International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Proximate Composition of Stored Dates (*Phoenix dactylifera* L.) Infested with *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae)

Musa Buba[1], Stanley O. N. Dimkpa[2], Usman Zakka[3], Ndowa Ekoate Sunday Lale[3]

[1]Graduate Student, Department of Animal and Environmental Biology, Faculty of Science, University of Port Harcourt, Rivers State, Nigeria

[2]Department of Crop and Soil Science, Faculty of Agriculture, Rivers State University, Port Harcourt, Rivers State, Nigeria

[3,] Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Rivers State, Nigeria

Abstract: ***Three date cultivars Jigawa, Deglet Noor and Mali were sourced from the open market in Gombe and infested with a pair of 2-3 days old O. surinamensis L. for 14 weeks to evaluate the effect of infestation on their nutrient composition. Nutritional status of fresh un-infested dates were also analysed before the onset of the experiment to determine their initial nutritional contents. The result shows significant increase in carbohydrates in dates after 14-weeks of storage but a decrease in in content with infestation. Findings of the research further show significant difference in nutritional composition of un-infested and infested dates after 14 weeks. Carbohydrate ranged from 74.2±0.2 to 66.7±0.6 and moisture from 12.4±0.4 to 16.2±0.1 in un-infested and infested dates respectively. In addition, percentage stored date ash content, fat, crude protein and crude fibre all decreased after infestation. Degree of post infestation carbohydrate status of the three date cultivars was in the descending order: Infested Mali cultivar < infested Deglet Noor cultivar < infested Jigawa cultivar. On the overall, carbohydrate content of infested dates, which constitutes about 70% of dates reduced significantly by O. surinamensis infestation, as well as the other parameters considered except moisture.***

Keywords: *Oryzaephilus surinamensis*, dates, nutritional composition, infestation

1. Introduction

Date palm (*Phoenix dactylifera* L.) belongs to the Arecaceae family which has up to 200 genera and 1500 species (Dowson, 1982; Al-daihan and Bhat, 2012). The date palm, whose origin is said to be the tropics and sub-tropics probably the Middle East, Western India and Iraq (Barrow, 1998), is one of the earliest crop plants that has been cultivated for its fruit for at least 5000 years B. C. (Khalid *et al*., 2011), while the name *Phoenix* itself is thought to be of Greek origin meaning purple or red fruit, and, dactylifera from another Greek word *daktulos* from the fruit's finger-like appearance (Zaid *et al*., 2002). In northern part of Nigeria, where the palm is grown, it is locally called 'dabino' in hausa language (Al-daihan and Bhat, 2012).

Date palm was one of the first five fruit trees to be domesticated along with olive, grapevine, fig, and pomegranate. These plants are known as members of the "first wave" of domesticated fruit trees which led to the increase in fruit and pulp quality and to a shift from sexual to vegetative propagation (Jaradat, 2011). Dates as a fresh fruit ranked number five in the list of tropical/sub-tropical fruits after citrus, mangoes, bananas, and pineapples, while as a dried fruit, it is on top of the list (Popoola, 2013).

The date palm is considered a symbol of life in the desert, because it tolerates high temperatures, drought and salinity more than many other crops (Lunde, 1978). Appropriately called "the palm of life", the date palm has provided food, ornament and material for shelter, fibre and fuel in harsh environments where few other plants are able to grow (Popenoe, 1973, Hodel and Pittenger, 2003). Date palm is considered an important source of food in the Middle East and North African (MENA) countries which is why it is seen as native to countries around the Arabian Gulf (Al-Qarawi *et al*., 2004, Al-Farsi *et al*., 2005).

