodder		6.12	6.02
Dry fodder (kg)		1.06	1.01
Sprout height (cm):			
Root layer		3.83	4.92
Green sprouts		16.67	15.02
Total sprout height		20.50	19.94

[1]HBF: Hydroponic barley fodder; [2]HBFY: Hydroponic barley fodder supplemented with

Table (2): Final body weight and total gain of male and female rabbits fed hydroponic barley fodder

Parameters	Males		Females	
	Final BW	**Total gain**	**Final BW**	**Total gain**
Breed effect (B)				
Sig.	**NS**	**NS**	**NS**	**NS**
CAL[1]	2250.0 ± 80.1	1157.5 ± 68.8	2213.8± 87.5	1143.6 ± 69.5
NZW[2]	2221.0 ± 75.1	1170.7 ± 50.5	2236.4± 85.2	1212.7 ± 67.8
Treatment effect (T)				
Sig.	**	*	**	*
Control[3]	2164.8 ± 83.5 ^{B}	1119.4 ± 55.9^{B}	2279.5± 88.9^{A}	1254.8 ± 52.2^{A}
HBF[4]	2389.5 ± 85.1 ^{A}	1305.1 ±51.9^{A}	2344.3± 61.9^{A}	1308.0 ± 34.4^{A}
HBFY[5]	2138.0 ± 79.2 ^{B}	1061.5 ± 61.6 ^{B}	2010.4 ± 122.8^{B}	928.8 ± 71.5^{B}
Interaction effect (B xT)				
Sig.	*	*	**	*
CAL x Control	2260.0 ±130.0 ^{B}	1240.5± 35.5^{A}	2266.6± 91.3^{AB}	1204.0 ± 87.5^{A}
CAL x HBF	2373.3±132.4^{AB}	1276.3± 87.1^{A}	2345.3± 124.0^{A}	1257.6 ± 55.6^{A}
CAL x HBFY	2120.0 ±143.6 ^{C}	983.3 ± 108.1^{B}	1937.5± 192.5^{c}	882.0 ± 97.0^{B}
NZW x Control	2101.3 ±112.1 ^{C}	1038.6 ±43.1 ^{B}	2289.2± 153.1^{AB}	1293.0 ± 67.7^{A}
NZW x HBF	2405.7 ±135.7 ^{A}	1334.0± 71.1^{A}	2343.3± 61.7^{A}	1358.3 ± 17.5^{A}
NZW x HBFY	2156.0 ± 102.0^{C}	1139.6±34.4^{AB}	2059.0± 187.1^{B}	960.0 ± 112.7^{B}

Means wititihin the breed, treatment or breed x treatment column with different letters are significantly different.
NS: Non significant; * Significant (P<0.05); ** Highly significant (P<0.01). [1]CAL, California rabbit breed; [2]NZW, White New Zealand rabbit breed; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus
hydroponic barley fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water

Table (3): Feed intake and feed conversion ratio of male rabbits fed hydroponic barley fodder

Parameters	CFI [6] (g/d)	BFI [7] (g DM/d)	TFI [8] (g/d)	FCR [9] (Feed: gain)
Breed effect (B)				
Sig.	**NS**	**NS**	**NS**	**NS**
CAL[1]	156.4 ± 13.4	15.9 ± 1.9	172.3 ± 13.6	7.1 ± 0.6
NZW[2]	166.8 ± 14.6	19.2 ± 2.6	186.1 ± 14.7	7.4 ± 0.5
Treatment effect (T)				
Sig.	**NS**	*	**NS**	**
Control3	160.5 ± 15.8	-	160.5 ± 15.8	6.8 ± 0.8B
HBF4	146.2 ± 15.8	30.1 ± 1.8A	176.4 ± 15.7	6.2 ± 0.5B
HBFY5	178.9 ± 19.7	22.7 ± 3.3B	201.5 ± 20.2	8.7 ± 0.4 A
Interaction effect (B x T)				
Sig.	**NS**	*	**NS**	**
CAL x Control	137.1 ± 8.3^{AB}	-	137.1 ± 8.3^{B}	5.0 ± 0.1^{C}
CAL x HBF	169.8 ± 30.9^{AB}	26.3 ± 2.5^{AB}	196.1 ± 31.0^{AB}	7.0 ± 0.5^{B}
CAL x HBFY	162.3 ± 24.9^{AB}	21.3 ± 3.3^{B}	183.6 ± 24.5^{AB}	8.6 ± 0.9^{A}
NZW x Control	183.9 ± 30.2^{AB}	-	183.9 ± 30.2^{AB}	8.0 ± 0.3^{AB}
NZW x HBF	122.7 ± 3.7^{B}	33.0 ± 2.4^{A}	156.6 ± 3.6^{AB}	5.3 ± 0.3^{C}
NZW x HBFY	197.7 ± 31.3^{A}	24.3 ± 6.0^{B}	222.0 ± 33.0^{A}	8.8 ± 0.3^{A}

