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The primary aims of peer review are to decide whether or not an article should be published (based on quality and relevance to the journal), and to improve the article before publication. All submissions first go through an internal peer review process: an assigned editor makes an initial decision to accept or to reject the manuscript (e.g. topic is outside the scope of the Journal, important flaws in scientific validity, etc). If the editor believes the article may be of interest, it is sent out for external peer review. The reviewers are selected by area of expertise (reviewers who grant high quality reviews within the requested time are preferred). The editorial board is frequently consulted. Once reviews are obtained, the editor makes a judgment considering the critiques and recommendations from reviewers, and other factors such as relevance to the Journal's aims and usefulness to clinicians or researchers.

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Research Articles

Review Article

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Research Article

Int J Agric Environ Food Sci 2(2):36-43 (2018)

The life tables of *Chrysomphalus aonidum* and *Coccus hesperidum* under laboratory conditions

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Abstract

Numerous species of insect pest have been found causing serious damage to citrus plants in Turkey. *Chrysomphalus aonidum* (L.) (Diaspididae), and *Coccus hesperidum* L. (Coccidae) from Hemiptera among them are potential insect pest, which cause huge economic losses to citrus. The current study investigated life table parameters of both pests, which included net production rate (R_0), intrinsic rate of increase (r_m), mean generation time (T_0), doubling time (T_2), total production rate (GRR) and finite rate of increment (λ). Results showed that net production rate (R_0) of both *C. aonidum* and *C. hesperidum* were 74.001 and 185.295 female/female/offspring, respectively. The intrinsic rate of increase (r_m) for the pests was calculated as 0.052 and 0.047 female/female/day, respectively. Similarly, the mean generation time (T_0) was recorded 82.030 days for *C. aonidum* and 110.985 days for *C. hesperidum*. The doubling time (T_2), gross reproduction rate (GRR), and finite rate of increase (λ) were recorded 13.320 days, 142.555 eggs/female and 1.054 egg/female/day respectively for *C. aonidum* whereas, in case of *C. hesperidum*, the aforementioned values were calculated as 14.732 days, 579.047 eggs/female and 1.048 eggs/female/day, respectively

Keywords: Brown soft scale, circular scale, life table, pumpkin

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Introduction

Citrus is one of the most important fruits with a total production of 130 million tons, which is grown on an area of about 9 million ha throughout the world. China, Brazil and U.S.A. are the major citrus producing countries, whereas Turkey ranks 9th with a total citrus production of 3.7 million tons, grown on area of 127 thousands ha respectively (FAO, 2014). In Turkey, citrus is mainly grown in the Mediterranean, Aegean, South Marmara and Eastern Black Sea Regions, respectively (Durmuş and Yiğit, 2003). About 1.7 million tons oranges in about 55 thousand ha area, about 950 thousand tons mandarins in about 39 thousand ha area, 726 thousand tons lemons in about 27 thousand ha area, 228 thousand tons grapefruits in about7 thousand ha area, and 3 thousand tons other citrus in about 47 ha area are produced in Turkey (TUIK, 2014). About 34 pathogens, 89 pest insects, 16 nematodes, and 155 weed species that causes economic losses or not were determined in citrus orchards of Turkey (Uygun and Satar, 2008; Karacaoğlu and Satar, 2010). Scale insects, whiteflies and aphids are the most important and potential insect pests among all these species, causing economic losses to citrus growers. Scale insects may cause severe economic damage by sucking leaves and fruits of citrus. The feeding damage caused by scale insects in citrus results in poor quality fruit formation, decreasing of the marketing value and may even cause death of the tree (Uygun et al., 2013).

Chrysomphalus aonidum (L.) (Diaspididae) and *Coccus hesperidum* L. (Coccidae) belong to superfamily Coccoidea. Severe economic damage to citrus plants has been reported by both species. These scales are oviparous pests and their eggs are laid under their female's shell. Crawlers hatched from eggs emerge from under the female scale's shell. Afterwards, the crawlers move over to find a suitable site for feeding and then, they settle on feeding site (Uygun et al., 2013). These pests feed on leaves, twigs and fruits and ultimately cut down the fruit quality. Feeding of *C. aonidum* on citrus leads to a dirty appearance on citrus fruits and resultantly lowers the market value of the produce. *C. hesperidum* damages citrus tree by secreting honeydew on leavestwigs, branches and fruits, which leads to the formation of a dark-colored sooty mold, known as fumagine. Thus, plant parts turn on black, and fruits fall down and also, fruit dump is occurred (Kessing and Mau, 2007; Uygun et al., 2013).

Deevey (1947) stated that life table is a systematic analysis of mortality factors occurring in a population.In the current study, some bioecological parameters of both scale insects (*C. aonidum* and *C. hesperidum*), which included incubation times, hatching rates, settled rates of crawlers, sexual indexes, times of preoviposition, oviposition and postoviposition, daily numbers of eggs were observed on pumpkins (*Cucurbita maxima* Jarrahdale and *Cucurbita moschata* Poir. (Cucurbitales: Cucurbitaceae)). Also, life table parameters were calculated to determine some bioecological parameters which may need when these pests are used as prey for mass production of their natural enemies.