Dates are nutritious, high-energy food, and important part of the diets of people in the Arab countries and are consumed fresh, dried, or in various processed forms (Kader and Hussein, 2009). Numerous studies have been conducted to study the benefits of dates, either from its fruit or seed, and it has been found to possess several highly beneficial properties such as antiviral, antifungal, antioxidant and hepato-protective activities (Al-Farsi and Lee, 2008). Specifically, its seed contains essential fatty acids (Boukouada and Yousfi, 2009). The health and nutritional benefits of dates are attributed to the rich content of antioxidants in the fruits such as the coumaric acid and ferulic acid; moreover, it contains flavonoids, sterols, procyanidins, carotenoids, anthocyanins, sugar (glucose, sucrose, fructose), dietary fibres, less protein and fats, vitamins such as riboflavin, biotin, thiamine, ascorbic acid, folic acid, and minerals for example calcium, iron, copper, cobalt, magnesium, fluorine, manganese, phosphorus, potassium, sodium, boron, sulphur, zinc and selenium within the date itself (Baliga *et al*., 2011, Anjum *et al*., 2012, Vayalil, 2012, Al-Hooti *et al*., 1995). In general, dates are considered to be a good source of sugars where they are used as date syrup in cake production instead of sugar Akubor and Yusuf (2007).

In spite of the aforementioned qualities, the date palm and its fruits, like other agricultural produce, often come under attack by several arthropod (insect and mite) pests (Lale, 2002). Attack on stored dates often results in both qualitative and quantitative damages which are often of tremendous economic consequences to growers and sellers. This is further exacerbated by the fact that many of the crop varieties that were developed during the past thirty years produced high yields, but more susceptible to insect pests (Kerin, 1994). Insect pests are capable of evolving to biotypes that can adapt to new situations, such as overcoming the effect of toxic materials or bypassing natural or artificial plant resistance, which further confounds the problem (Roush and McKenzie, 1987).

The saw-toothed grain beetle, *O. surinamensis* has been reported to be a major insect pest causing damage to stored products especially dates (Kader and Hussein, 2009) and has in fact been named as the most important insect pest of dates (Al-Deeb, 2012). Attack of *O. surinamensis* on stored dates leads to irreparable qualitative and quantitative losses (Lorini, 2005). Activities of *O. surinamensis* on dates involve digging tunnels between the rind and the content, affecting mostly dates with injuries and that do not have tops (Al-Hafidh *et al*., 1987). *O. surinamensis* causes the transfer of pathogenic organisms through the attachment of these microorganisms to the body of the insect (Trdan *et al*., 2005). Thus, as the population of the saw-toothed grain beetle increases, rate of decay in dates increases as well (Al-Dosary, 2009). *O. surinamensis* beetle is a widespread and abundant stored-product insect pest, but, secondary in nature, usually associated with *Sitophilus* infestation of grain (Hill and Waller, 1999). Both larva and adult are involved in causing date depredation which results in lowering the nutritional value of the fruit as well as reducing the germination capability of the seed (Lale, 2002). Further damage done to dates by *O. surinamensis* include reduction in total lipids, phospholipids, galactolipids, polar and non-polar lipids, essential amino acids, methionine, isoleucine and lysine (Jood *et al*., 1995; Kumar *et al*., 1996; Sudesh *et al*., 1996). An increase in the levels of free fatty acids and peroxides were noticed in infested stored produce which is an indication of produce deterioration (Mbata, 1994). From the foregoing, it is evident that dates are highly nutritious when consumed. However, *O. surinamensis* is a potential threat to accessing these nutritive content due to its feeding activity on it. This research will therefore attempt to evaluate nutritional content of dates and determine the quantity of these nutrients that can be lost due to infestation by *O. surinamensis.*

2. Materials and methods

Preparation of dates

Three date cultivars were purchased from the Gombe central market. The samples were divided into portions of 50g each and wrapped in an aluminium foil and sterilized in a hot air oven at 60°C for 2 hours (Beckel, 2007; Popoola, 2013) after which they were removed and spread on a cardboard paper and allowed to cool for 8 hours after which 200g of each date sample was weighed using an electronic kitchen scale and put in coded 1-L glass jars.

Sexing of *O. surinamensis* and infestation of dates

O. surinamensis adults were recovered from an already prepared date mixed cultivar culture from the laboratory and sexed. The males have a spine-like projection at the femur of the hind legs which is absent in females (Mason, 2003, Mallah *et al*., 2016). Five pairs of sexed adult *O. surinamensis* were introduced into each container containing date samples which served both as oviposition medium and feeding substrates. The adult *O. surinamensis* were allowed to mate and oviposit and were later removed from the date samples on the 8^{th} day and the eggs were allowed to develop. Each container was covered with a perforated lid and muslin and secured with a rubber band. This was done in order to prevent the escape of trapped insects, and to stop external insects and other organisms from gaining access into the containers. The experiment was laid out in completely randomized design (CRD) with five replications. The experiment was left undisturbed in the laboratory for 14 weeks under prevailing ambient temperature and relative humidity of 30±2°C and 80±5% respectively.

