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Azolla (*Azolla pinnata*) as a Feed Ingredient in Broiler Ration

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Abstract: An experiment was conducted with 120 seven days old Vencobb commercial broiler chicks and continued up to 42 days of age to determine the feasibility of Azolla (*Azolla pinnata*) as a feed ingredient in broiler ration. The broilers are randomly allotted to four dietary treatments; T_1 (control diet without Azolla meal), T_2 (diet with 5% Azolla meal), T_3 (diet with 10% Azolla meal) and T_4 (diet with 15% Azolla meal) diets replacing sesame meal by Azolla meal. The composition of Azolla meal contained 25.78% crude protein, 15.71% crude fibre, 3.47% ether extract, 15.76% ash and 30.08% nitrogen free extract on the air-dry basis. Live weight, production number and protein efficiency were ($P < 0.01$) significantly improved at the level off 5% Azolla meal in broiler ration. Feed conversion ratio and energy efficiency were significantly ($P < 0.01$) improved in diet with 5% Azolla meal and control diet. Total cost Tk/kg broiler was significantly ($P < 0.05$) better in the diet with 5% Azolla meal. Dressing percentage was significantly ($P < 0.01$) increased on diet with 5% Azolla meal. Giblet percentage on dietary treatment T_4 significantly ($P < 0.05$) increased than other treatments. It can be conducted that use of Azolla meal up to 5% in the broiler ration found to improve performance and may be used in broiler diet as a safe level. Azolla meal had no deleterious effect on the palatability of broiler diets.

Key words: Azolla meal, composition of Azolla, broiler, body weight, protein and energy efficiency and dressing percent

Introduction

Now a days, poultry industry as one of the most profitable business of agriculture in Bangladesh that provides nutritious meats and eggs for human consumption within the shortest possible time. Recently, broiler industry has become a rapidly developing enterprise among the other sector of poultry production. Large numbers of farms are being established in different parts of the country, which create employment opportunities to the peoples. But they are facing some problems. The two major problems are higher price and non-availability of feed ingredients to the growth of commercial poultry enter price. The feed cost incurred about 60-65% of the total cost of poultry production and cost incurred about 13% of the total feed cost of the poultry production (Singh, 1990; Banerjee, 1992). Availability of quality feed at a reasonable cost is a key to successful poultry operation. To sustain in the competitive market already develop in Bangladesh it would be wise to use unconventional feed to the diet formulation to reduce the production cost for poultry.

In poultry industry, the production of broiler is very rapid in Bangladesh due to its quick return. But the farmers are facing difficulty with the availability and high price of the feed ingredients. FAO program focuses on increasing the feed base production systems to locally available feed resources in developing countries (Sansoucy, 1993). Among the fed proteins plant originates are less costly than animal protein. Limited works have been done in our country on the use of unconventional feeds in poultry diets and these are quite inadequate (Rahman and Reza, 1983; Hossain *et al*., 1989; Bul Bul and Islam, 1991) to mark generalized conclusion.

The water fern Azolla (*Azolla pinnata*) is an unconventional feed ingredient. Azolla is a free floating fresh water fern belonging to the family Azollaceae and order Pteridophyta. There are six species of Azolla. It is commonly found in tropics and sub-tropics. It grows naturally in stagnant water of drains, canals, ponds, rivers, haors-baors, marshy lands. Anabaena-azollae, living in the cavity of Azolla leaf, can fix high amount of atmospheric dinitrogen due to presence of symbolic algae in the leaves (Becking, 1979). Azolla is a potential feed ingredient for broilers (Singh and Subudhi, 1978). Azolla is reach in protein, total protein is 25-30%. Other constituents in Azolla are minerals, chlorophyll, carotinoids, amino acids, vitamins etc. It is also a potential source of nitrogen and is a potential feed ingredient for livestock (Lumpkin, 1984; Pannerker, 1988). In addition Boyd (1968) Subudhi and Singh (1977); Maurice *et al*. (1984) started that inclusion of aquatic plants at low levels in poultry diets had shown better performance, specially when they supply part of the total protein or when they are included as a source of pigment for egg and broiler skin.

With those considerations, the experiment was under taken with the following objectives:

I) To investigate the performance of broilers fed Azolla at different dietary levels.
ii) To compare the production cost of broilers provided with diets containing different levels of Azolla in the broiler ration.