Keeping in mind the economic status of citrus in Turkey, the current investigation was therefore, designed to study the life tables of *C.aonidum* and *C.hesperidum* under laboratory conditions.

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Materials and Methods

Breeding of the Scale Pests

Twig parts, leaves and fruits infested with *Chrysomphalus aonidium* and *Coccus hesperidum* were initially collected from citrus farms at Antalya in 2012. Then, these infected plant parts were placed on clean pumpkins in a climatic room with 25±1ºC temperature, 60±5% relative humidity and 16:8 h. (light:dark) photoperiod conditions. Pumpkins(*Cucurbita maxima* and *Cucurbita moschata*)were used as hosts for *C. aonidum* and *C. hesperidum*, respectively. In this manner, contamination of newly hatched crawlers to the clean pumpkins in 28.0x37.2x7.5 cm size plastic trays was provided. Later on, increasing and continuity of scale pest production were ensured by adding new clean pumpkins in the trays.

The identification of *C. aonidum* was kindly performed by Prof.Dr. M. Bora KAYDAN (Çukurova University, Imamoglu Vocational School, Adana, Turkey).

Establishment of Experiments

Eggs laid by female adults on pumpkins infected with the scale pests were transferred to the same kind of pumpkins by gently touching with the tip of the fine paintbrush. The lights of climatic chamber were kept off for 24 hours in order to accelerate the egg hatching process and settlement of newly hatched crawlers (Karaca et al., 1987). Settlement of newly born crawlers on pumpkins was monitored, and afterwards, square cells about 2x2 cm were drawn with Tanglefoot® trademark a special stickem around the settled crawlers on pumpkins. Crawlers in the cells were observed every day, until they became adult and till their death. Each cell was considered as a replicate. Mortality, discrimination of male and female individuals, duration of preoviposition, oviposition and postoviposition of crawlers in the cells were recorded by referencing the age-mate individuals from out of cells on the same pumpkin. After mating of adult female scales, two female scales were left in each cell in experiment related to *C. aonidum*. However, one female scale was left in each cell in experiment related to *C. hesperidum* and the remaining female scales were removed from the cells in both experiments.Later on, newly hatched progenies of mated female scales left in the cells were counted daily. The experiments related to both of *C. aonidum* and *C. hesperidum* were conducted in a climatic chamber set to 25ºC temperature, 60% relative humidity and 16:8 h. photoperiod.

Life Table Analyses

Life table parameters were calculated by using RmStat-3 programmer (Özgökçe and Karaca, 2010). Intrinsic rate of increase (r_m, female/female/day) by taking advantage from Euler-Lotka equation ($\sum e^{(-r_m.x)}\, l_x.m_x = 1$) and net reproductive rate ($R_0 = \sum l_x.m_x$) female/female/offspring), i.e. the mean number of offsprings, which are laid by a female in her lifetime were calculated according to Birch (1948). Where "l_x" is the age-specific survival rate and "m_x," is fecundity rate (female/female) which is computed by multiplying the mean number of offspring by the sexual ratio (Birch, 1948).

Also following parameters were calculated:

Mean generation time (day), $T_o = \frac{\ln R_0}{r_m}$ (Birch, 1948),

Gross reproduction rate (egg/female), $GRR = \sum m_x$ (Birch, 1948),

Finite rate of increase (egg/female/day), $\lambda = e^{rm}$ (Birch, 1948),

Theoretical population-doubling time (day), $T_2 = \frac{\ln 2}{r_m}$ (Kairo and Murphy, 1995),

Reproductive value (female/female), $V_x = \frac{\sum_{y=x}(e^{r_m.y}.l_y.m_y)}{l_x.e^{-r_m.x}}$ Imura, 1987),

Life expectancy (day), $E_x = \frac{\sum_{y=x}\frac{(l_y+l_{y+1})}{2}}{l_x}$ (Carey, 1993; Southwood, 1978),

Stable age distribution, $C_x = \frac{l_x.e^{-r_m.x}}{\sum_{x=0}(l_x.e^{-r_m.x})}$ (Birch, 1948).

Where "x" is the female's age in days, "e" is Euler's number which is a mathematical constant (approximately equal to 2.71828).

Two-parameter Weibull distribution model was used to describe age-specific survival rate (l_x) of the pests (Deevey, 1947; Pinder et al., 1978; Tingle and Copland, 1989; Wang et al., 2000). The parameters of this distribution model were calculated according to the following formula:

$$S_p(x) = e^{\left[-\left(\frac{x}{b}\right)^c\right]} \qquad x, b, c > 0$$

Where "$S_p(x)$" is the probability of survival at x age, "x" is the female's age in days, "b" is a scale parameter and "c" is a shape parameter. The shape parameter of the curve belonged to the age-specific survival rate c>1, c=1 or c<1 correspond to Deevey's (1947) type I, II or III survivorship curves, respectively (Pinder et al., 1978; Tingle and Copland, 1989; Wang et al., 2000). Also, description of the age-specific fecundity rates (m_x) of the pests was performed by Enkegaard regression model (Enkegaard, 1993; Hansen et al., 1999).

$$F_{(x)=a.x.e^{(-bx)}}$$

Where "$F_{(x)}$" is the probability of fecundity at x age (female/female/day), "x" is the female's age in days, "a" and "b" are constant parameters, e: Euler's number which is mathematical constant (approximately equal to 2.71828).