Preparation of *O. surinamensis* infested date samples

Damaged samples were removed after 14 weeks and all insect stages were sieved out. Damaged dates were then dissected longitudinally and further cut into tiny pieces and thereafter spread in a single layer on an aluminium foil and put in a hot air oven for drying at 60°C for 18 hours and dried to constant weight. Date samples were turned/mixed every 2-3 hours to ensure uniform drying. After oven-drying, samples were removed and left for 8 hours to cool and then pulverised into powder and thereafter sieved with a 2mm mesh pore size. Fresh un-infested date samples which were kept for 14 weeks were equally prepared in the same way. Proximate composition of infested, fresh and 14-weeks old un-infested samples were analysed for major nutritional parameters such as carbohydrate, crude protein, fat, crude fibre, ash and moisture content.

Procedure for proximate analysis

The method of the Association of Official Analytical Chemists (AOAC, 2006) was used for the determination of Crude Protein (CP), Crude Fibre (CF), Fat (F) and Carbohydrate (CHO), while the Pearson's Chemical Analysis of Foods (Harold *et al*., 1981) was used for determination of Moisture Content (MC).

Data were analysed with Minitab statistical package using Analysis of Variance (ANOVA) at the 5% probability level. In the *post hoc* test, means were separated using Tukey's method.

3. Results

The result of the nutrient composition analysis of three freshly harvested date cultivars and that of 14-weeks old un-infested stored dates indicates that the mean moisture content was highly significant ($P \leq 0.05$) in fresh Deglet Noor (16.4±0.3) followed by both fresh and 14-weeks old Jigawa cultivars while 14-weeks old Mali cultivar recorded the lowest mean moisture content (Table 1). Mean fat content was highest in 14-weeks old Jigawa cultivar (2.9±0.1) while the least was fresh Mali date cultivar (1.2±0.0). There was significant ($P \leq 0.05$) difference in the carbohydrate contents of all the three 14-weeks old date cultivars compared with the fresh dates. Crude protein was highest in 14-weeks old Deglet Noor (4.8±0.1) and lowest in fresh Jigawa (3.1±0.0) and fresh Mali (3.1±0.0). Lastly, crude fibre was significantly higher in 14-weeks old Deglet Noor (6.7±0.1) followed by 14-weeks old Mali (5.4±0.1) while fresh Jigawa date cultivar was the least (3.3±0.0).

Table 1: Nutritional composition (%) of three freshly harvested and 14 weeks old un-infested dates

Composition	Date status					
	Fresh Jigawa	14 weeks old Jigawa	Fresh Deglet Noor	14 weeks old Deglet Noor	Fresh Mali	14 weeks old Mali
Moisture	14.5^{b}	12.9^{c}	16.4^{a}	14.5^{bc}	12.0^{c}	9.9^{d}
Ash	3.6^{c}	4.8^{a}	3.3^{c}	3.9^{ab}	3.4^{c}	3.7^{ab}
Fat	2.0^{b}	2.9^{a}	1.7^{b}	2.3^{ab}	1.2^{c}	1.6^{bc}
CHO	70.7^{b}	74.7^{a}	70.6^{b}	74.0^{a}	70.0^{b}	73.9^{a}
Crude protein	3.1^{c}	4.0^{b}	3.8^{b}	4.8^{a}	3.1^{c}	4.1^{b}
Crude fibre	3.3^{d}	4.9^{b}	4.5^{bc}	6.7^{a}	4.0^{c}	5.4^{b}

Means that do not share a letter within a row are significantly ($P \leq 0.05$) different by Tukey's method at 95% confidence interval