Materials and Methods

The experiment was conducted at Bangladesh Agricultural University (BAU) poultry farm, Mymensingh to study Azolla (*Azolla pinnata*) as a feed ingredient in broiler ration. The experiment was started with 7 days old Vencobb commercial broiler chicks and continued up to 42 days of age.

Collection and preparation of Azolla meal: Azolla was collected from a few ponds located at Bangladesh Agricultural University Soil Science farm. It was then dried in the sun. After sun drying, it was ground and stored in the plastic bags until used for feeding.

Layout of the experiment: Chicks were equally and randomly divided and distributed in four dietary treatments groups (T_1, T_2, T_3 and T_4) having three replications in each. Each dietary treatment group consists of 30 chicks distributed in three replicated pens (R_1, R_2 and R_3) with 10 chicks in each. The layout of the experiment is shown in Table 1.

Table 1: Layout of the experiment

Dietary treatments	Number of birds per replication			Total number of birds
	R_1	R_2	R_3	
T_1	10	10	10	30
T_2	10	10	10	30
T_3	10	10	10	30
T_4	10	10	10	30
Grand total				120

Where, T_1 = Control diets without Azolla meal; T_2 = Control diets with 5% Azolla meal; T_3 = Control diets with 10% Azolla meal; T_4 = Control diets with 15% Azolla meal

Preparation of the experimental diets: Four-broiler starter and four broiler finisher diets were replacing sesame meal by Azolla meal. However, to adjust the nutrient level of the diets proportion of

Table 2: Composition of the starter diets (g/kg)

Ingredients	Treatments			
	T_1	T_2	T_3	T_4
Maize	520	500	490	490
Rice polish	150	145	140	110
LNB 60%	90	90	90	90
Sesame meal	95	70	35	0
Soybean meal	140	140	140	155
Azolla meal	0	50	100	150
Common salt	5	5	5	5
Vit –Min. Premix 2.5g	+	+	+	+
Calculated nutrient composition				
ME Kcal/kg	2915	2903	2906	2901
CP%	22.11	22.17	21.91	22.10
CF%	3.47	4.06	4.65	5.15
Ca%	1.15	1.17	1.17	1.18
Av. P%	0.52	0.49	0.45	0.41
Lysine%	1.14	1.13	1.12	1.13
Methionine%	0.49	0.47	0.43	0.41
Tryptophan%	0.24	0.22	0.20	0.20
Cystine%	0.35	0.34	0.32	0.31

Table 3: Composition of the finisher diets (g/kg)

Ingredients	Treatments			
	T_1	T_2	T_3	T_4
Maize	580	570	570	560
Rice polish	175	165	145	130
LNB 60%	90	90	90	90
Sesame meal	55	40	10	0
Soybean meal	95	80	80	65
Azolla meal	0	50	100	150
Common salt	5	5	5	5
Vit. –Min. Premix 2.5g	+	+	+	+
Calculated nutrient composition				
ME Kcal/kg	3010	3002	3003	2990
CP%	19.39	19.20	19.04	18.95
CF%	3.37	3.93	4.46	5.01
Ca%	1.06	1.09	1.10	1.15
Av. P%	0.47	0.45	0.41	0.40
Lysine%	1.00	0.97	0.95	0.91
Methionine%	0.43	0.41	0.38	0.37
Tryptophan%	0.19	0.18	0.16	0.15
Cystine%	0.32	0.30	0.28	0.27

soybean meal and rice polish was little changed. Nutrient levels of the diets were adjusted in accordance with the BSTI (1988) feeding standard. The composition of the experimental diets shown in Table 2 and Table 3.

Management: The experimental birds were managed properly including housing environment, providing floor space, feeder and waterer space, litter management, lighting management, sanitation, immunization and medication. During the managemental period, body weight, feed consumption etc. are recorded and dressing percentage also recorded.

Statistical analysis: All the recorded and calculated data were analyzed for ANOVA (Steel and Terrie, 1980) using a Completely Randomized Block Design (CRD) with the help of computer packaged program MSTAT. Least Significant Differences (LSD) was calculated to compare the variations between the treatments were ANOVA showed significant differences. The dressing yield parameters were converted to the percentage of their respective body weights for statistical analysis.

