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Effect of adding Jerusalem artichoke (*Helianthus tuberosus* L.) and Sprout germinated barley as a prebiotics in diets of common carp (*Cyprinus Carpio* L.) fingerling on growth performance and food utilization

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Abstract

Various levels of Jerusalem Artichoke Tubers (Helianthus tuberosus L.) (JAT) powder and Sprout Germinated Barley (SGB) powder were added to diets of young common carp fish (Cyprinus carpio L.) with a content of 30% of crude protein in this study to detect their effect on growth performance, for a period of ten weeks. It's a Weight Gain (WG), Daily Weight Gain (DWG), Relative Growth Rate (RGR) and Specific Growth Rate (SGR), and feed utilization, it's a Feed Conversion Rate (FCR), Feed Efficiency Rate (FER) and Protein Efficiency Ratio (PER). The (JAT) powder was added at the rate of 2.5, 5 and 7.5 g/kg, for the first, second, and third treatments, respectively, and adding (SGB) powder 2.5, 5 and 7.5 g/kg for the fourth, fifth and sixth treatments, respectively, then control without addition, The third treatment 7.5 g/kg JAT outperformed significantly $p<0.05$ for all parameters over all treatments, and this significant $p<0.05$ superiority involved the sixth 7.5 gm/km SGB treatment for two criteria were WG and RGR, and did not differ significantly $p<0.05$ from the rest of the trial treatments, except for the control group which decreased significantly $p<0.05$ for all treatments and for all criteria. The feed utilization criteria significantly $p<0.05$ outperformed both the third treatment, 7.5 gm/kg JAT and the sixth treatment, 7.5 gm/kg, for the terms FER and PER. And criteria FCR, the same treatments recorded the best ratios for feed transfer significantly $p<0.05$ on all transactions, while the worst one was the control significantly $p<0.05$ for all treatments and all criteria.

Keywords: Jerusalem artichoke (Helianthus tuberosus L.), germinated barley, common carp (Cyprinus Carpio L.), growth performance

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INTRODUCTION

Common carp is considered the most important group among the groups of aquatic organisms invested for breeding and commercial production that contribute globally to over 72% of freshwater fish production (Pineiro, et al. 2008). The means of global fish farming have evolved significantly, in the recent years to become an economic importance within the agricultural sectors, because their meat has a high nutritional value because it contains protein, fat and mineral salts, as the protein content in fish meat ranges between 20- 90% of dry weight and 18.5% of wet weight it exceeds the protein percentage in beef 16.18%, and for the purpose of satisfying the human need of animal protein, they found their way towards fish (Subasinghe, Soto, & Jia, 2009). SGB and JAT are functional foods that aim to provide more health benefits, as well as basic, which is the nutritional value presents in foods depending on the specialized products that may be their contribution to disease prevention or improving health or support the structure or function of the body's functions (Agriculture & Agri-Food 2015; Ansari, & Hanief, 2015). (Dawood, et al. 2020) There are (β-glucans) in SGB at a rate of 2.5 - 11.3% very stable, which helps with that compatibility with dietary fiber It is resistant to glycolysis by gastric acid and digestive enzymes and thus, its able to work in the intestine more effectively (Jung-Schroers, et al. 2015), As for the dietary fiber produced from SGB, it is a

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Table 1. Percentage of experimental diet components for fish

The ingredients	Ratio%	Dry matter	Crude protein	Raw fiber	Fat	Energy (Kcal/Kg)
Animal protein conc.	20	18.58	8.00	0.44	1.00	421.4
Soybean meal	39	24.71	17.16	2.73	0.43	869.7
Yellow corn	10	8.9	0.85	0.22	8.90	335.0
Barley	9	8.01	0.99	0.50	0.17	237.60
Wheat bran	20	17.80	3.14	2.20	8.00	260.0
Vit.& minerals	2	-------	-------	-----	-----	-------
Total	100	78.00	30.14	6.09	18.5	2123.7