Table 2 shows that mean moisture content was significantly ($P \leq 0.05$) higher in infested Deglet Noor (18.3±0.4) compared with un-infested Deglet Noor (14.5±0.4), likewise, infested Jigawa cultivar had significantly ($P \leq 0.05$) higher mean moisture (16.2±0.4) compared with un-infested Jigawa cultivar (12.9±0.4). Mean moisture content was highest in infested Deglet Noor cultivar and least in un-infested Mali cultivar (9.9±0.4). Mean ash content was highest in un-infested Jigawa date cultivar (4.8±0.2) which was significantly ($P \leq 0.05$) higher compared with infested Jigawa cultivar, the least (2.4±0.2). Mean ash content in un-infested Jigawa cultivar was significantly ($P \leq 0.05$) higher (4.8±0.2) compared with infested Jigawa (2.4±0.2). However, there was no significant ($P > 0.05$) difference between infested and un-infested Deglet Noor, and, infested and un-infested Mali cultivars. There was significant ($P \leq 0.05$) difference in mean fat content of un-infested Jigawa cultivar (2.9±0.1) compared with infested Jigawa cultivar (1.1±0.1). In the same vein, un-infested Deglet Noor had significantly ($P \leq 0.05$) higher mean fat content compared with infested Deglet Noor (1.1±0.1). The highest mean fat content was in un-infested Jigawa cultivar which was significantly ($P \leq 0.05$) higher than infested Mali, the least (0.8±0.1). Mean carbohydrate content was significantly ($P \leq 0.05$) higher in un-infested Jigawa cultivar (7.47±1.0) compared with infested Jigawa cultivar (67.5±1.0). In line with this, there was significantly ($P \leq 0.05$) higher mean carbohydrate content in un-infested Deglet Noor cultivar compared with infested Deglet Noor cultivar (66.6±1.0). Mali date cultivar had the least carbohydrate content (66.0±1.0). Highest mean crude protein value was recorded in un-infested Deglet Noor (4.8±0.1) which was significantly ($P \leq 0.05$) higher than mean crude protein value recorded on Jigawa infested and Mali infested (2.2±0.1). Mean crude protein in un-infested Mali cultivar (4.1±0.1) was significantly higher compared with mean crude protein in infested Mali date cultivar (2.2±0.1). Also, mean crude protein in un-infested Jigawa cultivar (4.0±0.1) was significantly higher compared with infested Jigawa cultivar (2.2±0.1). There was significantly ($P \leq 0.05$) higher mean crude fibre content in un-infested Deglet Noor cultivar (6.7±0.1) compared with infested Deglet Noor cultivar (2.4±0.1). Similarly, mean crude fibre was significantly ($P \leq 0.05$) higher in un-infested Jigawa cultivar (4.9±0.1) compared with infested Jigawa cultivar (1.7±0.1).

Table 2: Proximate composition of three date cultivars infested and un-infested with *O. surinamensis* after 14 weeks

Composition / Treatment	Moisture Mean	Ash	Fat	Carbohydrate	Crude protein	Crude fibre
Jigawa un-infested	12.9^{c}	4.8^{a}	2.9^{a}	74.7^{a}	4.0^{b}	4.9^{b}
Deglet Noor un-infested	14.5^{bc}	3.9^{ab}	2.3^{ab}	74.0^{a}	4.8^{a}	6.7^{a}
Mali un-infested	9.9^{d}	3.7^{ab}	1.6^{bc}	73.9^{a}	4.1^{b}	5.4^{b}
Jigawa infested	16.2^{ab}	2.4^{c}	1.1^{cd}	67.5^{b}	2.2^{c}	1.7^{d}
Deglet Noor infested	18.3^{a}	2.8^{bc}	1.1^{cd}	66.6^{b}	2.8^{c}	2.4^{cd}
Mali infested	14.0^{bc}	3.1^{bc}	0.8^{d}	66.0^{b}	2.2^{c}	2.7^{c}

Means that do not share a letter within a column are significantly ($P \leq 0.05$) different by Tukey's method at 95% confidence interval

4. Discussion

Proximate composition of freshly harvested dates and those kept for 14 weeks in storage without insect infestation