The parameters and the coefficients of determination (R^2) in both models were obtained by using SigmaPlot® (Version 11.0, Systat Software, Inc., San Jose California, USA) package program.

Results and Discussion

Previous study conducted by Serag (1998) on biological cycle of *Chrysomphalus aonidum* reported that mean times of preoviposition, oviposition and postoviposition of the pest were 6.79, 6.38 and 5.56 days, respectively. Similarly, Serag (1998) further stated that the number of daily fecundity was 13.96 eggs/female/day and the number of total fecundity was 88.07 eggs/female. The pest may give 3-6 generations each year (Alkan, 1953; Uygun et al., 2013) and overwinters as the first and secondstage nymphs in Turkey (Tunçyürek and Öncüer, 1974). The mortality rate of *C. dictyospermi* in the first and second nymphal stages due to abiotic factors was 78% in Georgia (Chkhaidze and Yasnosh, 2001) and 40% in Turkey (Tunçyürek-Soydanbay and Erkin, 1981). Salama (1970) suggested that optimum development temperature and relative humidity for this pest was 22-25ºC and 50-58%. The present study demonstrated that adult lifespan of *C. aonidum* was 121 days (Table 1). However, Hlavjenková and Šefrová (2012) reported that *Chrysomphalus dictyospermi* was a devastating pest of ornamental plants in Czech Republic. Also, the further authors stated that sexual index of this pest was 0.82/1 (male/female), hatching time of its eggs was 10 days, and adult lifespan was 62 days, respectively.

Coccus hesperidum deposits its eggs under female scale's shell, and after hatching, crawlers may feed under female's shell for 3-4 days. Later on, the crawlers moved out from mother's shell, 85% of which settle on the food for active feeding in 1-2 days (Serag, 1998). Also in the present study, the crawlers moved out from mother's shell in 2-3 days and then, settled on the pumpkin in 1 day. In additionally, Serag (1998) pointed out that the mean development times of the first and second stage nymphs of this pest were 7.62 and 10.74 days, respectively and total development time of the pest was 41.4 days. Similarly, in the current study, total development time of the pest was recorded as 52.09 days (Table 1). Reed et al. [23] declared that the mean development time was 33 days. Annecke (1959) studied that adult lifespan of *C. hesperidum* was approximately 90-125 days under hot weather conditions, and also it was reported that the development time of this pest was 40-60 days (Gill, 1988; Kosztarab, 1996; Malais and Ravensberg, 2003).

Serag (1998) reported that duration of preoviposition, oviposition and postoviposition were 7.85, 5.61 and 9.59 days, respectively. However, in the present study, durations of these biological stages were calculated as 40.95, 67.72 and 31.38 days, respectively. Kessing and Mau (2007) reported that daily fecundity of *C. hesperidum* was 5-19 eggs per female, and total eggs laid by a female for 30-65 days was 80-250 eggs. The present study found that the daily fecundity and total fecundity were 4.07 eggs/female/day and 579.05 eggs/female, respectively (Table 1).

The net production rates (R_0) of *C. aonidum* and *C. hesperidum* were 73.963 and 246.920 females/female/offspring, respectively. The intrinsic rates of increases (r_m) for the pests were calculated as 0.052 and 0.047 females/female/day, respectively. The mean generation time (T_0) was calculated as 82.030 days for *C. aonidum*, and was determined as 110.985 days for *C. hesperidum*. The doubling time (T_2), total production rate (GRR) and finite rate of increment (λ) were recordedas 13.320 days, 142.555 eggs/female and 1.054 eggs/female/day, respectivelyfor *C. aonidum*. In case of *C. hesperidum*, the aforementioned values were calculated as 14.732 days, 579.047 eggs/female and 1.048 egg/female/day, respectively (Table 2).

Table 1. Mean development times, fecundities and lifespans of *Chrysomphalus aonidum* and *Coccus hesperidum* under laboratory conditions

	Species	N	Mean±SEM
Development time	*C. aonidum*	211	30.00±0.71
	C. hesperidum	65	52.09±0.05
Preoviposition time	*C. aonidum*	121	34.06±0.32
	C. hesperidum	64	40.95±0.22
Oviposition time	*C. aonidum*	121	54.49±0.20
	C. hesperidum	64	67.72±0.48
Postoviposition time	*C. aonidum*	121	2.88±0.07
	C. hesperidum	64	31.38±0.53
Lifespan	*C. aonidum*	121	91.69±2.78
	C. hesperidum	64	140.05±1.86
Generation time	*C. aonidum*	121	65.32±0.15
	C. hesperidum	64	94.05±0.19
Daily fecundity	*C. aonidum*	121	1.54±0.10
	C. hesperidum	64	4.07±0.12
Total fecundity	*C. aonidum*	121	244.46±4.05
	C. hesperidum	64	579.05±17.48

