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SUSCEPTIBILITY OF COMMERCIAL FRUITS OF DATE PALM CULTIVARS TO *Oryzaephilus surinamensis* (L.) INFESTATION

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ABSTRACT

Laboratory studies were carried out to investigate the susceptibility of seven date palm fruit cultivars to the *Oryzaephilus surinamensis* infestation. Chemical properties of these fruits were also determined to emphasize their relation with the number of progeny produced by the *0. surinamensis* and the loss percentage caused in the fruits.

Date fruits of all examined date palm cultivars were relatively susceptible to *0. surinamensis* infestation. Clear significant differences were found between the fruit cultivars in the number of *0. surinamensis* progeny produced and loss percentage. The fruit cultivars showed clearly differences in their chemical properties which are positively significant correlated with the number of progeny and loss percentage. Amino acids followed by carbohydrates were considered the most important fruits components which affected the number of progeny produced by *0. surinamensis*.

Keywords: Oryzaephilus surinamensis, date palm, cultivars, infestation, chemical composition, progeny number and loss percentage.

INTRODUCTION

About 735,000 tones of date fruits are produced each year in the Kingdom of Saudi Arabia (http://apps.fao.org, 2001). These fruits are considered the most important crop in Saudi Arabia and it is contains high nutrition value according to their chemical and physical composition. The fruits are rich in sugars especially glucose and fructose, protein, amino acids, ash , fats and fibers. Date fruits are susceptible to many insect infestations. The saw-toothed grain beetle, *Oryzaephilus surinamensis* is one of the most common insect pests infesting date fruits during the storage and causes considerable loss in weight and great reduction in quality (EL-Kalyfah, 2001 and EL-Hag and Abu-Sabanh, 2001).

A tremendous amount of effort has been spent trying to determine the forces that regulate populations of insect pests, and the importance of density dependence continues to be vigorously debated (Dempster 1983; Dempster and Pollard 1986; Den Boer 1988; Turchin *et al.* 1998). Bancroft (2001) used the saw-toothed grain beetle, *O. surinamensis* as a model to gain insight into the mechanisms of population regulation. He found that, food depletion caused increased mortality of immature beetles, sharply reduced **oviposition,** and increased adult dispersal. He also added that *O. surinamensis* is a good model for population dynamics because of better mobility and shorter development time.

Oryzaephilus surinamensis is generally encountered in stored foods, which has prompted studies of its reproduction and mortality at various temperature, humidity, and in various grains (Collins *et al.* 1989; Beckett and Evans 1994). In optimal conditions, females lay as many as 400 eggs over six to ten months and development lasts= 3, 13 and 5 days for the egg, larval and pupal stages, respectively (May 1975).

Our objectives were to determine susceptibility of commercial fruits of seven date palm cultivars to the *O. surinamensis* and to determine whether insect development on these cultivars could be correlated with chemical properties of date fruits.

MATERIALS AND METHODS

1. Date palm fruits: Date fruits used in the present study were obtained from the harvesting year 2001. The fruits were collected from the following seven date palm cultivars; Hatmi and Ruziz from AL-Hassa, Khashram, Sery and Shager from AL-Karj, while Khadry and Safry from Riyadh. Date palm fruits from each cultivar were divided into two samples of about 500.00g each, and insect bioassays and chemical analysis were conducted on each of these two samples. Date fruits were stored below 0Cº for two weeks to kill any incipient insect infestation.

2. Insect bioassays: Fruits of each date palm cultivar were replicated four times, each replicate consisted of one plastic jar containing 500.00 g of fruits. Insects of the study *O. surinamensis* were obtained from cultures that have been maintained for many years at the laboratory of plant protection department, King Faisal University, Hofuf. Adult insects were two–four weeks old and 50 pairs of males and females were placed in the appropriate cage to mate and oviposit for seven days. Identification of ovipositing females was confirmed after the beetles removing from jars. Emerging adults were removed every four days by pouring the contents of a cage into a white enamel pan and removing progeny with forceps, starting 14 days after the middle of the oviposition period and continuing until no beetles had emerged in each cage for two weeks. At the end of the experiment, fruits of each cage were weighted to determine the loss of weight caused by the insects. All studies were conduct at 30Cº and 75% r.h., conditions which are nearly optimal for development of these insects.