The study showed that dates kept for up to 14 weeks under storage undergo certain nutrient composition changes. There was decrease in moisture content from fresh date samples to 14-weeks old date samples, but increase in the other nutrients, especially carbohydrates. Increased carbohydrate content can be related to loss of moisture which causes a concentration in total sugars. This is in line with the findings of Kader and Hussein (2009), who reported increased sweetness with ripening and prolonged storage of dates which is as a result of increase in total sugars, and in soft cultivars the conversion of sucrose to fructose and glucose. This result suggests that as dates age, they become more attractive to *O. surinamensis* due to high increased concentration of sugars and other nutrients caused by a slight moisture loss. This has been buttressed by Omamor (1988) that high sugar content is partly responsible for insect infestation in dates. Tunio (2002) and Katz (2003) reported reduction in moisture content as most favourable for storage insect pest. Kader and Hussein (2009) have classified dates with <20% moisture as dry.

Proximate composition of infested and un-infested dates

This research had evaluated proximate composition to determine date quality reduction after infestation by *O. surinamensis*. Result showed that date nutrient composition decreased with infestation in all the parameters measured which included ash content, fat, carbohydrate, crude protein and crude fibre, except moisture content, which increased after infestation which is probably as result of insect feeding activities. This is in line with the findings of Jood *et* al. (1995), Kumar *et al*. (1996) and Bamaiyi *et al*. (2007) who reported a reduction in nutritional content of dates, and an increase in moisture content after insect infestation. The increase in moisture content of infested stored dates could be as a result of high relative humidity of the storage environment from where the dates readily absorbed moisture in addition to increased insect metabolic activities. This agrees with the finding of Mallah *et al*. (2016) that food commodities tend to absorb moisture in storage especially after infestation due to insect activities. Other studies corroborate this finding where moisture has been shown to be higher in infested dates than in un-infested ones (Adja *et al*., 2016).

Specifically, the result of the study shows that un-infested dates have higher ash content than infested dates which is probably due to *O. surinamensis* feeding activities. This is in agreement with the findings of Ameh (2006) and Bamaiyi *et al*. (2007) that ash content depletes after insect infestation. Un-infested Jigawa date cultivar shows the highest fat content while Mali cultivar shows the lowest. All un-infested date cultivars gave higher fat content than the infested ones. This could be attributed to feeding activities of *O. surinamensis* and is in line with findings by Reed *et al*. (2007) that date fat content decreases after infestation by insect pests. The high carbohydrate level in Un-infested Jigawa date cultivar explains the reason why it had the highest level of infestation as shown by this study which may be attributed to the fact that *O. surinamensis* is attracted to sugar as reported by Mallah *et al*. (2016) and Sahito *et al*. (2017). Sugar levels were shown to reduce significantly in all infested dates compared with un-infested ones which may be attributed to infestation by *O. surinamensis*. This agrees with the report of Jood *et al*. (1992) that sugar level in commodities decreases after insect infestation and by implication this shows that consuming *O. surinamensis* infested dates deprives the consumer significant sugar content. Crude protein content was highest in un-infested Deglet Noor cultivar and lowest in Jigawa infested and Mali infested date cultivars. Generally, there was a marked depletion of crude protein in all infested date cultivars compared to the un-infested ones in all the date samples considered. *O. surinamensis* feeding activities could easily be fingered as a possible reason for this development. This is in consonant with the findings of Jood and Kapoor (1993) which shows a drop in crude protein content after insect infestation. Fibre content acted in the same way as crude protein where infested dates cultivars show reduced levels than un-infested ones. Reduction in crude fibre content of date after infestation means that the part of the fruit necessary for helping digestion (Al-Farsi *et al*., 2007), preventing constipation (Grigelmo-Miguel and Martin-Belloso, 1999) and coronary heart diseases (Ishida *et al*., 2000) among others is lost.

5. Conclusion

The study showed differences in nutritional composition of fresh dates and 14-weeks old dates that were not infested, where moisture decreased with prolonged storage and carbohydrates and other nutrients increased. This explains a probable reason why prolonged storage of dates makes them predispose to *O. surinamensis* infestation. Also, the study showed that *O. surinamensis* infestation affected stored dates negatively by causing not only quantitative damage to dates, but affecting date quality by reducing their different nutritional components and making them less beneficial to man. The study revealed that the affected nutrients are carbohydrates, ash, fat, protein, and crude fibre which were all reduced by *O. surinamensis* feeding activity. Moisture level however increased after infestation. Deglet Noor and Jigawa date cultivars were the most affected while Mali was the least affected.