Result and Discussion

The result on chemical composition and feeding effect to Azolla meal are presented and discussed under the following subheading.

Table 4: Chemical composition of Azolla meal

Constituents	Percentage
Dry matter	90.8
Crude protein	25.78
Crude fibre	15.71
Ether extract	3.47
Nitrogen free extract	30.08
Total ash	15.76

Chemical composition of the Azolla: Chemical composition of the Azolla was analyzed and presented in the Table 4. The analysis was carried out following the method of AOAC (1990) and Kjeldhal method was used for crude protein estimation. The analysis was done in the Department of the Poultry Science Laboratory, Bangladesh Agricultural University, Mymensingh for proximate composition.

The dry matter of Azolla was 90.8 percent. The result are almost similar with earlier observation of Tamang & Samanta (1993), Ali and Leeson (1995); Ghosh (1978).

The crude protein level of Azolla was found 25.78 percent. The result was close to crude protein level found by the

Table 5: Weekly average body weight (g/bird) of the broilers at different dietary treatments

Age in week	Treatments				SED (LSD) and level of significance
	T_1	T_2	T_3	T_4	
Initial week (1st week)	126.67	126.67	126.67	128.33	3.12NS
2nd week	240.00	236.67	226.67	225.00	10.54NS
3rd week	525.00	541.67	486.67	486.33	30.07NS
4th week	830.00	846.00	794.00	772.00	42.96NS
6th week	1199.00ab	1230.00a	1115.00bc	1073.33c	116.65**
7th week	1579.00b	1637.00a	1462.00c	1394.33d	76.86**

Table 6: Weekly average feed consumption (g/ bird) of the broilers at different dietary treatments

Age in week	Treatments				SED (LSD) and level of significance
	T_1	T_2	T_3	T_4	
2nd week	335.00	343.33	343.33	341.67	13.54NS
3rd week	460.00	453.33	443.33	443.33	16.33NS
4th week	635.00	648.33	655.00	653.33	21.86NS
6th week	791.67	763.33	785.00	798.33	22.55NS
7th week	981.33	896.67	906.67	913.33	16.75NS

Table 7: Feed conversion ratio of broilers at different dietary treatments

Age in week	Treatments				SED (LSD) and level of significance
	T_1	T_2	T_3	T_4	
2-4 week	2.04	2.02	2.20	2.24	0.158NS
5-6 week	2.30ab	2.10a	2.55bc	2.7c	0.341*
2-6 week	2.17a	2.06a	2.38b	2.50b	0.258**

Table 8: Protein efficiency of broilers at different dietary treatments

Age in week	Treatments				SED (LSD) and level of significance
	T_1	T_2	T_3	T_4	
2-4 weeks	2.23	2.25	2.11	2.03	0.148NS
5-6weeks	2.26ab	2.48a	2.07bc	1.92c	0.299*
2-6 weeks	2.18ab	2.47a	2.10b	1.98	0.285**

Sreemannaryana *et al*. (1993) and is consistent with Subudhi and Singh (1977); Fujiwara *et al*. (1947). Singh (1977) also reported that the crude protein might vary from 25-37.36 percent.

Ether extract content of Azolla was 3.47 percent. Though the composition may vary but similar result was reported by Subudhi & Singh (1977) and Sreemannaryana *et al*. (1993). But variation in ether extract value was reported by Ali and Lesson (1995) and Querubin *et al*. (1986b). They found 1.58 and 2.63 percent of ether extract. On the other hand, Buckingham *et al*. (1978) and Fujiwara *et al*. (1947) reported 5.1 and 4.4 percent ether extract. Crude fibre level in Azolla meal was 15.71 percent. The results are similar with the earlier observation of Querubin *et al*. (1986b) for *Azolla pinnata*. On the other species of Azolla (*Azolla microphylla*) they found 15.02 percent crude fibre.

Nitrogen free extract (NFE) content of Azolla sample was 30.08 percent. The result is similar with the observation of Bhuyan *et al*. (1998); Ali and Leeson (1995); Querubin *et al*. (1986b).

Ash content of Azolla was 15.76 percent. The results are consistent with Buckingham *et al*. (1978) who reported 15.50 percent of ash in *Azolla pinnata*.