2.3. Chemical analysis: The chemical analysis of fruits of the examined seven date palm cultivars was carried out and the following properties were determined: Percentages of moisture content, total protein, ether, fiber, ash, and total carbohydrates which were carried out according to the method of A. O. A. C. (1985). Mono, di and tri sugars percentages were determined according to the method of Goodall *et al.* (1995). Amino-acids % were also determined according to the method of (Tanaka *et al*, 2003).

2.4. Statistical analysis: Data collected on the progeny number and loss percentage for the evaluated fruits of seven date palm cultivars were subjected to the proper statistical analysis as the technique of Analysis of variance (ANOVA) for the completely randomized design as published by

Gomez and Gomez (1984). The treatment means were compared using the Baysian Least Significant Difference test, as published by Waller and Duncan (1969). The relationship between each of progeny number and loss percentage with the chemical properties of fruits was done individually for each data palm fruit cultivar and over all these examined date palm cultivars. This was done through the statistical techniques of simple correlation coefficients (Snedecor and Cochran 1981) and stepwise multiple linear regression (Draper and Smith 1966). Computations and statistical analysis were done using the facility of computer and SAS software (SAS Institute 2001).

RESULTS AND DISCUSSION

Data listed in Table 1 show that the progeny number produced by *O. surinamensis* in date palm fruits was clearly dependence on type of date palm CVs. Shakr cultivar ranked the first producing the highest number of progeny (739.1), however Hatmi and Ruziz CVs followed Shakr in progeny number without significant differences. The lowest progeny number (389.8) was associated with Serry CV, followed by Khashram, Khadry and Safry CVs.

Variances for the loss percentage which caused by the produced progeny of *O. surinamensis* in the examined date fruit cultivars were clearly homogeneous (Table 1). Safry CV. was associated with the lowest loss percentage (1.38 %), followed by Shager CV (1.83%). Khashram and Sery CVS came in the second rank in producing the lowest loss %, while Khadry was associated with the highest loss %, followed by Ruziz and Hatmi. Although, date fruits of Shakr CV. recorded the highest number of *O. surinamensis* progeny, it was associated with the lowest loss %. In contrast, fruits of Khadry cultivar which recorded relatively low number of progeny, showed the highest loss percentage among the examined CVs (Table 1).

In general, it can be concluded that date fruits of all examined date palm CVs were relatively susceptible to *O. surinamensis* infestation. Shakr cultivar followed by Hatmi and Ruziz were more susceptible, while Sery followed by Khashram, Khadry and Safry were less susceptible to the infestation. Safry and Shakr CVs. recorded the lowest levels of loss percentages, whereas Khadry and Ruziz cultivars showed the highest levels. It could be suggested that the differences in the produced progeny and the loss percentage between the date fruit cultivars may be due to the differences in the chemical properties of date fruit cultivars (Tables 2, 3) and the competition on food resources which may be occurred between the produced progeny in each date fruits cultivar. Bancroft (2001) found that, *O. surinamensis* has strong negative exponential feedback on reproduction, mortality and dispersal in response to density and food quality. Density and food limitation cause direct and indirect population control. He suggested also that researchers studying organisms that deplete their food resources measure variation in immature development and mortality over periods of resource cycling. On the other hand, Jacob and Fleming (1989), found that *O. surinamensis* populations may be regulated by cannibalism of active stages.

Table (1): Averages and SD of progeny number produced by O. surinamensis and loss percentages on seven date fruit cultivars.

Date palm fruit CVs.	Average No. of produced Progeny		SD	Loss %		SD
Hatmi	585.3	AB	11.2	3.92	AB	2.04
Khadry	436.9	B	11.5	5.13	A	2.41
Khashram	415.6	B	9.3	3.38	BC	1.56
Ruziz	576.5	AB	11.9	4.43	AB	1.44
Safry	442.5	B	9.4	1.38	D	0.56
Sery	389.8	B	12.4	3.55	ABC	1.42
Shager	739.1	A	10.2	1.83	CD	1.03

Averages followed by the same letter(s) is (are) not significantly differed at 5 % level of probability.

Wide variations were observed in the chemical properties of fruits taken from the examined seven date palm cultivars (Tables 2 and 3).