Means witithin the breed, treatment groups or breed x treatment groups column with different letters are significantly different.
[1]CAL, California rabbit breed; [2]NZW, White New Zealand rabbit breed; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus hydroponic barley Fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water; [6] CFI, concentrate feed intake; [7]BFI (DM), barley fodder intake (dry matter); TFI[8], total feed intake (6+7); [9]FCR, feed conversion ratio.

Table (4): Feed intake and feed conversion ratio of growing rabbit females fed hydroponic barley fodder

Parameters	CFI [6] (g/d)	BFI [7] (g DM/d)	TFI[8] (g/d)	FCR[9] (Feed:
Breed effect (B)				
Sig.	NS	NS	NS	NS
CAL	137.6 ± 10.9	20.9 ± 2.3	158.4 ± 10.8	6.4 ± 0.3
NZ	126.9 ± 5.0	25.5 ± 2.6	152.4 ± 5.1	6.0 ± 0.7
Treatment effect (T)				
Sig.	* *	NS	NS	* *
Control	157.6 ± 4.4^{A}	-	157.6 ± 4.4	5.7 ± 0.2^{B}
HBF	111.9 ± 13.3^{B}	35.4 ± 2.3	147.4 ± 13.3	5.3 ± 0.7^{B}
HBFY	124.0 ± 6.4^{B}	35.9 ± 3.0	159.9 ± 7.8	7.9 ± 0.7^{A}
Interation effect (B x T)				
Sig.	* *	*	*	*
CAL x Control	151.0 ± 5.8^{A}	-	151.0 ± 5.8^{B}	5.7 ± 0.4^{B}
CAL x HBF	152.8 ± 29.5^{A}	36.7 ± 3.2^{A}	189.5 ± 28.6^{A}	6.8 ± 0.3^{B}
CAL x HBFY	105.0 ± 7.6^{B}	26.6 ± 2.6^{B}	131.6 ± 8.8^{B}	6.8 ± 0.8^{B}
NZW x Control	162.5 ± 6.2^{A}	-	162.5 ± 6.2^{AB}	5.7 ± 0.3^{B}
NZW x HBF	81.9 ± 3.0^{B}	34.4 ± 3.3^{AB}	116.3 ± 5.3^{C}	3.9 ± 0.1^{C}
NZW x HBFY	136.3 ± 8.8^{A}	41.9 ± 4.4^{A}	178.3 ± 10.4^{AB}	8.57 ± 0.92^{A}

Means withithin the breed, treatment or breed x treatment column with different letters are significantly different. NS: Non significant; * Significant (P<0.05); ** Highly significant (P<0.01).

[1]CAL, California rabbit breed; [2]NZW, White New Zealand rabbit breed; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus hydroponic barley fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water; [6] CFI, concentrate feed intake; [7]BFI (DM), barley fodder intake (dry matter); TFI[8], total feed intake (6+7); [9]FCR, feed conversion ratio.