References

[1] Adja, N. A., Danho, M., Alabi, T. A.F., Zimmer, J., Francis, F., Gnago, A. J., Kouassi, K. P., Bi, I. A. Z. and Baudoin, J. (2016). Identification and impact of insects feeding on stored seeds of *Lagenaria siceraria* Molina (Standl., 1930) and *Citrullus lanatus* thumb (Matsum and Nakai, 1916), two oilseed curcubits of the Ivory Coast. *American Journal of Research Communication*, 4(2): 104-132.

[2] Akubor, P. I. and Yusuf, D. (2007). Effect of incorporation of date palm syrup on the sensory and physical properties of wheat flour biscuit. *Journal of Applied Sciences and the Environment*, 1: 25-28.

[3] Al-daihan, S. and Bhat, R. S. (2012). Antibacterial activities of extracts of leaf, fruit, seed and bark of *Phoenix dactylifera*. *African Journal of Biotechnology*, 11(42): 1021-1025.

[4] Al-Deeb, M. A. (2012). Lethal time at different temperatures and date variety preference of the saw-toothed grain beetle in stored dates. *Agricultural Sciences*, 3(6): 789-794.

[5] Al-Dosary, N. H. (2009). Role of the Saw-toothed grain beetle (*Oryzaephilus surinamensis* L.) (Coleoptera: Silvanidae) in date palm fruit decay at different temperatures. *Basrah Journal of Date Palm Research*, 8(2): 1-14.

[6] Al-Farsi, M. A. and Lee, C. Y. (2008). Nutritional and functional properties of dates: a review. *Critical Review of Food Science and Nutrition*, 48: 877-887.

[7] Al-Farsi, M., Alasalvar, C., Al-Abid, M., Al-Shoaily, K., Al-Amry, M. and Al-Rawahy, F. (2007). Compositional and functional characteristics of dates, syrups, and their by- products. *Food Chemistry*, 104: 943-947.

[8] Al-Farsi, M., Alasalvar, C., Morris, A., Baron, M. and Shahidi, F. (2005). Comparison of antioxidant activity, anthocyanins, carotenoids, and phenolic of the native fresh and sun-dried dates (*Phoenix dactylifera*) varieties grown in Oman *Journal of Agriculture and Food Chemistry*, 53:7592-7599.

[9] Al-Hafidh, E. M. T., Al-Kawaga, A. A. and Al-Ahad, I. A. (1987). Infestation of date palm varieties by stored

product insects in orchard. *Date Palm Journal*, 5(2): 233-237.

[10] Al-Hooti, S., Sidhu, J. S. and Qabazard, H. (1995). Studies on the physico-chemical characteristics of date fruits of five UAE cultivars at different stages of maturity. *Arab Gulf Journal of Science Researches*, 13: 553-569.

[11] Al-Qarawi, A., Mousa, H. M., Ali, B. H., Abdel-Rahman, H. and El-Mougy, S. A. (2004). Protective of extracts from dates (*Phoenix dactylifera* L.) on carbon tetrachloride- induced hepatoxicity in rats. *International Journal of Applied Research of Veterinary Medicine*, 2:176-180.

[12] Ameh, U. (2006). Standard operating procedure, National Agency for Food and Drug Administration and Control (NAFDAC), Boriki, Port Harcourt, Nigeria. PP 07/14. Heinemann Medical Books Ltd, New York, NY., 122:184.

[13] Anjum, F. M., Bukhat, S. I., El-Ghorab, A. H., Khan, M. I. and Nadeem, M. (2012). Phytochemical characteristics of date palm (*Phoenix dactylifera*) fruits extracts. *Pakistan Journal of Food Sciences*, 22: 117-127.

[14] AOAC (2006). Official methods of analysis. 17th ed. Washington, DC, USA. Association of Analytical Chemists.

[15] Baliga, M. S., Baliga, B. R. V., Kandathil, S. M., Bhat, H. P. and Vayalil, P. k. (2011). A review of the chemistry and pharmacology of the date (*Phoenix dactylifera* L.) fruits *Food Research International*, 44: 1812-1822.