low-wooded hemicellulose, which is abundant in its parts and a living aleurone layer that later expands to form buds and roots during the germination process (Fincher, Stone. 1993). It can be used as a Prebiotics for improving growth performance and enhancing immunity (Pineiro, et al. 2008), JAT also contains dietary fiber 16.6% and inulin 9.98% (USDA 2016). They are functional nutritional components that are able to play an important role in important impacts on human and animal health (Vincenzo & Vito 2016). upon reaching the intestine intact, it resists digestion and absorption and works as Prebiotics to feed and reproduce beneficial microorganisms selectively at the expense of harmful microorganisms, which enhances health and growth performance, and JAT works to improve the performance and qualitative characteristics of fish feeding (Hien, Sompong, Suksri 2015). There are plenty of informations about the positive effects on growth performance, immune response, and disease resistance of fed fish weth β-clocan on fish farms (Dawood, et al. 2015). And its use in feeding carp fish according to the standards studied in the feed to enhance growth performance, and enhance the innate immune response and increase disease resistance (Dawood, et al. 2020) (Falco, et al. 2014). (Iraporda, et al. 2019).

Our current study aims to detect the effect of adding a different percentage of SGB powder and JAT powder to the diets of young common carp fish (Cyprinus Carpio L.) with a protein rate of 30.14% on growth rates and feed utilization indicators.

MATERIAL AND METHODS

The fish. Young common carp fish, which is available from local fish farmers, are used. The fish were transported to the pre-prepared laboratory with the available means of transportation and without anesthesia or any means of reducing transport stress, as they were transported in the early morning hours and near by the laboratory. Fish were sterilized with NaCl 3% saline for 5-10 minutes upon arrival in the laboratory, for the purpose of adaptation ten days before the experiment began, the fish were housed in the study aquarium (30 x 30 x 60 cm, capacity 50 liters) which equipped with a continuous source of air supply by air pumps, 147 fish were randomly distributed This experiment was carried out with three replications of six treatments in addition to a control treatment, 147 fish were randomly distributed with seven fish in each aquaria with a weight of 7.58 ± 1.42 grams per fish and at a rate of 53.09 ± 0.67 grams for biomass. 3% was fed by weight of biomass, and in two meals, and the temperature was controlled, all the duration of the study was 70 days.

Feed: The diets were made laboratory from fodder materials available in the local market after they were well ground, shifted and mixed until homogeneous, as shown in **Table 1**. It was divided into seven sections to produce treatment diets, control C without addition, Add JAT powder in different quantities (2.5, 5 and 7.5 gm/kg feed) for treatments T1, T2 and T3, respectively, and Add SGB powder quantities (2.5, 5 and 7.5 gm/kg feed) for treatments T4, T5 and T6, respectively, To experimental diets containing 30.14% raw protein for common carp fish.

Chemical analysis of fish meat: Fish meat samples were taken after the experiment 3 fish from each treatment to perform a various analyzes in the laboratory for the purpose of knowing the chemical composition of the components of fish meat, where the humidity was determined by drying the samples by a thermal convection oven at 60 °C for 24 hours, then the sample was placed in a glass dryer (Desiccators) containing silica gel, the sample was weighed, then returned to the oven for an hour and weighed again until a constant weight is obtained, The crude protein was analyzed by the Kjeldahl Micro apparatus to calculate the total nitrogen after digestion and multiplied by 6.25, and the fat was extracted by the Soxhlet apparatus extractor, The organic hexane solvent was used with heating for 16 hours, and the ash was obtained by the Maffle Furnace (Carbolite S30-2RR) English-origin incinerator at a temperature of 550 ° C and for 8 hours in order to ensure the stability of the sample weight (AOAC Association of Official Analytical Chemists.1980).

Studied traits: To find out the growth parameters, the following characteristics have been tested**.** weight gain (WG), Daily Weight gain (DWG), Relative Growth Rate (RGR) and Specific Growth Rate (SGR). To find out the food utilization parameters, the following characteristics were tested: Feed conversion rate (F.C.R), feeding efficiency rate (FER) and protein efficiency ratio (PER).