Table (5): Dressing percentage (%) and carcass cuts (g) of male rabbits fed green hydroponic barley fodder

Carcass cuts (g)	Breed		Treatment			Significance		
	CAL[1]	**NZW[2]**	**Control[3]**	**HBF[4]**	**HBFY[5]**	**Breed**	**Treat**	**Breed x Treat**
Dressing (%)	56.9±3.3	56.2±2.5	56.0±2.7	58.1±2.9	55.7±3.2	NS	NS	NS
Chilled carcass	1161.3 ± 39.8	1136.9±40.7	1111.2±36.2^{B}	1258.6 ± 38.4^{A}	1077.5±37.4^{B}	NS	*	NS
Forelegs	254.1± 5.9	261.1 ± 19.7	234.8 ± 7.0^{B}	300.8 ± 18.5^{A}	237.0 ± 8.4^{B}	NS	**	*
Thoracic cage	202.7±10.0^{A}	163.4 ± 9.0^{B}	193.1 ± 12.3	193.0 ± 17.3	162.9 ± 10.1	* *	NS	NS
Loin weight	274.9± 11.8	281.9 ± 11.6	273.3 ± 11.6	286.2 ± 10.9	275.7 ± 19.9	NS	NS	NS
Hind part	429.6± 16.1	430.6 ± 18.5	409.8± 13.8^{B}	478.6 ± 18.8^{A}	401.8± 13.6^{B}	NS	*	NS
Perirenal fat	18.0 ± 1.8	24.7 ± 10.1	13.8± 2.7^{B}	15.6± 2.9^{B}	34.5 ± 13.8^{A}	NS	*	NS
Dissectible fat	25.3±2.3	36.20 ± 16.5	23.0 ± 3.7	22.8± 2.3	45.3 ± 22.4	NS	NS	*

Means witithin the breed or treatmentrow with different letters are significantly different. NS: non significant; * significant (P<0.05); ** Highly significant (P<0.01). [1]CAL, California rabbit breed; [2]NZW, New Zealand White rabbit breed; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus hydroponic barley fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water

Table (6): Internal organ weights of male rabbits fed green hydroponic barley fodder

Traits	Breed		Treatment			Significance		
	CAL[1]	**NZW[2]**	**Control[3]**	**HBF[4]**	**HBFY[5]**	**Breed**	**Treat**	**Treat x Breed**
Head (g)	127.9±5.1	124.7±2.4	125.5 ± 2.7	133.5± 4.9	119.8 ±5.2	NS	NS	NS
Liver (g)	82.2± 4.6	76.3 ± 3.1	74.5 ± 4.1	87.5±4.1	75.8 ±4.9	NS	NS	NS
Heart (g)	6.6± 0.4	6.4 ±0.2	6.2 ± 0.3^{AB}	7.1±0.4^{A}	6.0 ±0.4^{B}	NS	*	NS
Lungs (g)	14.1±0.8^{A}	12.4±0.7^{B}	11.7 ± 0.8^{B}	15.3±0.7^{A}	12.7 ±0.6^{AB}	*	*	NS
Spleen (g)	1.5±0.2	1.5±0.2	0.8± 0.2^{B}	2.0±0.1^{A}	1.5 ±0.2^{A}	NS	**	NS
Kidneys (g)	19.2± 0.9	16.8±0.7	17.2± 0.9^{B}	19.9±1.2^{A}	17.8 ±1.1^{B}	NS	*	NS
Testes (g)	4.3± 0.4^{B}	5.6±0.3^{A}	4.9 ± 0.3	5.5±0.4	4.5 ±0.7	*	NS	NS
Intestine (g)	419.1±22.2	402.9±21.1	401.7 ± 27.4	453.4±23.9	377.9 ±19.2	NS	NS	NS
Secum (g)	35.7±1.5	33.4±2.6	31.7± 2.0^{B}	40.2±2.7^{A}	31.8±1.3^{B}	NS	*	NS
Secum Length(cm)	52.9±2.1	53.0±1.6	51.5± 2.0	56.9±2.2	50.5±1.7	NS	NS	NS

Means witithin a breed or treatment row with different letters are significantly different; * Significant (P<0.05); ** Highly significant (P<0.01). [1]CAL: California; [2]NZW: White New Zealand; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus hydroponic barley fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water, Giblets weight (weights of Liver+ Heart+ Kednyes), Dressing weight (%) without head weight (%)= Cacass weight (%)+ Giblets weight (%)