Table 2. Life table parameters of *Chrysomphalus aonidum* and *Coccus hesperidum*

Parameters	*C. aonidum*	*C. hesperidum*
Intrinsic rate of increase, r_m	0.052	0.047
Net reproductive rate, R_0	74.001	185.295
Mean generation time, T_0	82.030	110.985
Theoretical population-doubling time, T_2	13.320	14.732
Gross reproduction rate, GRR	142.555	579.047
Finite rate of increase, λ	1.054	1.048
N	233	150

Curves of the survival rate (l_x), stable age distribution (C_x) and life expectancy (E_x) of *C. aonidum* given in Figure 1. Based on the results, the whole adult females of the pest were died on the124th day of the experiment. The survival rate of the pest began to decrease after the 27th day, and was counted as 0.03 on the 124th day. The stable age distribution shows the relationship between the number of individuals in the current age and the initial number of individuals of an organism. Due to the increase in the number of neonate individuals who participated in the population with the increment of reproductive rate of the population, an increase was seen in the stable age distribution, which was initially 0.06. Thus, the stabile age distribution was reached the top level with 1.00 values on the 124th day, by adding age distribution value at each age. The life expectancy of initially 80.81 values showed a decrease until the 39th day and then, reached the initial value on the 40th day, due to encountered deaths. Afterwards, it showed again a decrease in a fixed manner until the 122nd day, but it could not go back upward as in the 40th day, due to quite low survival as 0.12 proportions (Figure 1).

The generation time of *C. aonidum* was calculated approximately 64 days (Table 1 and Figure 2). The reproductive value of females (V_x) was reached the top level on the 64th day. According to fecundity rate curve, the first egg production was realized on the 64th day, and after this day, fecundity rate was began to decline in proportion to the reproductive value of females (V_x). The maximum daily egg production of the pest was on the 69th day with 3.89 eggs/day, and last egg production was noticed on the 122nd day of the experiment (Figure 2).

The age-specific survival rate (l_x) of *C. aonidum* was described by two-parameter Weibull distribution model. The parameters "b" and "c" of the model was found as 47.55±2.98 and 1.40±0.14 (R^2= 0.62), respectively. Based on these results, it is possible to say that the population of *C. aonidum* had the Type 1 survivorship curve, which means the increasing population type (Figure 3).

The Enkegaard regression model was applied on the age-specific fecundity rate (m_x) of *C. aonidum*, and the coefficient of determination (R^2) was used as suitability criteria of the model on the data (Kontodimas et al., 2004). However, this model could not be obtained satisfactory fit. The parameters "a" and "b" of the model were 0.78±0.07 and 0.07±0.00 (R^2= 0.46), respectively (Figure 4).

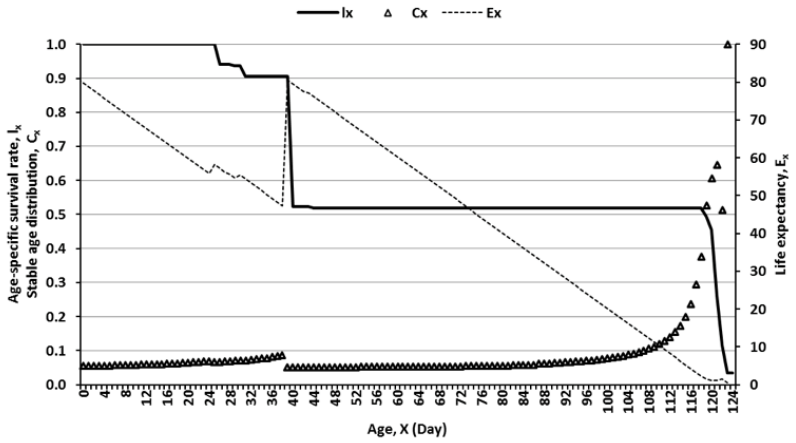

Figure 1. The age-specific survival rate (l_x), stable age distribution (C_x) and life expectancy (E_x) of *Chrysomphalus aonidum* under laboratory conditions.

