The use of quinoa (*Chenopodium quinoa Willd*) as a new forage crop and its effect on performance, individual production and feed efficiency of ruminants

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Abstract:

Due to a significant increase in the price of the protein sources in the feed rations for ruminants in recent years, there has been a significant increase in the cattle industry of prices for milk and meat. This has resulted in a need to find new local protein sources of high quality and cost that will be attractive to cattle breeders in Israel.

These new sources will also allow diversification of the fodder plants in use, currently based mostly on wheat, that contributes to the need to deal with diseases, pests and weeds and will permit the growth of plants with high water utilization in the rotation cycle. Growing quinoa for fodder has great potential for providing a solution to the problems mentioned above.

In the first year of the experiment, 5 dunam of quinoa from the "Mint vanilla" line were grown in Kibbutz Gadot. At the end of the growing season, the quantity, percentage of dry matter (DM), pH, chemical composition and digestibility of the plant material were tested. The harvested plant material was ensiled in glass jars at 13-18% DM, and in bales wrapped in polyethylene at about 29% DM for three months. Samples of the silage were tested for chemical composition and digestibility.

In the second year, 10 dunam of quinoa from the "Mint vanilla" line in Kibbutz Gadot were harvested for silage when the crop reached aprox. 29% DM, and the plant material was transferred for fermentation in bales wrapped in polyethylene for three months. The silage samples were tested for chemical composition and digestibility.

The silage bales were transferred to the individual feedlot in Neve Yaer and were used for a feeding trial of fattening bull calves for 100 days.

Twenty-four Holstein calves participated in the feeding experiment and were divided into two treatment groups, the experimental group was fed total mix ratio (TMR) containing 20% quinoa silage (% of TMR) and the control group was fed a TMR containing 20% wheat silage. During the experiment, individual feed intake, weight and average daily gain (ADG), *in vivo* digestibility, eating behavior and individual feed utilization efficiency was calculated.

In the third year 13 dunam were used to cultivate quinoa from the "Mint vanilla" line in Avney Eitan. The quinoa hay was harvested when the plants reached 18.4% DM.

After harvesting; the bales of hay were transferred to the individual dairy farm in Beit Dagan and were used for a feeding trial of dairy cows for 60 days.

The trial consisted of 42 dairy cows of the Israeli Holstein breed that were divided into a treatment group fed a TMR that contained 16.4% quinoa hay and the control group was fed a TMR that contained 14.5% wheat hay.
In the first year, the quinoa yield was 942 kgDM per dunam (harvested at 28.6% DM). The pH values ranged between 3.98% to 4.32%, the total protein values ranged between 13% to 18%, the NDF % ranged between 28% to 30%, lignin% ranged between 4.2% to 3.5%, DM digestibility ranged between 76%-71% and NDF digestibility ranged between 39%-41%.
All the jars that contained a vegetable of a young origin (12-13% DM), were rotten 6 days after ensiling. On the other hand, all the jars that contained a mature vegetable that was pickled without the presence of molds and fungi.
The results of the nutrition experiment in fattening calves showed that the average DM intake (DMI) of the quinoa group was significantly lower ($P<0.001$) compared to that of the wheat group. No significant difference was found in the ADG between the groups.
The percentage of *in vivo* digestibility, feed efficiency and residual feed efficiency (RFI) of the treatment group was significantly higher ($P<0.01$) relative to the control group. The protein percentage in the carcass samples of calves from the treatment group was significantly higher ($P<0.05$) relative to the control group. In the third year, the results of the individual feeding trial in dairy cows showed that the DMI of the treatment group tended to be lower ($P=0.08$) relative to the control group and the milk yield of the treatment group tended to be higher ($P=0.09$) relative to the control group. In addition, body weight and physical condition did not differ between the groups. The percentage of *in vivo* digestibility of quinoa group was significantly higher ($P<0.05$) compared to wheat group. The % fat and protein in milk, metabolic energy consumption, the amount of energy in milk, the amount of energy stored in milk and in the body and the efficiency of energy conversion were significantly higher ($P<0.05$) in the quinoa group compared to wheat group. The SCC and rumination were also significantly lower in the quinoa group compared to the wheat group.
In conclusion, the results of the nutritional experiments in fattening calves and dairy cows in combination with the yield data and the forage quality of quinoa point to the high potential of the quinoa to be used as a high-quality and new forage crop in Israel. In order to substantiate these results, it is necessary to examine feeding livestock with quinoa compared to wheat at a commercial level and with a larger number of animals in the nutritional experiments. Additionally, it is of great importance to continue testing more quinoa varieties, especially varieties that contain a higher percentage of NDF and varieties with a low level of saponins ("sweet quinoa") and to perform additional feeding experiments with these varieties and at different percentages of quinoa in the diets.
Since it is known that saponins reduce greenhouse gas emissions in ruminants, it is also necessary to examine greenhouse gas emissions at the level of the whole animal in additional nutritional experiments with ruminants.