Table (7): The muscle weights of male rabbits fed green hydroponic barley fodder

Muscle weight (g)	Breed		Treatment			Significance		
	CF[1]	NZ[2]	Control[3]	HBF[4]	HBFY[5]	Breed	Treat	Treat x Breed
Longissimus dorsi	56.2± 2.6	54.8 ± 1.0	55.7 ± 3.0	56.7 ± 1.8	54.0 ± 2.5	NS	NS	*
Gluteus Medius	27.2± 2.1	24.0 ± 1.6	24.7 ± 3.6	26.2± 1.2	25.8 ± 1.8	NS	NS	NS
Vastus Lateralis	2.6 ± 0.2	2.2 ± 0.1	2.4± 0.2	2.3 ± 0.1	2.5 ± 0.2	NS	NS	NS
Gastrocnemius	12.1± 0.5	12.4 ± 0.5	11.7 ± 0.6	13.2 ± 0.5	11.9 ± 0.7	NS	NS	NS
Triceps	8.1 ± 0.5	9.1 ± 0.8	7.7 ± 0.5	9.0± 0.9	9.1 ± 0.8	NS	NS	NS
Biceps Femoris	16.2± 1.1	16.4 ± 0.9	14.5± 1.7	18.2 ± 0.3	16.2 ± 0.9	NS	NS	NS
Tibialis Anterior	1.0 ± 0.1	1.1 ± 0.1	1.0± 0.1	1.8± 0.1	0.9 ± 0.1	NS	NS	NS

Means witithin a breed or treatment row with different letters are significantly different; * Significant (P<0.05); ** Highly significant (P<0.01). [1]CAL: California; [2]NZW: White New Zealand; [3]Control, rabbits fed with a pelleted feed concentrate; [4]HBF, Rabbits provided with a feed concentrate plus hydroponic barley fodder; [5]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water.

Table 8: Feed cost per gain of rabbits fed hydroponic barley sprouts

Parameters	Exp. 1: Males			Exp. 2: Females		
	Control[1]	HBF[2]	HBFY[3]	Control[1]	HBF[2]	HBFY[3]
Contribution to the total FI (%)						
Concentrate feed (%)	100	82.91	88.75	100	75.97	77.55
Barley fodder DM (%)	-	17.09	11.25	-	24.03	22.45
FCR (feed: gain)	6.79	6.15	8.68	5.70	5.33	7.86
Price of 1 g (EP)[4]	0.50	0.52	0.56	0.50	0.52	0.56
Feed cost per g gain (EP)	3.40	3.10	4.40	2.85	2.69	4.04
FCPG[5] as compared with that of the control (%)	100.00	91.17	129.41	100	94.39	141.86
FCPG[5] change percent (%)	-	- 8.83	+ 29.41	-	- 5.61	+41.86
Economical effiency(%)[6]						

[1]Control, rabbits fed with a pelleted feed concentrate; [2]HBF, Rabbits provided with a feed concentrate plus hydroponic barley fodder; [3]HBFY, Rabbits provided with a feed concentrate plus hydroponic barley fodder supplemented with yeast in irrigating water; [4]EP = Egyptian piaster; [5]FCPG, feed cost per gain. [6] Calculated

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الملخص العربى

تقييم تغذية أرانب النيوزيلندى والكاليفورنيا الناميه على بادرات الشعير المستنبه مائيا والمضاف لها الخميره (Saccharomyces cerevisiae)

خالد ابوالعز فؤاد[1] و أحمد محمد عبدالله [2]

[1] قسم إنتاج الدواجن، كلية الزراعة، جامعة أسيوط، [2] قسم الإنتاج الحيوانى ، كلية الزراعة، جامعة أسيوط، مصر.