Body weight: The body weights of broiler were shown in Table 5. The body weight differed significantly at 5 and 6 weeks of age. In both the weeks almost similar trend in body weight were obtained. In this experiment, the diet containing of 5% level of Azolla meal was best in respect of body weight (1637g) while control diet was second the best (1579g) in 6 weeks of age. The result is similar with the earlier observation of Subudhi and Singh (1977).

In this experiment sesame meal was replaced by Azolla meal. The digestible protein percent in sesame meal was 89.9 percent (NRC, 1994) but in Azolla meal it was 56.6 percent (Tamany *et al*., 1992). So use of higher level of Azolla meal may had deleterious effect on body weight as in T_3 (140% Azolla meal) and T_4 (15% Azolla meal). While Cambel (1984) found better result using 10% and 15% Azolla meal.

The higher level of Azolla (T_3 and T_4) meal resulted poor growth than T_1 and T_2 treatments. This might be due to higher level of NDF in Azolla meal is the main limiting factor for efficient utilization in monogastic animals (Buckingham *et al*., 1978). Tamany *et al*. (1992) reported higher lignin i.e. 17.48% might cause poorer growth as against the diet containing 10 and 15 percent Azolla meal.

Feed consumption: Feed consumption was almost similar in different dietary treatments and the differences were non significant at all ages of the experimental period (Table 6). The results are similar with the earlier observation of Bhuyan *et al*. (1998) and Querubin *et al*. (1986a). They found that the inclusion of Azolla in broiler diet did not affect feed consumption upto 15%. Similar result also found by Castillo *et al*. (1981) and Sreemannryana *et al*. (1993). But Bested and Morento (1985) stated that Azolla affected the palatability of the feed and reduced feed consumption.

Feed Conversion Ratio (FCR): Feed conversion ratios obtained in different treatments are shown in Table 7. Feed conversion ratios obtained by the treatments by the T_2 and T_1 were respectively 2.06 and 2.17 during 2-6 weeks of age which were very close to the standard (1.87:1) (Shalev and Pasternak, 2000). The feed conversion ratios differ significantly among the treatment during 5-6 weeks and 2-6 weeks periods. Poorest feed conversion ratio

Table 9: Energy efficiency of broilers at different dietary treatments

Age in week	Treatments				SED (LSD) and level of significance
	T_1	T_2	T_3	T_4	
2-4 weeks	16.89	17.16	15.94	15.43	1.125NS
5-6weeks	14.56ab	15.87a	13.14bc	12.15c	2.79**
2-6 weeks	15.76a	16.52a	14.34b	13.79b	1.98**

Table 10: Cost of production and profit/ broiler at different dietary treatments

Variables	Diets				SED (LSD) and level of significance
	D_1	D_2	D_3	D_4	
Cost per chick (Tk./chick)	20.00	20.00	20.00	20.00	--
Miscellaneous cost (Tk./chick)	9.95	9.95	9.95	9.95	--
Cost per kg starter diet (Tk.)	12.61	12.31	12.00	11.80	--
Cost per kg finisher diet (Tk.)	12.26	11.92	11.64	11.32	--
Feed cost (Tk./ broiler)	39.00a	37.57b	36.99c	36.35d	0.802**
Feed cost (Tk./ kg broiler)	26.91ab	24.89b	27.77a	28.72a	2.38*
Total cost (Tk./broiler)	68.95a	67.52b	66.94c	66.30d	0.802**
Total cost (Tk./kg broiler)	47.57bc	44.73c	50.24ab	52.39a	4.10*
Sale (Tk./broiler)	94.41a	98.17a	86.80b	82.29b	10.66**
Profit (Tk./broiler)	25.46ab	30.65a	19.86bc	15.99c	10.99**
Profit (Tk./kg broiler)	17.43ab	20.27a	14.76bc	12.61c	4.10*

Table 11: Meat yield traits of male and female broilers of different dietary treatments

Variable	Sex	Treatments					SED (LSD) and level of significance		
		T_1	T_2	T_3	T_4	Mean	T	S	Tx S
Dressing %	M	69.58	72.92	67.84	69.86	70.05	4.36**	1.75NS	0.758NS
	F	69.18	71.40	68.64	67.70	69.23			
	Maen	69.38b	72.16a	68.24b	68.78b				
Abdominal fat %	M	1.42	1.28	1.39	1.39	1.37	0.435NS	0.416NS	0.089
	F	1.53	1.51	1.28	1.59	1.48			
	Maen	1.48	1.40	1.33	1.49				
Giblet %	M	5.12b	5.17b	6.46a	6.21a	5.77	0.971*	0.487NS	1.58**
	F	5.98b	5.98b	5.55c	6.66a	6.04			
	Maen	5.55c	5.62bc	6.01b	6.44a				

was obtained in treatment T_4 (2.5) that was similar to the treatment T_3 (2.38). These might be due to higher fibre content of Azolla.