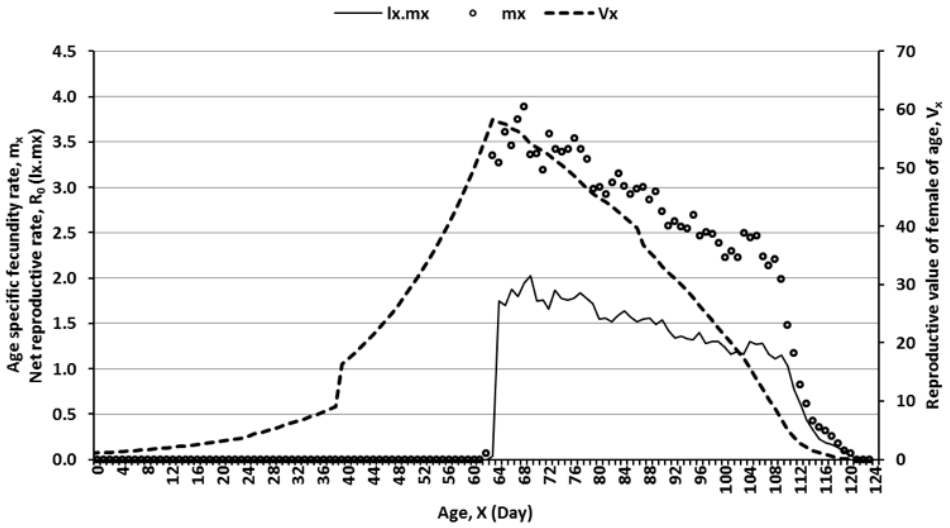

Figure 2. The Fecundity rate (m_x), net reproductive rate (R_0) and reproductive value (V_x) of *Chrysomphalus aonidum* under laboratory conditions.

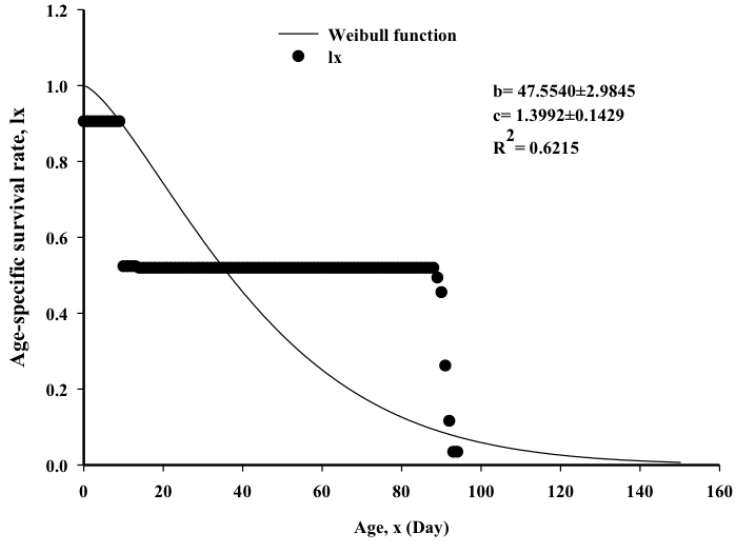

Figure 3. The Weibull function of the age-specific survival rate (l_x) of *Chrysomphalus aonidum*.

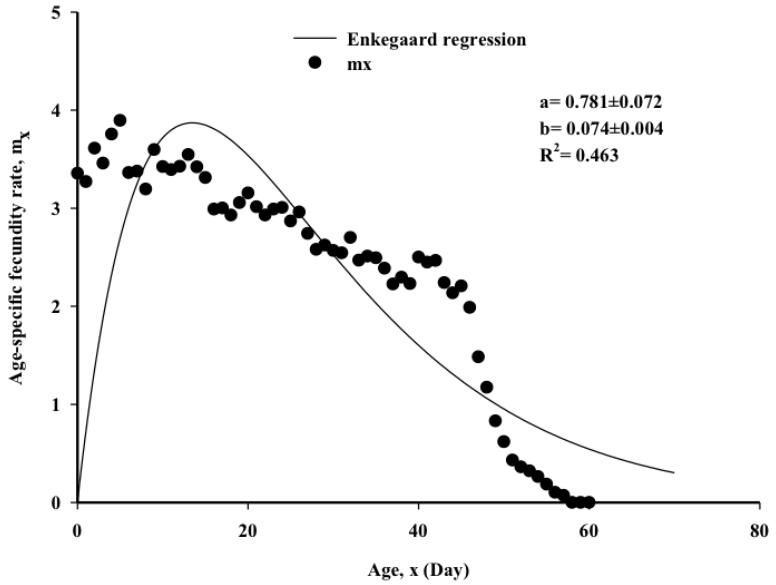

Figure 4. The Enkegaard regression of the age-specific fecundity rate (m_x) of *Chrysomphalus aonidum*.

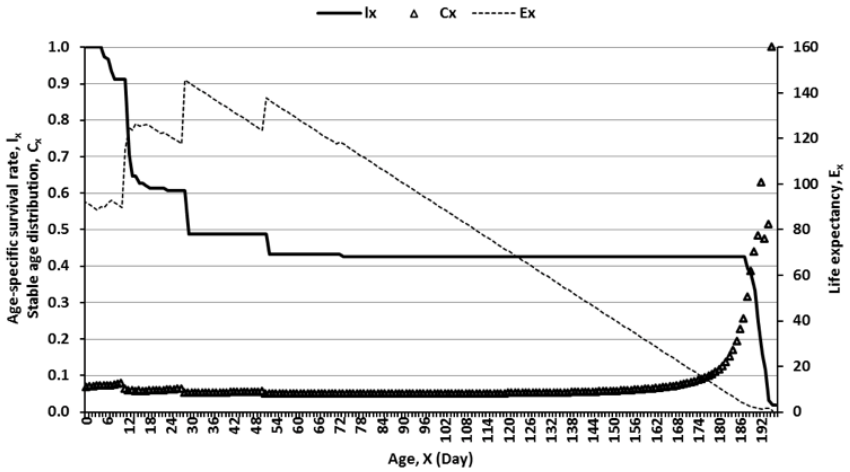

Figure 5. The age-specific survival rate (l_x), stable age distribution (C_x) and life expectancy (E_x) of *Coccus hesperidum* under laboratory conditions