Statistical analysis of the experiment: The Data Analysis XLSTAT and JMP7 2012, was used to analyze the relevant data which was obtained at the end of the experiment to determine the impact of the experiment treatments. Using Complete Randomized Design (CRD) to the analysis significant differences between mean averages of studied parameters and the significance

Table 2. Effect of Addition JAT of and SGB Powder on Different Growth Rates of Common Carp Fish

The treatment	Initial weight gm	WG gm	DWG gm/fih/day	RGR %	SGR%
Control	7.575 a 0.005±	6.470 b 0.430±	0.092 a 0.007±	85.365 b 4.305±	0.3760 b 0.000±
T1 (2.5 g/kg) JAT	7.560 a 0.015±	7.760 ab 0.590±	0.111 a 0.009±	102.640 ab 5.960±	0.4381 ab 0.001±
T2 (5 g/kg) JAT	7.505 a 0.025±	7.565 ab 0.365±	0.108 a 0.005±	100.790 ab 3.810±	0.4325 ab 0.000±
T3 (7.5 g/kg) JAT	7.620 a 0.035±	8.455 a 0.300±	0.121 a 0.005±	110.950 a 3.220±	0.4631 a 0.000±
T4 (2.5 g/kg) SGB	7.595 a 0.010±	7.645 ab 0.240±	0.110 a 0.004±	102.215 ab 2.310±	0.4320 ab 0.000±
T5 (5 g/kg) SGB	7.580 a 0.100±	7.755 ab 0.055±	0.111 a 0.001±	102.440 ab 1.000±	0.4371 ab 0.000±
T6 (7.5 g/kg) SGB	7.610 a 0.015±	8.200 a 0.265±	0.117 a 0.004±	107.750 a 2.555±	0.4537 a 0.000±

level ($p<0.05$) that were tested by Dunkin Directional Test (Duncan, 1955).

RESULTS AND DISCUSSION

Growth performance: Table 2 shows the results of growth performance.

WG criterion, The third treatment (JAT 7.5gm/kg) and the sixth treatment (SJB 7.5 gm/kg) fish were significantly $p<0.05$ superior on all treatments, and recorded 8.455 gm, and 8,200 gm, respectively, with no significant $p<0.05$ differences between them and the rest of the treatments. Except the control treatment, that decreased significantly $p<0.05$ for all treatments and recorded 6.470 gm.

DWG criterion, there were no significant $p<0.05$ differences for the daily weight gain on all fish treatments.

RGR criterion, The third treatment (JAT 7.5gm/kg) and the sixth treatment (SJB 7.5 gm/kg) fish were significantly $p<0.05$ superior on all treatments, and recorded 110.95% and 107.75%, respectively, with no significant $p<0.05$ differences between them and the rest of the treatments, except the control treatment, that decreased significantly $p<0.05$ for all treatments and recorded 85.365%.

SGR criterion, The third treatment (JAT 7.5gm/kg) and the sixth treatment (SJB 7.5 gm/kg) fish were significantly $p<0.05$ superior on all treatments, and recorded 0.4931% and 0.4537%, respectively, with no significant $p<0.05$ differences between them and the rest of the treatments, except for the control treatment, that decreased significantly $p<0.05$ for all treatments and recorded 0.3760%.

Averages with similar characters in the same columns do not differ significantly between each other at probability level 05.0≥P.