Feed conversion ratios decreased significantly at 10 and 15% Azolla meal in the diet. Similar results are reported by Querubin *et al*. (1986a). Higher level of fibre and tannin in aquatic plant may be responsible for decreased the nutrient utilization and ultimately decreased FCR (Muzlar *et al*., 1978). Buckingham *et al*. (1978) reported the high level of NDF in Azolla affected the utilization of feed or feed efficiency in monogastic animals.

Protein efficiency: Protein efficiencies were calculated for different treatments shown in Table 8. The best protein efficiency was observed in treatment T_2 at all periods. On the other hand, T_2 had 2.48 and 2.37 during 5-6 weeks and 2-6 weeks, which differed significantly than other treatments. T_3 and T_4 had poorer protein efficiencies. These probably due to the low digestibility make Azolla meal and may be unfit as the sole source of feed for broilers (Buckingham *et al*., 1978).

As in dietary treatment T_2 diet was formulated with minimum (5%) level of Azolla meal and T_1 (control) diet was formulated without Azolla meal. Poorer digestibility and higher fibre content in Azolla meal may be responsible for poorer protein efficiency in T_3 and T_4. Khatun (1996) found lower digestibility in *Azolla piñata* at increasing level in the diet. Digestible protein level in Azolla is 56.6% (Tamany *et al*., 1992) where as digestible protein percentage in sesame meal is 89.8% (NRC, 1994) and that is why the control diet and diet containing 5% Azolla meal might have shown better result.

Energy efficiency: Energy efficiency of broiler at different dietary treatments was highly significant during 5-6 and 2-6 weeks of age (Table 9). At 5-6 weeks of age the energy efficiency was best at T_2 group, which differ significantly than T_3 and T_4 but not from T_1. At 2-6 weeks of age energy efficiency was best at both T_2 and T_1 and poorer energy efficiency in T_3 and T_4 treatment groups. The protein efficiency and energy efficiency showed similar trend.

Survivability: No bird died in any treatment during the experimental period. So, survivability was cent percent in all dietary treatment groups. This indicates that Azolla meal had no any deleterious effects on broilers. The results are similar with Castillo *et al*. (1981) who also found no toxic effect of dietary Azolla on broiler.

Cost of production: Except feed cost, other cost was constant and feed cost was only factor that differed the total production cost of broiler. The total cost per broiler was highest in D_1 (68.95 Tk/broiler) and gradually lower in D_2 (Tk. 67.52), D_3 (Tk. 66.94) and D_4 (Tk. 66.30) dietary treatments and the difference was significant between treatments (Table 10). As the Azolla is an unconventional feed and the price per kg was lower than sesame meal and that is why the feed cost and total production cost per broiler was highest in the D_1 group and the cost gradually lower in the other treatment groups for the same reason. But total cost and feed cost per kg broiler were higher in D_3 and D_4 groups, which differed significantly fro D_1 and D_2 dietary groups. The body weight in Dietary treatments T_3 and T_4 were low (Table 5). So, the total costs of production per kg broilers were increased which reduced profit. Total cost per broiler was highest in D_1 but the profit per broiler highest in D_2, which was statistically similar with D_1. The main cause of highest profit in broiler in D_2 and D_1

groups were body weight of broilers. As the body weight were higher in D_2 and D_1 increase the profit for the same.

Meat yield characteristics: The effect of dietary treatments on the dressing percentage, giblet percentage and abdominal fat percentage of broilers are shown in Table 11.