The moisture content was the highest (12.35%) in Sery and the lowest (3.28%) in Khashram CVs. However, Hatmi CV. recorded the highest protein % (2.87), while Khashram CV. recorded the lowest (0.92). Safry CV. was associated with the highest total carbohydrates (83.2 %), but Khashram CV. fruits ranked the last in total carbohydrates (60.57 %) in cultivars. Glucose reached its maximum with Khadry CV (35.82 %) and was negligible (0.0) in Hatmi and Safry cultivars. However, fructose was highest (71.35 %) in Hatmi and lowest (31.13 %) in Khadry CVs. Fruits of Safry CV. ranked the first in its components from amino acids and Sery ranked the last in it. It could be concluded that the differences of the chemical properties between the date fruit cultivars may be one of the most factors which affecting the *O. surinamensis* progeny produced and the loss percentage.

Data listed in Table (4) show simple correlation coefficients between each of chemical properties in fruits and each of progeny number and loss percentage in fruits of each date palm CV. individually and all over the examined seven date palm CVS. Results of statistical analysis showed that most of the estimated chemical compositions of the examined date palm CVs. had positive significant correlation coefficients with each of progeny number and loss %., meanwhile protein, fiber, and ash indicated negative significant correlations for each of progeny number and loss percentage. To summarize, brief notes will be scoped light on the result of simple correlation over all date palm CVs. Obtained results revealed that sucrose (0.36), amino acids including serine (0.35), Glutamine (0.37), Glycine (0.31), alauine (0.41), Cystine (0.39), Tyrosine (0.35) and Phenylalanine (0.36) indicated positive significant correlation with progeny number in date fruits. Fiber and Ash % had negative significant correlation coefficients (-0.35 and -0.41), respectively with the progeny number. Data also showed no limiting significant relation between any chemical properties and loss %, despite the positive significant correlations for most of chemical properties (as percentages of moisture, ash, glucose, total carbohydrates, serianine, glutamine) and loss % in each date palm individually. This might be due to the wide variations in the chemical properties among the examined date palm CVs, as previously mentioned (Tables 2 and 3). Data listed in table (4) show the partial coefficient of determination (R2) for the accepted chemical properties as limiting variables in progeny number prediction in fruits of each date cultivar as well as over all examined date palm CVs. Results of stepwise regression in Hatmi CV., revealed that amino acids; alanine and cystine explained 0.992 % of the total variation in progeny number.

However, in Khadry cultivar amino acids; Serine, Valine and Histidine explained 0.985 % in progeny number. Carbohydrates, ash, mannose and amino acid lucine explained 0.995 % of the total variation in progeny number of Khashram CV. For Ruziz CV. total carbohydrates, ash and amino acid mannose explained 0.994% of the total variation in progeny number.

Protein, methionine, ether, fructose and cystine were the most closely related compositions in progeny number prediction in fruits of Safry CV. In Shakr cultivar, alanine, cystine, glycine, hisitidine, vaine and protein explained 0.998% were the accepted significant variables in affecting progeny number of fruits.

Table (2): Averages of chemical properties of date palm fruit cultivars.

Variety	Hatmi	Khadry	Khashram	Ruziz	Safry	Sery	Shager	LSD 5%
Moistutre	11.22	11.53	9.28	11.94	9.34	12.35	10.17	0.67
SD	0.47	0.72	0.22	0.53	0.49	0.19	0.26	
Protein	2.87	2.17	0.92	2.09	1.81	2.22	2.30	0.36
SD	0.11	0.10	0.04	0.12	0.06	0.01	0.10	
Ether	0.17	0.11	0.12	0.14	0.12	0.12	0.15	0.02
SD	0.07	0.01	0.01	0.01	0.01	0.01	0.01	
Fiber	1.15	1.37	1.12	1.05	1.26	1.06	1.16	0.06
SD	0.12	0.15	0.08	0.07	0.03	0.06	0.03	
Ash	1.66	2.13	1.74	2.06	2.15	2.04	1.98	0.08
SD	0.11	0.12	0.04	0.12	0.14	0.08	0.1	
Carbohydrates	81.38	81.76	60.57	79.19	83.2	80.76	81.28	1.82
SD	1.95	1.89	1.2	1.7	2	1.44	1.83	
Glucose	0	35.82	7.93	18.48	0	17.04	17.14	0.72
SD	0	1.54	0.85	1.7	0	0.37	0.79	
Fructose	71.53	31.13	61.59	53.77	68.32	65.52	63.79	2.21
SD	2.03	0.73	1.99	2.9	1.63	1.96	2.47	
Sucrose	0	0	0	0	0	0	3.12	0.06
SD	0	0	0	0	0	0	0.2	
Galactose	0	0	0	26.13	3.59	0	0	0.18
SD	0	0	0	0.64	0.19	0	0	
Arabnose	0	0	12.57	0	27.4	0	0	0.12
SD	0	0	0.1	0	0.45	0	0	
Mannose	8.72	32.02	16.71	0	0	8.48	0	0.28
SD	0.4	0.84	0.18	0	0	0.31	0	
Xylose	0	0	0	0	0	4.04	14.79	0.14
SD	0	0	0	0	0	0.1	0.49	

Table (3): Averages of amino acids of seven date palm fruit cultivars.