The survival rate (l_x), stable age distribution (C_x) and life expectancy (E_x) of *C. hesperidum* were shown in Figure 5. The survival rate of the pest began to decrease after the 5th day of the experiment and reached the 0.02 proportion on the 196th day. The stable age distribution of initially 0.07 showed an increase after the 149th day of the experiment due to the increase in the number of neonate individuals who participated in the population with the increment of reproductive rate of the population. The life expectancy of initially 92.62 values showed an increment after the 12th day because of encountered deaths and then, reached the highest level on the 29th day with 145.51 values (Figure 5).

The elapsed time from hatching of the pest until the time of egg-laying again after emergence as adult, which means the generation time was approximately 94 days (Table 1 and Figure 6). The reproductive value of females (V_x) was reached the top level on the 94th day. Based on the fecundity rate curve too, the first egg production was realized on the 94th day. Also, the fecundity rate started to decline in parallel with the reproductive value of females (V_x) after this day. The pest reached the maximum level of daily fecundity rate on the 96th day with 18.28 eggs per day (Figure 6).

The age-specific survival rate (l_x) of *C. hesperidum* was described by two-parameter Weibull distribution model. The parameters "b" and "c" of the model was found as 38.72±4.22 and 0.81±0.08 (R^2= 0.45), respectively. Based on the coefficient of determination (R^2), the Weibull model could not be obtained satisfactory fit. However, although the low coefficient of determination, it is possible to say that the population of *C. hesperidum* followed a decline trend due to the high residual sum of squares (RSS= 61.98) of this model (Figure 7).

The parameters "a" and "b" of the Enkegaard regression model applied on the age-specific fecundity rate (m_x) of *C. hesperidum* were 3.71±0.31 and 0.09±0.00 (R^2= 0.70), respectively. Based on the coefficient of determination (R^2), the Enkegaard regression model could be obtained satisfactory fit (Figure 8).

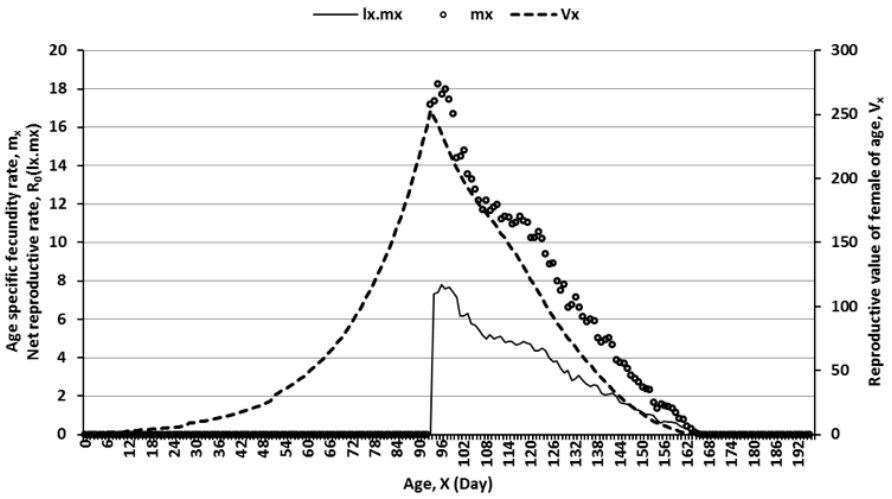

Figure 6. The Fecundity rate (m_x), net reproductive rate (R_0) and reproductive value (V_x) of *Coccus hesperidum* under laboratory conditions.

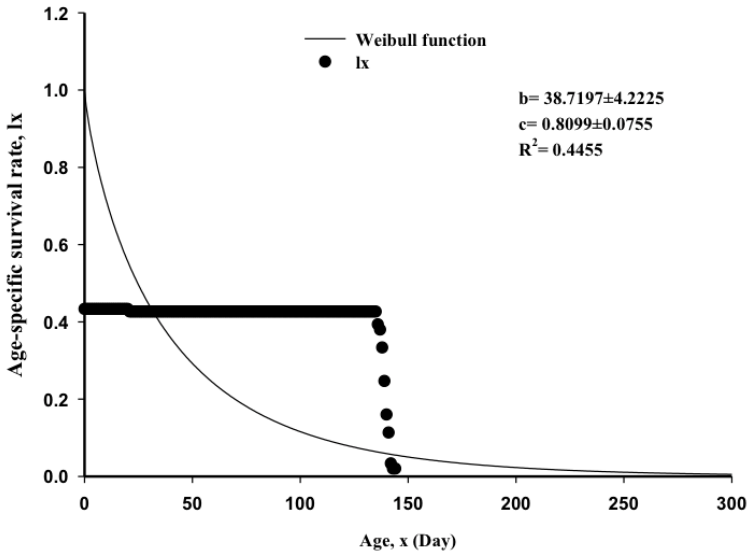

Figure 7. The Weibull function of the age-specific survival rate (l_x) of *Coccus hesperidum*.