Table 3. Effect of adding JAT powder and SGB powder on some indicators of feed utilization for common carp fish

The treatment	FCR	FER %	PER %
Control	a 3.020±0.020	b 30.520±1.590	b 1.020±0.080
T1 (2.5 g/kg) JAT	a 3.015±0.305	ab 36.600±2.185	ab 1.220± 0.110
T2 (5 g/kg) JAT	ab 2.760±0.205	ab 35.685±1.350	ab 1.190± 0.065
T3 (7.5 g/kg) JAT	b 2.555±0.185	a 39.885±1.110	a 1.330±0.055
T4 (2.5 g/kg) SGB	ab 2.720±0.095	ab 36.475± 0.890	ab 1.230±0.040
T5 (5 g/kg) SGB	ab 2.825±0.035	ab 36.580±0.205	ab 1.220±0.010
T6 (7.5 g/kg) SGB	ab 2.645±0.195	a 38.680±0.985	a 1.285±0.050

Food utilization parameters: Table 3 shows the results of growth performance.

FCR criterion, the results showed that the best treatments for the FCR were the third treatment JAT 7.5gm/kg, fish record 2.555 and the sixth treatment SJB 7.5 gm/kg record 2.645 with a significant $p<0.05$ difference when compared to what the control, which recorded 3.020.

FER criterion, The third treatment fish (JAT 7.5gm/kg) and the sixth treatment fish (SJB 7.5 gm/kg) significantly $p<0.05$ outperformed all treatments, registering 39.885% and 38.680%, respectively, compared to control treatment fish (30.520%). While they did not differ significantly $p<0.05$ from the rest of the other experimental treatment.

PER criterion, The third treatment fish (JAT 7.5gm/kg) and the sixth treatment fish (SJB 7.5 gm/kg) significantly $p<0.05$ outperformed all treatments, registering 1.330% and 38.680%, respectively, compared to control treatment fish (30.520%). While they did not differ significantly $p<0.05$ from the rest of the other experimental treatment.

Averages with similar characters in the same columns do not differ significantly between each other at probability level 05.0≥P.

Discussion of Growth performance:

The results of growth rates and feed utilization for experimental treatments are shown in **Table 2** and **3**, as those for which the third level (7.5 gm/kg of feed) for both JAT powder and SGB powder was outperformed in most indicators. This is due to the presence of a high-content JAT of the inulin and FOS (Frictooligoscharid) which improves growth performance and enhances the immune response by modifying the social formation of the enteric flora in favor of beneficial bacteria, Through the creation of the appropriate environment and the basis for the growth and reproduction of beneficial bacteria (Iraporda, et al. 2019). The fact that Inulin is a functional food with varying properties and its effect appears stable and increases with increasing dose, and the change caused by prebiotic may be from the enhancement and domination of beneficial organisms of bacteria lactobacilli or bifidobacterium that have rivaled harmful microorganisms over place and food, or have reduced their metabolic processes by stimulating the non-specific immune response of the host (Jirayucharoensak, et al. 2018) (Panchev, et al. 2011). The same applies to SGB containing β-glucan that has prebiotics specifications in addition to containing dietary fiber, which is considered a functional food. This improves growth performance and enhances the immune response by modifying the social composition of the enteric flora in favor of the host, moreover, SGB has the advantage of significantly increasing vitamins (B1, B2, C) and proteins after germination (Rico, et al. 2020). The by-products of the prebiotics fermentation process by beneficial bacteria such as (lactobacilli) play a major role in improving host health through the fermentation process that secretes an enzyme (Inulinase) for the inulin breakdown by breaking β-bonds and converting it to a carbon source, It feeds on it and activates and multiplies at the expense of harmful microorganisms that do not possess this enzyme and as a by-product producing lactic acid, it increases the amino acid lysine, which increases the effectiveness of phagocytic cells, analytic enzymes, and complement system (Kazuń, et al. 2018), that pushes the pH to acidity of the environment to be unsuitable for the growth and reproduction of pathogenic organisms (Hoseinifar, et al. 2015), and analyzing the nutrients of the diet, which raises the value of feed utilization and its readiness to absorb (Falco, et al. 2012), on the health side, it enhances the immune response and increases disease resistance (Dawood, et al. 2020).