هدفت هذه الدراسه إلى تقييم الأثار الغذائيه لتغذية سلالتين من أرانب النيوزيلندى الأبيض والكاليفورنيا خلال فترة النمو على بادرات الشعير المستنبه مائيا وأخرى زودت بالخميره فى مياه الرى. إشتملت الدراسه على تجربتين متتاليتين، فى التجربه الأولى كان تصميم هذه التجربه عاملى(2 x 3)، والذى اشتمل على نوعين من الأرانب و ثلاثة معاملات غذائيه حيث تم استخدام عدد 36 أرنب بعمر ستة أسابيع، 18 أرنب من كل من نوع الكاليفورنيا والنيوزيلاندى، كما تم اسكان كل نوع من الأرانب فى تسعة أقفاص بطاريات مزدوجه (عدد 2 ارنب داخل كل قفص)، ومنها تم تخصيص ثلاث مجاميع تجريبيه داخل كل سلاله لدراسة المعاملات الغذائيه التاليه (سته ارانب لكل مجموعة تجربية / سلالة) : المجموعه الأولى غذيت على عليقه أساسيه محببه (الكونترول)، والمجموعه الثانيه غذيت على نفس العليقه الأساسيه وزودت يوميا ببادرات الشعير المستنبته مائيا، بينما غذيت المجموعه الثالثه على نفس العليقه الأساسيه وزودت يويما ببادرات الشعير المستنبته مائيا المضاف لها الخميره فى مياه الرى. تم إجراء التجربه الثانيه باستخدام أعداد مماثله من كلا النوعين وبتطبيق نفس معاملات التجربه الأولى ولكن على إناث الأرانب بدلا من الذكور. تم إتباع هذه المعاملات لمدة سبعة أسابيع، وإعتبر الأسبوع الأول منها كفتره تمهيديه، بينما تم تسجيل الصفات المدروسه خلال الستة أسابيع التاليه.

أظهرت النتائج ما يلى:

1. أحتوت بادرات الشعير المستنبه مائيا والأخرى المضاف لها الخميره على 17.30% و 16.84% ماده جافه، و 17.75% و 16.68% بروتين خام، و 15.90% و 15.67% ألياف خام، على التوالى. خلال ثمانية أيام من الاستنبات المائى، كل كجم من بذور الشعير الجافه أعطى 6.12 كجم من البادرات الخضراء المستنبته مائيا، مقابل 6.02 كجم من البادرات التى زودت بالخميره فى مياه الرى.

2. فى التجربه الأولى، سجلت ذكور الارانب فى المجموعه الثانيه، أعلى وزن جسم، وأعلى زياده فى وزن الجسم، وأعلى وزن ذبيحه، بينما سجلت ذكور المجموعه الثالثه أسوأ معدل تحويل غذائى ($P<0.01$).

3. فى التجربه الثانيه، سجلت إناث المجموعه الثالثه المغذاه على بادرات الشعير المزوده بالخميره أقل وزن وأقل زياده فى وزن الجسم، وأسوأ معدل تحويل غذائى بالمقارنه ببقية المجاميع.

4. فى كلتا التجربتين، سجلت تأثيرات معنويه متباينه على كمية العلف المستهلك وكمية البادرات المأكوله بين المعاملات المختلفه.

5. إنخفضت تكلفة الغذاء لكل وحدة زياده فى وزن الجسم فى أرانب المجموعه الثانيه بنسبة 5.61% فى الإناث وبنسبة 8.83% فى الذكور بالمقارنه بالكونترول، بينما سجلت أرانب المجموعه الثالثه فى كلتا التجربيتين تكلفة أعلى مقارنة بالكونترول.

6. لم يسجل أى تأثير معنوى ($P\geq0.05$) نتيجة للمعاملات التى تم دراستها فى التجربتين على نسبة التصافى، أو أوزان قطع الذبيحه المختلفه، أو أعضاء الجسم الداخليه، أو أوزان العضلات التشريحيه المختلفه.

7. لم توجد أية فروق معنويه فى أى من الصفات التى تم دراستها بين أرانب النيوزيلندى والكاليفورنيا.

التوصية: يتبين من هذه الدراسه أن تزويد أرانب النيوزيلندى والكاليفورنيا الناميه ببادرات الشعير المستنبة مائيا أظهر تأثيرات غذائية مفيده على النمو ومعدل تحويل الغذاء وعلى توفير تكلفة الغذاء، كما أدت التغذية على البادرات المرويه بمياه تحتوى على الخميره إلى نتائج سلبيه على معدل النمو وتحويل الغذاء وزودت تكلفة الغذاء اللازم للنمو.