Variety	Hatmi	Khadry	Khashram	Ruziz	Safry	Sery	Shager	LSD 5%
Asparagine	25.13	10.05	18.74	11.97	20.64	15.53	13.84	0.58
SD	0.58	0.94	0.48	0.69	0.8	1.07	0.44	
Threonine	2.64	3.06	2.21	3.1	5.45	1.65	4.46	0.10
SD	0.2	0.13	0.06	0.07	0.12	0.15	0.09	
Serine	5.5	4.67	5.03	6.25	10.25	2.56	8.64	0.42
SD	1.22	0.35	0.38	0.02	0.56	0.06	0.33	
Glutamine	20.39	12.27	17.36	18.57	25.86	12.28	21.05	0.76
SD	1.73	0.38	0.45	0.8	1.1	0.67	1.34	
Proline	6.21	5.64	5.79	6.69	11.81	3.7	10.79	0.28
SD	0.46	0.18	0.1	0.5	0.46	0.43	0.23	
Glycine	5.54	4.72	5.29	8.46	11.09	3.75	9	0.34
SD	0.47	0.47	0.47	0.35	0.77	0.32	0.18	
Alanine	8.42	4.71	6.6	7.35	11.54	4.92	9.78	0.34
SD	1.02	0.34	0.12	0.25	0.12	0.27	0.35	
Cystine	1.14	0.83	0.5	2.25	0.99	0.51	1.84	0.05
SD	0.1	0.06	0.02	0.08	0.01	0.03	0.05	
Valine	2.16	2.6	2.3	2.83	5.44	1.32	4.08	0.21
SD	0.51	0.33	0.18	0.14	0.26	0.07	0.18	
Isoleucine	2.19	1.99	2.19	2.28	3.71	1.2	3.36	0.08
SD	0.04	0.09	0.18	0.11	0.1	0.08	0.08	
Leucine	4.17	3.44	3.52	5.1	8.69	2.75	6.56	0.16
SD	0.17	0.17	0.16	0.09	0.4	0.07	0.07	
Tyrosine	1.51	1.65	1.25	1.85	2.45	0.82	2.62	0.06
SD	0.07	0.18	0.05	0.06	0.04	0.06	0.06	
Phenylalanine	1.07	2.52	1.08	2.63	1.49	0.05	4.95	0.08
SD	0.03	0.09	0.05	0.12	0.08	0	0.08	
Histidine	3.35	2.64	3.25	4.12	5.54	2.23	4.53	0.07
SD	0.2	0.08	0.11	0.07	0.1	0.05	0.11	
Lysine	2.47	2.21	2.5	3.44	5.23	1.52	4.11	0.08
SD	0.15	0.11	0.13	0.07	0.08	0.02	0.08	
NH_4+	48.47	30.51	52.98	62.09	103.36	32.9	51.62	1.22
SD	0.79	3.05	2.13	0.68	2.13	0.58	0.52	
Arginine	0.13	1.56	2.21	2.74	5.47	0.01	0	0.08
SD	0.08	0.12	0.07	0.13	0.19	0	0	
Methionine	18.53	0.05	0	0	1.08	0	0.03	0.42
SD	1.48	0.01	0	0	0.1	0	0	

Data showed also that serine, histidine, valine, methionine, glutamine, isolucine, $NH4^{+}$, arginine, ash, carbohydrates and glucose explained were the most effective compositions in progeny number prediction in fruits of Sery CV. Over all cultivars, moisture content, glycine, isoleucine, phenylalanine, serine, lysine, sucrose, ash, carbohydrates, ethr, fructose, alanine, cystine, leuceine explained were the most closely properties affecting progeny number prediction (Table 4).

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According to the obtained results, the significant variances in the chemical properties which recorded between the date fruits cultivars (Table 2), it could be suggested that the chemical properties, particularly amino acids and carbohydrates, play the important role in the differences recorded in the number of progeny of *O. surinamensis* (L.) produced and the loss percentage between the date palm fruit cultivars. This was clear in the positive significant correlation which detected between these properties and the number of progeny produced and loss percentage in the tested fruit cultivars (Table 4).