The SGB is a beneficial dietary supplement as a prebiotic to improve growth performance, improve activity of some digestive enzymes, enhance immune response and increase stress resistance (Dawood, et al. 2015a), it contains hemicellulose fibers, which are functional nutrients that can make a beneficial change in the intestinal flora formation in favor of the host, SGB also contains a large percentage of dietary fiber that can reach the colon intact (Holscher, 2017), one of the by-products of metabolism is butyrate, which is favored by the epithelial cells lining the colon as an energy source, giving it health and activity (Song, et al. 2014), Everyone agrees that Prebiotics should improve the health of the host and provide him with a beneficial physiological effect (Hutkins. et al. 2016). Studies have documented that β-glucan can enhance growth performance, feed use, Innate immunity and disease resistance to carp (Jung-Schroers, et al. 2015) (Brogden, et al. 2014).

From the foregoing, we can say that the reason for the weight gain may be due to the fact that Prebiotics improves the value of growth performance and raises the values of the rate of protein efficiency and the percentage of feed conversion by supporting beneficial bacteria and creating the environment of the gut for growth and reproduction at the expense of pathogens in favor of the host.

Table 4. The effect of adding JAT powder and SGB powder on meat ingredients for common carp fish

The treatment	Moisture	Protein	Fat	Ash
Control	72.995 ab 0.165±	12.880 ab 0.270±	7.860 ab 0.420±	2.600 a 0.100±
T1 (2.5 g/kg) JAT	72.245 b 0.305±	13.520 a 0.640±	7.765 ab 1.175±	2.785 a 0.255±
T2 (5 g/kg) JAT	74.015 ab 0.795±	13.595 a 0.235±	6.470 b 0.660±	2.630 a 0.070±
T3 (7.5 g/kg) JAT	73.400 ab 0.520±	13.910 a 0.030±	6.865 b 0.265±	2.505 a 0.125±
T4 (2.5 g/kg) SGB	72.430 b 0.000±	11.830 b 0.110±	9.105 a 0.125±	2.815 a 0.045±
T5 (5 g/kg) SGB	72.745 b 0.225±	12.800 ab 0.330±	8.280 ab 0.170±	2.580 a 0.050±
T6 (7.5 g/kg) SGB	74.420 a 0.240±	12.865 ab 0.285±	6.520 b 0.280±	2.790 a 0.120±

As for feed utilization indicators, it is clear that the feed consumption ratio decreased compared to the production of 1 kg of meat of fish (FCR), The experimental treatment was proportional to the percentages of addition of diets of fish that outperformed growth and the values of FER and PER increased, This may be due to the addition of JAT in these ratios, as well as SGB, to experimental diets, Prebiotics enabled the Inulin in JAT and β-glucan in SGB to demonstrate the prebiotics characteristic of its positive effect on growth performance and feed utilization after improving host health and providing it with a beneficial physiological effect.

Chemical analysis of fish meat: Table 4 shows the results of Chemical analysis.

Humidity percent: The results showed that the fish of the sixth treatment (SGB 7.5 gm/kg) significantly $p<0.05$ outperformed to the percentage of moisture content in the flesh of their bodies and recorded rate (74.420%), which did not differ significantly $p<0.05$ from the control treatment (72.995%), the second one (74.015%) and the fourth (72.430%) as it recorded 72.995%, 74.015% and 72.430 respectively. While the rest of the treatment all behind these values for humidity ratios.

Protein percent: Significant $p<0.05$ superiority for the first treatment (JAT 2.5 gm/kg), the second (JAT 5 gm/kg) and the third (JAT 7.5 gm/kg) on all experimental treatments for the protein precipitation rate in its flesh and recorded 13.220%, 13.595% and 13.910, respectively, and the fourth treatment lagged behind SGB 2.5 gm/kg significantly $p<0.05$ as it recorded 11.830%.

Fat percent, The results showed that the fourth treatment (SGB 2.5 gm/kg) significantly $p<0.05$ increased at a rate of 9.105% on each of the second (JAT 5gm/kg), third (JAT 7.5 gm/kg) and sixth (SGB 7.5

gm/kg) treatments, as it recorded 6.470%, 6.865% and 6.520%, respectively, and did not differ Morally with the rest of the treatments.