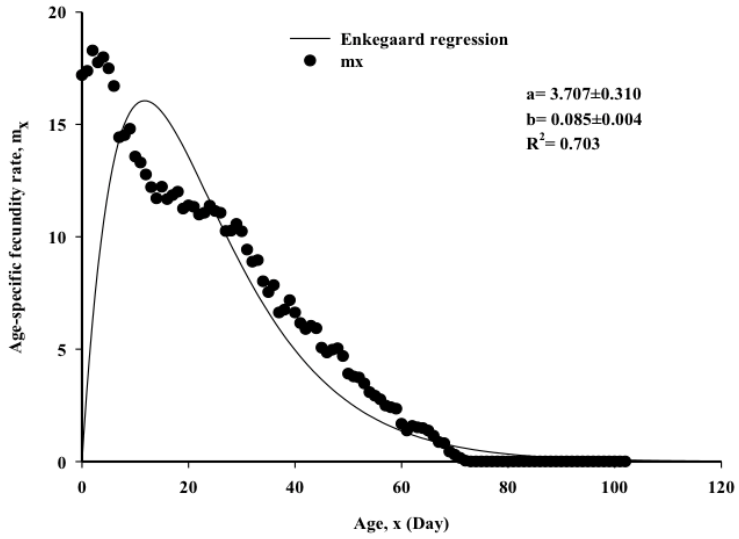

Figure 8. The Enkegaard regression of the age-specific fecundity rate (m_x) of *Coccus hesperidum*.

The present study found some bioecological characteristics of both *C. aonidum* and *C. hesperidum*. Based on the Weibull function of the age-specific survival rate (l_x) of *C. aonidum*, the population level of this pest followed an increase trend. According to our results, it is understood that the pest has a potential to be a feasible prey in the production of beneficial insects in terms of time and economic. Also, population level trend during mass production of this pest under laboratory conditions can be assumed by using this obtained Weibull distribution model. In additionally, fecundity level of the pest in oviposition period was simulated by the Enkegaard regression model.

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Identification of bioactive peptides in kashar cheese and its antioxidant activities

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Abstract

This study analyzed the peptide profile and antioxidant activity in commercially sourced Kashar cheese. The antioxidant activity of Kashar cheese was found to be 41.09 mM Trolox g−1. However, the antioxidant activity of its F3, F4, F5 and F14 fractions was found to be 920.726 mM Trolox g−1, 545.544 mM Trolox g−1 , 783.864 mM Trolox g−1, and 392.12 mM Trolox g−1, respectively. In Kashar cheese, the Tandem Mass Spectrometry (MS/MS) spectrum for the 875 g mol−1 m/z signal was matched to αs1-casein, and it showed that 1012 g mol−1 (875+137) histidine can be a part of 1140 (1012+128) glutamine amino acid. Peptide sequences were matched to 875:RPKHPIK-H-Q peptide 1012:RPKHPIK+H peptide and 1140:RPKHPIKH+Q peptide. It can be concluded that the peptide fractions of Kashar cheese demonstrated antioxidant activity.

Keywords: Bioactive peptides, kashar cheese, antioxidant activity

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Introduction

Kashar cheese is a type of cheese that is boiled in hot water and kneaded after its curd has become acidized to a specific level. It is included in the semi-hard "pasta filata" group (Ucuncu, 2008). Kashar cheese is the most widely produced and consumed type of cheese in Turkey after Beyaz cheese (Cetinkaya and Soyutemiz, 2006; Urkek, 2008).With its 80,000 tons of production per year, it is the most widely consumed type of cheese with a semi-hard characteristic in Turkey. In terms of its production and components, it resembles Caciocavallo, Provolone, Mozzarella and Kashkaval cheeses (Turhan and Oner, 2015).

Generally, Kashar cheese is produced from raw milk, and the ripening process is important in determining its features. Many biochemical events occur during ripening, and these biochemical events need to occur properly during the ripening period to deliver a cheese output with unique quality characteristics (Ozturk, 1993).

Proteolysis is the breakdown of the proteins, and this is the most complex biochemical event that occurs in cheese during the ripening period (Mc Sweeney, 2004). Proteolysis plays a vital role in the development of textural changes in cheese curd; it contributes to the flavour and it may also have an effect on the off-flavour (bitterness) of cheese through the formation of peptides and free amino acids (FAA) (Law and Goodenough, 1995). FAA are the final products of proteolysis, their concentrations depend on the cheese variety and they have been used as ripening indices (Mc Sweeney and Fox, 1997a; 1997b).

Bioactive peptides have been isolated from cheese, yoghurt and fermented foods. They are released from protein molecules by enzymatic hydrolysis (Korhonen, 2009).

