Effect of wheat production system components on food preference in rats

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Abstract

In the study presented the effects of two major system components - fertility management and crop protection - were tested in a rat preference test for the first time. Wheat samples produced under 4 combinations of these management factors: - ***a)*** *organic fertility and crop protection management,* ***b)*** *organic fertility management and conventional crop protection* ***c)*** *conventional fertility management and organic crop protection and* ***d)*** *conventional fertility management and crop protection - generated in the Nafferton factorial systems comparison (NFSC) trial at Newcastle University, were used as experimental diets. Results showed that the organically fertilised wheat was preferred by rats (*P *= 0.001) while the organic crop protection resulted in reduced wheat consumption (not significant). This might indicate that the rats did not sense or did not select against possible traces of plant protection agents but responded more clearly to differences that were caused by the fertility management.*

Introduction

There is extensive evidence that rats are able to sense toxicants and essential nutrients in their food and avoid foods that either contain toxins (Garcia et al., 1974) or are deficient in essential nutrients (e.g. Feurte et al., 2000; Rutkoski and Levenson, 2000). This ability was first employed by (Plochberger and Velimirov, 1992) to investigate nutritional differences between organically and conventionally produced foods. In several studies it was found that rats preferred organically produced foods (Mäder et al., 2007; Mäder et al., 1993; Plochberger and Velimirov, 1992; Velimirov, 2003, 2005). However, so far, it has been difficult to elucidate which components of these production systems (e.g. tillage, seed choice, fertility management, crop protection) or quality parameters in the food might influence this preference. In the present study we intend to elucidate the influence of two major management components, fertility management and crop protection, on the food preference in rats.

Materials and methods

Wheat of the variety Malacca was produced in the Nafferton factorial systems comparison (NFSC) at the University of Newcastle's Nafferton Experimental Farm, Northumberland, UK. Conventional crop protection is applied according to the British Farm Assured standards, and organic crop protection according to Soil Association organic farming standards. Under conventional fertility management mineral fertilisers

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are applied, and composted manure is used under organic fertility management. The combination of the two factors results in four factor combinations: **a)** organic fertility and crop protection management, **b)** organic fertility management and conventional crop protection **c)** conventional fertility management and organic crop protection and **d)** conventional fertility management and crop protection. Wheat samples from these factor combinations were used in four replicates as experimental diets in the preference test (n=16). A total of 20 rats (male adults; Long Evans) were supplied standard rat food (conventional feed mixture T 779; Tagger Co., Graz, Austria) in order to prevent any deficiency symptoms. The feeding rack is divided by the water bottle into a right and left section, into which the two experimental diets were apportioned. The identity of the samples was unknown to the experimenter. The remaining feed was weighed every 24 hours. Position of the diet was swapped and new feed was supplied over a feeding period of four days. Each four-day-feeding period was carried out using 5 to 6 rats and was repeated four times. Between the different rats 6 possible pairs of the 4 different experimental diets (a-d) were compared four times in a fully randomised design. In addition, random replicates of pairs of the same experimental diet were included. The amount of experimental diet eaten from each of the two sections was analysed with a General Linear Model (GLM) and subsequent Tukey test using Minitab. The residuals were tested for normality and a transformation of the data was not found to be necessary.

Results

When the consumption of individual samples was compared by GLM analysis it was shown that the organic fertility management significantly increased wheat consumption (Table 1) of individual samples (P=0.006) while organic crop protection resulted in reduced wheat consumption (not significant, P= 0.286). The interaction between fertility management and crop protection was significant (P=0.020); consumption for both treatments under organic fertility management was similar but consumption of samples from conventional fertility management combined with organic crop protection was very low compared to the fully conventional treatment.

Tab.1: Effect of fertility management and crop protection on the amount of individual cereal samples consumed by rats (g rat^{-1} day^{-1})

Fertility Management	Health management		
	conventional	organic	mean
conventional	9.986	4.934	7.311
organic	10.634	12.545	11.590
mean	10.288	8.264	

The total amount of experimental diet consumed per day (sum of both samples in a comparison) increased with increasing proportion of cereal produced under organic fertility management (100%>50%>0%) in the feed offered to rats (Table 2). The intermediate combination with one of the foods organically fertilised is not significantly different from either both conventional or both organic. Total consumption was lower when one or both experimental diets were produced under organic crop protection. The GLM analysis comparing the total amount of cereal consumed (Table 2), showed that there was a nearly significant effect of the fertility management (P=0.051) and the Tukey test confirmed significant differences, but the difference caused by the health management had no effect (P= 0.229).

Tab.2: Effect of fertility management and crop protection on the total amount of cereal (both samples in a comparison) consumed by rats (g rat^{-1} day^{-1})

Fertility Management	Health management			
	both samples organic	one sample organic	no sample organic	mean
both samples organic	15.41	21.53	22.71	20.71a*
one sample organic	21.50	16.94	20.53	18.98ab
neither sample organic	11.03	18.38	19.30	16.13b
mean	16.81	18.45	20.49	

* Significance in the Tukey test: different letters indicate a statistically significant difference, shared letter indicate no significant difference

A correlation analysis was carried out to relate the mean amount eaten from each of the 16 samples with a set of 14 quality parameters, 21 minerals, 12 indicators of wheat diseases and 16 defence related parameters. Significant correlations are summarized in Table 3. It seems that the rats preferred food with high P and K contents and low N and Cd contents. There was no correlation with different levels of contaminants such as chlormequat and mycotoxins. The experimental food uptake was also significantly correlated to a number of defence related compounds and disease severity indicators that were recorded prior to the harvest of the grain (correlations not shown).

Tab. 3: Significant Pearson's product-moment correlations for the mean amount of rat feed eaten with wheat quality parameters of the grain

Parameter	correlation coefficients	p-value
N (%)	-0.537	0.032
P (%)	0.576	0.020
K (%)	0.695	0.003
Ca (%)	-0.676	0.004
Cd (µg kg-1 dry wt.)	-0.670	0.005

Discussion

In general, previous food preference tests (Mäder et al., 2007; Mäder et al., 1993; Plochberger and Velimirov, 1992; Velimirov, 2003, 2005) comparing organic and conventional foods were confirmed. Consumption of the experimental diet was highest for the organically produced food. By considering the two management components it becomes clear that this was predominantly caused by the preference of the rat for organically fertilised wheat. This might indicate that the rats did not sense or did not select against possible traces of plant protection agents but responded more clearly to differences that were caused by the fertility management.

The high positive correlations with P and K and negative correlation with Cadmium suggest that the mineral composition might have contributed to the food preference in this experiment. This is possible because rats have been reported to select for food that contains needed minerals (e.g. Rutkoski and Levenson, 2000). However, it cannot be concluded that the mineral composition is responsible for the preference since the rat food varied in a multitude of (measured and unmeasured) parameters that might

have been co-correlated with the mineral composition and contributed to the preference.

The only indicator for plant health of wheat grain in the data set available, the content of *Fusarium* mycotoxins (all values were below MRL), was not correlated to food preference. However, strong, reproducible differences in the plant health between organic and conventional fertility management in the NFSC have been observed (Cooper et al., 2006). It seems possible that the health status of the plants caused a variation in the quality of the wheat grain that was detectable for the rats.

Conclusions

Samples from the NFSC trial allowed the influence of fertility management and crop protection on preference of rats for organic food to be assessed. Findings emphasize the role of fertility management for producing food of a quality that was preferred by rats and in the organic production system in general. Based on these findings the test design has been improved and further quality parameters have been chosen for a repeat with samples of the 2007 harvest.

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