Ash percent, the results did not record any significant $p<0.05$ differences between the results of the study's treatment of ash content in fish meat.

Averages with similar characters in the same columns do not differ significantly between each other at probability level 05.0≥P.

Discussion of Chemical meat analysis of fish:

The results obtained from the analysis of the fish meat of the current study, Which showed a noticeable increase in the rate of protein precipitation in the body of the fish treated with JAT powder, as this may be due to the presence of inulin and dissolved fibers in their tubers (Iraporda, et al. 2019),which showed a noticeable increase in the rate of protein precipitation in the body of the fish treated with JAT powder, as this may be due to the presence of inulin and dissolved fibers in their tubers (Tsai, Chi, & Liu, 2019), It is a natural foodstuff that resists digestion and absorption in the gut and reaches intact the colon. It grows and multiplies on it by beneficial bacteria such as bacteria lactobacllus and bifidobacteriumb (Hsu, et al. 2004), moreover, Prebiotic increases the Apparent Digestible Coefficient, and Apparent protein digestible in diet (Patkai,et al. 2002), Inulin is the basis for the fermentation of beneficial bacteria, which gives them high potential for growth and reproduction and it's not used effectively by pathogenic bacteria, which reduces the space they occupy inside the intestine (Das, Mondal, & Haque, 2017), and by fermenting on these carbohydrates, the increase in the number and size of colonized colonies within the gut is achieved, in competition with pathogens in the intestinal flora over the place and food within the gut and for the limited space the pathogenic organisms are excluded (Dawood, Abo-Al-Ela, & Hasan, 2020), In addition to the fact that it stimulates the immune system and creates a suitable internal physiological environment that positively reflects on improving the productive performance of fish and the production of inhibitors of pathogenic microorganisms, Short chain fatty acids are products of beneficial bacterial metabolism which is fortified with prebiotics, which works to reduce (pH) the environment of the gut and this is suitable for beneficial bacteria and determines the effectiveness of pathogens, and increases the readiness to absorb minerals such as calcium and magnesium in the gut (Hoseinifar, et al. 2017), (B.subtillus) also secretes some digesting and analyzing enzymes for the nutrients of the diet, which raises the value of benefiting from food, and from the healthy side it enhances the immune response and increases disease resistance (Ahmadifar, et al. 2019). The results of the analysis of the fish meat which feed fish on diets fortified with SGB powder supplemented by an increase in the percentage of moisture in their body meat is proportional to the reduction in the percentage of fats and the absence of significant protein deposition compared to the control treatment, its effect may be due to the SGB content of dietary fibers that are able to reach the colon intact in a large percentage (Holscher, 2017).

These fibers are part of the SGB components that modify the water content inside the colon because of its high susceptibility to water holding capacity (Holscher, 2017), and the insoluble fiber also contains protein-rich clotamine and hemicellulose rich in dietary fiber (Rico, et al. 2020) these specifications and functions SGB and his Prebiotic are capable of showing improvement in health characteristics, growth performance, and the preservation of carcass component proportions (Hsu, et al. 2004) while fat deposition in carcass formation decreases when using β-glucan to feed young mirror carp (Cyprinus carpio L.). fish (Kuhlwein, et al. 2014).

CONCLUSIONS

This research tries to uncover the effect of adding JAT and SGB powder was tested at different levels which are 2.5, 5 and 7.5 g per kg of feed, each on growth indicators and feed utilization, And on the meat components after feeding for a period of 70 days. the best achieved result was percentages added for the purpose of growth and utilization of feed were due to (JAT) which is 7.5 g/kg, it concluded that the best percentages added for the purpose of growth and utilization of feed were due to (JAT) which is 7.5 g / kg. As for the purpose of protein precipitation, the addition of 5 and 7.5 g / kg of SGB did not differ significantly from all JAT additions. That significantly outperformed all transactions. While the control treatment was significantly lower than all the experimental treatment

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