Dressing percentage: Dressing percentage among the different treatments differed significantly. T_2 had had the best dressing yield while the other treatments had almost similar dressing yield. In T_2, average dressing percentage was 72.16 (Mixed sex) where as male and female birds were 72.92 and 71.40 respectively in the same treatment0. Hayse and Marion (1973) obtained similar result (72.04 and 70.08 percent eviscerated yield for male and female broilers). As body weight was higher (Table 5) in T_2 treatments, so the dressing percentage also became higher than the other dietary treatments.

Abdominal fat: Abdominal fat was not significantly affected by dietary treatments and sexes (Table 11). However, females had slightly more abdominal fat than males. The results are consistent with Plavnik and Hurwitz (1983). Treatment and sex interaction on abdominal fat was not significant.

Giblet percentage: The mean giblet percentage was significantly (Table 11). Among the treatments T_4 had the highest (6.44) giblet percentage. On the other hand T_1 and T_2 groups had significantly lower giblet percentage. Though the sex did not differ significantly, comparatively higher giblet percentage was obtained for female broilers. The results are similar with Broadbent *et al*. (1981) and Newell (1954), who also observed higher giblet yield in females than males.

Conclusion: An experiment was conducted with 120 seven-days old Vencobb commercial broiler chicks and continued upto 42 days of age. Birds were reared on littered floor and with management e.g. feeding, watering, vaccination, medication, etc. the diets were prepared with Azolla meal at a level of 0, 5, 10, and 15% by replacing sesame meal from control diet. Azolla was analyzed for its proximate composition.

The average body weights at marketing (42 days) were 1579.00, 1637.00, 1462.00 and 1394g for T_1, T_2, T_3 and T_4 respectively. The highest body weight was obtained in T_2 followed by T_1, which differ significantly ($P < 0.01$) from each other.

The feed consumption was similar for all treatments all over the experimental period. Cumulative feed consumption for T_1, T_2, T_3 and T_4 3140, 3104.99, 3133.33 and 3149.99g respectively.

Feed conversion ratio (FCR) improved significantly for T_2 and T_1 which were 2.06 and 2.17 respectively during 2-6 weeks of age. FCR for T_3 and T_4 were poorer i.e. 2.38 and 2.50. Survivability was distinctly better for all of the treatment groups, which indicate Azolla had no toxic effect.

Protein efficiency differed significantly among treatments. The best protein efficiency was obtained in T_2, which was similar to control groups. At 2-6 weeks of age protein efficiencies were 2.18, 2.37, 2.10 and 1.98 for T_1, T_2, T_3 and T_4 treatments respectively.

Energy efficiency differed significantly among the treatments during 2-6 weeks and in 5-6 weeks of age. T_1 and T_2 had better protein efficiency than T_3 and T_4. Energy efficiencies were 15.76, 16.52, 14.34 and 13.79 for T_1, T_2, T_3 and T_4 treatments respectively during 2-6 weeks of age.

Production cost differs among dietary treatments. This might be due to feed cost as other costs were constant. Total cost per broiler was minimum at D_4 (Tk. 66.30) and gradually increased for D_3, D_2, and D_1 respectively. Profit per broiler was better for T_2 and T_1 groups. Total feed cost per broiler was highest in D_1 (Tk. 39.00) and lowest in D_4 (Tk. 36.35), which differed significantly. The main factor responsible for better profit was body weight, which was significantly higher for these treatments groups.

Dressing percentage differed significantly ($P < 0.01$) among treatments. The highest dressing percentage was observed for T_2 treatment. Dressing yield among the treatments were 69.38, 72.16, 68.28 and 68.78 percent for T_1, T_2, T_3 and T_4 treatments respectively. Dressing yield of male was slightly higher than female but the difference was not significant. Abdominal fat in different dietary treatments and in different sexes were more or less similar and the difference were not significant. Giblet yield differed significantly among the different dietary treatments. The highest giblet yield was obtained in T_4 and second highest in T_3 where as comparatively less for T_1 and T_2 groups.

From the above discussion it may be concluded that:

i) Azolla is a good source of protein and may be used upto 5% level in the broiler diet for better performance.
ii) Azolla meal had no deleterious effect on palatability of the diets.
iii) Azolla meal is an unconventional feed ingredients at low price and may be used as a poultry feed to reduce feed cost.

However, further research using large number of birds with similar objectives is needed before giving final recommendation to use Azolla meal as a feed ingredient in broiler ration.

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