[16] Bamaiyi, L. J., Onu, I., Amatobe, C. I. and Dike, M. C. (2007). Effect of *Callosobruchus maculatus* infestation on nutritional loss on stored cowpea grains. *Arch. Phytopathol. Plant Protect.*, 39(2): 119-127.

[17] Barrow, S. C. (1998). A monograph of Phoenix L. (Palmae: Coryphoideae). *Kew Bulletin*, 53: 513-575.

[18] Beckel, H., Lorini, I. and Lazzari, S. (2007). Rearing method of *Oryzaephilus surinamensis* in various wheat grain granulometry. *Revista Brasileira de Entomologia*, 51(4): 501- 505.

[19] Boukouada, M. and Yousfi, M. (2009). Phytochemical study of date seeds lipids of three date (*Phoenix dactylifera* L.) fruits produced in Ouargla region. *Annales de la Faculte des Sciences et Sciences de I'Ingenieur*, 1:66-74.

[20] Dowson, V. H. W. (1982). Date production and protection with special reference to North Africa and the Near East. *FAO Plant Protection Paper*, 162pp.

[21] Grigelmo-Miguel, N. and Martin-Belloso, O. (1999). Characterization of dietary fibre from orange juice extraction. *Food Research International*, 3: 355-361.

[22] Harold, E., Ronald, S. K. and Ronald, S. (1981). Pearson's chemical analysis of foods, 8th edition. Churchill Livingstone, New York, pp23-232.

[23] Hill, D. S. and Waller, J. M. (1999). *Pests and diseases of tropical crops* Vol. 2, field handbook. Longman Scientific and Technical pp 179-432.

[24] Hodel, D. R. and Pittenger, D. R. (2003). Date palm establishment. *Palms*, 47(4): 191-200.

[25] Ishida, H., Suzano, H., Sugiyama, N., Innami, S., Todokoro, T. and Maekawa, A. (2000). Nutritional evaluation of chemical component of leaves stalks and stems of sweet potatoes (*Ipomoea batatas*). *Food Chemistry*, 68: 359-367.

[26] Jaradat, A. A. (2011). Biodiversity of date palm. Land use, land cover and soil sciences (ed.) in Encyclopaedia of life support systems, UNESCO, Eolss Publishers, Oxford, UK. http://www.eolss.net.

[27] Jood, S. and Kapoor, A. C. (1993). Protein and uric acid contents of cereal grains as affected by insect infestation. *Food Chemistry*, 46: 143-146.

[28] Jood, S., Kapoor, A. C., Ram, S., Jood, S. and Singh, R. (1995). Amino acid composition and evaluation of protein quality of cereals as affected by insect infestation. *Plant Foods for Human Nutrition*, 48(2):159-167.

[29] Jood, S., Kapoor, A. C. and Singh, R. (1992). Biological evaluation of protein quality of maize as affected by insect infestation. *Journal of Agricultural and Food Chemistry*, 40(12): 2439-2442.

[30] Kader, A. A. and Hussein, A. (2009). Harvesting and post-harvest handling of dates. The International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria pp1-6.

[31] Katz, S. H. (2003). Storage of food. *Encyclopaedia of Food Culture* Vol. 3.

[32] Kerin, J. (1994). Opening address. *Proceeding of the 6th international Working Conference on Stored-product Protection*, 17-23 April 1994, Canberra, Australia, 1:14-20.

[33] Khalid, O. A. M., Eldoush, A. K. T., Tag, E. I. M. I., Omar, A., Sidahmed, A., Fakhr, E. A., Hatim, G. M. (2011). Application of plant-based extracts for the control of the green pit scale insect (*Asterolicanium phoenicis* Rao.) with yield enhancement on date palm. *Emirates Journal of Food and Agriculture*, 23(5): 404-412.

[34] Kumar, T. P., Moorthy, S. N., Balagopalan, C., Jayaprakas, C. A. and Rajamma, P. (1996). Quality changes in market cassava chips infested by insects. *Journal of Stored Products Research*, 32(2): 183-186.