Amino acids were considered the most imoprtant chemical properties affected the number of progeny produced in a total of five date fruits cultivars. (Khadry, Sery, Hatmi, Shakr and Safry cultivars), while total carbohydrates were considerd the main chemical properties which affected the number of progeny produced by *O. surinamensis* in Khashram and Ruziz cultivars (Table 4). Throne *et al.* (2003) found that number of *O. surinamensis* progeny produced on oats cultivar was less on whole otana cultivar than on all other cultivars. While the variances on whole oats were not homogeneous. They also stated that chemical and physical properties of the oat kernels differed with cultivar. But they were unable to correlate insect development on oat with chemical and physical properties of the oats. Baker *et al.* (1991) investigated rice weevil, *Sitophilus oryzae*, development on 30 US eastern soft wheat *Triticum aestivum* cultivars and found that mean number of progeny produced varied by only 30 individuals. Giles (1998) found that Maize *Zea mays* is very diverse in its susceptibility to *O. surinamensis*. Also, Arnason *et al.* (1994) stated that the number of progenies produced by the maize weevil, *S. zeamais* varied by 265 individual on 28 Mexican land races of maize. While, Halid (1988) found in Indonesian milled rice that *S. zeamais* can develop rapidly from a low population into very damaging levels in a large habitat.

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قابليــة أصـناف التمـور التجاريــة المختلفـة للأصــابة بخنفســاء الحبـوب المنشـارية **Oryzaephilus surinamensis**.

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تم أجراء هذه الدراسات المعملية لتحديد قابلية سبعة أصناف تجارية من التمور للأصابة بخنفساء الحبوب المنشارية *Oryzaephilus surinamensis* . كما تم تقدير المحتوى الكيمائي لثلاثة أصناف من تلك التمور لتوضيح العلاقة بين المحتوى الكيمائي للتمور و الكثافة العددية لخنفساء الحبوب المنشارية و حجم الفقد في التمور نتيجة التغذية.

أوضحت الدراسة قابلية التمور الخاضعة للدراسة للأصابة بخنفساء الحبوب المنشارية. كما أوضحت الدراسة أنه هناك فروق معنوية واضحة في تأثير أصناف التمور المختلفة على الكثافة العددية لخنفساء الحبوب المنشارية و حجم الفقد في التمور. كما أوضح التحليل الكيميائي للتمور فروق معنوية واضحة بين أصناف الدراسة و الذي كان مرتبط بتأثيرها على الكثافة العددية للحشرات و الفقد في التمور. كما بين التحليل الأحصائي أن محتوى الأحماض الأمينية و الكربوهيدرات كانت أهم محتويات التمور تأثيراً على الكثافة العددية لخنفساء الحبوب المنشارية.

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Table (4): Simple correlation coefficients (r) between progeny number, loss percentage and chemical properties of the valuated seven date palm fruit cultivars.