[35] Lale, N. E. S. (2002). Stored-product entomology and acarology in tropical Africa. Mole Publication pp. 15-203.

[36] Lorini, I. (2005). Manual tecnico para o manejo integrado de pragas de graos de cereais armazenados. Embrapa Trigo. Passo Fundo. RS, 80pp.

[37] Lunde, P. (1978). A history of dates. *Saudi Aramco World*, 29(2): 176-179.

[38] Mallah, N. A., Sahito, H. A., Kousar, T. Kubar, W. A., Jatoi, F. A. and Shah, Z. H. (2016). Susceptibility of different varieties of stored date palm fruits infested by saw-toothed grain beetle, *Oryzaephilus surinamensis* L. (1758) under laboratory conditions. *Journal of Entomology and Economy Studies*, 4(6): 438-443.

[39] Mason, L. J. (2003). Grain insect fact sheet E-228-W. Cooperative Extension Service. Department of Entomology, Purdue University, West Lafayette.

[40] Mbata, G. N. (1994). Effect of infestation of cultivars of Bambara groundnuts (*Vigna subterranean* (L.) Verde) by *Callosobruchus subinnotatus* (Pic.) (Coleoptera: Bruchidae) on biochemical deterioration and germination of the seeds. *Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz*, 101(4): 350-356.

[41] Omamor, I. B. (1988). Black rot of date fruit: a new post-harvest decay caused by *Botryodiplodia theobromae Date Palm Journal*, 6(1):299-305.
[42] Popenoe, O. (1973). The date palm. Field Research Projects, Miami, Florida.
[43] Popoola, K. O. K. (2013). Application of selected bio-insecticides in management of *Oryzaephilus surinamensis* (Coleoptera: Silvanidae) on *Phoenix dactylifera* (date) fruits. *Nature and Science*, 11(1): 110-115.
[44] Reed. C., Doyungan, S., Loerger, B. and Getchell, A. (2007). Response of storage moulds to different initial moisture contents of Maize stored at 25°C, and effect on respiration rate and nutrient composition. *Journal of Stored Products Research*, 43: 443-458.
[45] Roush, D. K. and McKenzie, J. A. (1987). Ecological genetics of insecticide and acaricide resistance. *Annual Review of Entomology*, 32:361-380.
[46] Sahito, H. A., Mallah, N. A., Kousar, T., Kubar, W. A., Shah, Z. H., Jatoi, F. A. and Mangrio, W. M. (2017). Life table parameters of saw-toothed grain beetle, *Oryzaephilus surinamensis* (L., 1758) on different varieties of stored date palm fruits infested under laboratory conditions. *Journal of Entomology and Zoology Studies*, 5(1): 95-99.
[47] Sudesh, J., Kapoor, A., Ram, S., Jood, S. and Singh, R. (1996). Evaluation of some plant products against *Trogoderma granaruim* Everts in sorghum and their effects on nutritional composition and organoleptic characteristics. *Journal of Stored Products Research*, 32(4):345-352.
[48] Trdan, S., Valic, N., Urek, G. and Milevoj, L. (2005). Concentration of suspension and temperature as factors of pathogenicity of entomopathogenic nematodes for the control of granary weevil, *Sitophilus granaries* (L.) (Coleoptera: Curculionidae). *Acta. Agriculturae Slovenica*, 85(1): 117-124.
[49] Tunio, S. (2002). Grain storage problems in Pakistan. Pakistan and Gulf Economics. www.pakistaneconomist.com/issue200236/i&e4.htm.
[50] Vayalil, P. K. (2012). Date (*Phoenix dactylifera* L.) fruit. An emergent medicinal food. *Critical Review of Food Science and Nutrition*, 52:249-271.
[51] Zabar, A. F. and Borowy, A. (2012). Cultivation of date palm in Iraq. *Annals Universitatis MariaeCurie-Sklodowska Lublin-Polonia*, 22(1): 39-54.
[52] Zaid, A., de Wet, P. F., Djerbi, M. and Oihabi, A. (2002). Diseases and pests of date palm, in: Zaid A and Arias, E. J. (ed.). Date palm cultivation. Rev. 1. FAO Plant Production and Protection Paper 156, Rome, pp227-281.