Variety	Hatmi		Khadry		Khashram		Ruziz		Safry		Shakr		Sery		Over all varieties	
Characters	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**	**Progeny**	**Loss**
Moisture	0.97	0.90	0.94	0.83	0.97	0.96	0.91	0.98	0.91	0.97	0.95	0.98	0.97	0.90	0.22	0.06
Protein	-0.29	-0.48	-0.71	0.92	-0.97	-0.99	-0.55	-0.75	-0.92	-0.96	0.84	0.88	0.07	0.12	0.17	-0.01
Ether	0.30	0.13	0.04	-0.72	0.35	0.36	0.26	0.17	-0.44	-0.75	-0.48	-0.59	0.09	0.24	0.25	0.00
Fiber	-0.87	-0.88	-0.89	0.14	-0.79	-0.86	-0.66	-0.77	-0.76	-0.95	0.43	0.52	-0.87	-0.74	-0.35	-0.06
Ash	-0.93	-0.78	---	-0.93	-0.94	-0.91	-0.60	-0.78	-0.80	-0.98	-0.92	-0.94	-0.74	-0.52	-0.41	-0.04
Carbohydrates	0.97	0.92	-0.75	-0.67	---	---	0.93	0.99	0.91	0.98	0.96	0.99	0.99	0.92	0.21	0.04
Glucose	0.99	0.93	0.95	0.26	0.99	0.97	0.93	0.99	0.91	0.98	---	---	0.99	0.92	0.01	0.00
Fructose	0.96	0.85	0.94	0.99	0.95	0.98	0.93	0.99	0.89	0.86	0.96	0.99	0.99	0.92	0.17	-0.01
Sucrose	---	---	---	---	---	---	0.87	0.96	---	---	---	---	---	---	0.36	-0.09
Galactose	---	---	---	---	---	---	---	---	---	---	0.96	0.97	---	---	0.10	0.04
Arabnose	---	---	---	---	0.96	0.91	---	---	0.88	0.97	---	---	---	---	-0.15	0.05
Mannose	0.82	0.72	0.71	0.95	0.98	0.98	---	---	---	---	---	---	0.97	0.88	-0.19	0.02
Xylose	---	---	---	---	---	---	---	---	---	---	0.96	0.96	0.88	0.80	0.28	-0.10
Asparagine	0.92	0.80	0.94	0.97	0.99	0.98	0.93	0.99	0.83	0.97	0.96	0.99	0.99	0.92	0.10	0.04
Therionine	0.87	0.78	0.79	0.80	0.37	0.33	-0.17	-0.46	-0.07	0.14	0.94	0.97	0.89	0.78	0.22	0.03
Serinine	0.99	0.94	0.98	0.98	0.99	0.98	0.91	0.98	0.91	0.98	0.96	0.99	0.99	0.92	0.35	0.04
Glutamine	0.99	0.93	0.94	0.97	0.99	0.98	0.93	0.99	0.91	0.98	0.96	0.99	0.99	0.92	0.37	0.04
Proline	0.96	0.93	0.89	0.89	0.67	0.65	0.89	0.96	0.91	0.98	0.97	0.95	-0.19	-0.09	0.29	0.01
Glycine	0.98	0.90	0.91	0.92	0.95	0.94	0.92	0.95	0.91	0.98	0.92	0.94	0.96	0.93	0.31	0.04
Alanine	0.99	0.92	0.89	0.90	0.71	0.68	0.83	0.89	0.84	0.90	0.96	0.95	0.94	0.86	0.34	0.03
Cystine	0.70	0.52	0.62	0.64	0.23	0.20	-0.15	-0.32	0.18	-0.07	0.66	0.71	0.50	0.66	0.39	-0.01
Valine	0.93	0.89	0.97	0.95	0.89	0.83	0.64	0.77	0.38	0.68	0.87	0.84	0.38	0.44	0.26	0.06
Isoleucine	0.62	0.44	0.81	0.80	0.90	0.95	-0.37	-0.63	0.05	0.03	0.76	0.75	0.87	0.78	0.27	-0.01
Leucine	0.99	0.93	0.87	0.88	0.53	0.43	0.38	0.38	0.88	0.97	0.42	0.38	0.75	0.67	0.21	0.03
Tyrosine	0.74	0.85	0.88	0.92	0.62	0.65	0.38	0.54	0.28	0.35	0.51	0.55	0.88	0.80	0.35	0.01
Phenylalanine	0.33	0.32	0.60	0.59	-0.12	0.02	0.55	0.56	0.45	0.30	0.13	-0.01	0.37	0.31	0.36	-0.05
Histidine	0.90	0.80	-0.13	-0.34	-0.04	-0.06	0.57	0.55	0.40	0.49	-0.06	0.00	0.16	0.20	0.22	0.01
Lysine	0.41	0.35	0.06	0.19	0.95	0.90	0.70	0.82	0.52	0.50	0.35	0.41	0.17	0.17	0.21	0.02
NH4+	0.97	0.88	0.59	0.71	0.97	0.93	0.93	0.98	0.87	0.97	0.97	0.92	0.92	0.82	0.07	0.05
Arginine	0.59	0.50	0.35	0.36	0.18	0.18	0.31	0.36	-0.12	-0.35	0.96	0.99	---	---	-0.12	0.07
Methionine	---	---	0.36	---	---	---	---	---	0.26	0.09	---	---	---	---	0.16	0.03
Progeny	1.00	0.89	1.00	0.95	1.00	0.98	1.00	0.93	1.00	0.87	1.00	0.96	1.00	0.95	1.00	0.08
loss	0.89	1.00	0.95	1.00	0.98	1.00	0.93	1.00	0.87	1.00	0.96	1.00	0.95	1.00	0.08	1.00

Tabulated r at 5 and 1%= 0.31 and 0.41, respectively. Symbol --- denotes that there is no values, i.e. the value in estimation was zero.