There are no studies on the characterization of peptides in Kashar cheese, whereas there are many investigations on the specific activities of bioactive peptides in different cheeses, such as antimicrobial antioxidant, anticancer and antihypertensive activities (Saito et al., 2000, Gomez-Ruiz et al., 2006; Silva and Malcata, 2005; Ong et al., 2007). Mass spectrometry has been employed for characterizing the proteins of different milk species (Bernardi et al., 2015), and to identify peptides in artisan or industrial Manchego cheese and Cheddar cheese (Karametsi et al., 2014; Gomez Ruiz et al., 2004). Mass spectrometry has also been employed to identify peptides in cheese.

In this study, three commercially sourced Kashar cheeses were investigated to determine their peptides and the antioxidant properties of those peptides. Peptides were separated using High Performance Liquid Chromatography (HPLC) and identified by peptide sequencing after MALDI-TOF MS/MS fragmentation.

Materials and Methods

Cheese samples

The samples of cheese were provided by a producer using traditional techniques to produce Kashar cheese in the Kars region. The cheese samples were maintained under refrigeration at 4ºC for 90 days. Peptide analyzes were carried on day 1 and on day 90. The cheeses were sampled three times, and analyses were duplicated.

The Kjeldahl method was used to produce 12% (v/v) trichloroacetic acid-soluble nitrogen (TCA-SN) and 5% (v/v) phosphotungstic acid-soluble nitrogen (PTA-SN) (IDF 1993).

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The total free amino acid levels were determined by the previously published method of Folkertsma and Fox (1992).

Extraction of Kashar peptides

To obtain bioactive peptides, cheese samples were prepared according to Donkor et al. (2007). Sixty grams of grated (commercial Kashar cheeses A, B and C) cheese were homogenized in 180 mL of distilled water and then centrifuged at 100 rpm at a temperature of 40°C. After centrifuging at 4000 rpm and 4°C for 30 minutes, the supernatant was again centrifuged using the same conditions. Following this step, the centrifuged samples were filtered through a roughing filter and the cheese samples were lyophilized (freeze dried). These lyophilized samples were dissolved in 0.1% trifluoroacetic acid (TFA) at a rate of 0.2 g $5mL^{-1}$, centrifuged at 14000 rpm at a temperature of 4°C for 30 minutes and then filtered through a 0.45 µm diameter filter to prepare them for chromatographic analyses.

Separation of water soluble peptides by reversed-phase chromatography (RP-HPLC)

The analysis of water-soluble peptides in cheese was carried out with reversed-phase (Shimadzu LC-20 AT series) HPLC and a Zorbax 300 SB-C8 monomeric column (250 × 9.4 mm i.d., 6.5 µm particle size and 300 A^0 pore diameter, Agilent, Waldbronn, Germany). The samples were dissolved in 0.1% TFA at the rate of 0.2 g $5mL^{-1}$, and 750 µL were injected into the HPLC column by filtering it through a 0.45 µm diameter filter. The peptides were eluted over a linear gradient from 100 to 0% solvent A (0.1% trifluoroacetic acid in deionized water) in solvent B (0.1% trifluoroacetic acid in 90% (v/v) acetonitrile in deionized water) over 80 minutes.

Analysis of peptide sequence

The SDS-PAGE technique and molecular sizes of the peptides obtained were determined according to Sambrook and Russell (2006). SDS-Polyacrylamide Gel Electrophoresis was performed by using a Mini-Protean® Tetra Cell from the Bio Rad Company and the procedure was carried out first at 60 volts for 30 minutes and then a 100 volts for 2 hours. It was dyed with Jeller Coomassie Brilliant Blue G-250 (Mitra et al., 1994). The peptide mixture purified from salts with ZipTip was observed by mixing it with a matrix solution (Dai et al., 1999).

The MS/MS spectrums, created by the fragments of the signals with sufficient MS/MS intensity, were obtained by the collision-induced dissociation (CID) method using argon gas in the LIFT mode (Suckau et al., 2003).

Determination of antioxidant activity

The antioxidant activity of either WSE, or the isolated peptides from them, was assayed according to the method described by Re et al., (1999). 2,2′-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical cation (ABTS+) was produced by the reaction of 7 mM of ABTS stock solution with 2.45 mM of potassium persulfate (final concentration in 10 mL of water) and keeping the mixture in the dark at room temperature for 12 to 16 hours before use.

Scavenging of the ABTS+ radical was observed spectrophotometrically (UV-1601, Shimadzu, Kyoto, Japan) by monitoring the decrease in absorbance at 734 nm. A reading was taken 1 minute after initial mixing and then periodically up to 6 minutes. A solvent blank was run in each assay (negative control). All procedures were carried out in triplicate, and their average was used as a datum point. The percentage inhibition of absorbance at 734 nm was calculated and plotted as a function of the concentration of antioxidants, and of the Trolox standard. To calculate the Trolox equivalent antioxidant capacity (TEAC), the gradient of the plot of the percentage inhibition of absorbance versus the sample concentration was divided by the gradient of the plot for Trolox to give TEAC at a specific time.

Statistical analysis

SPSS software for Windows (SPSS Inc., Chicago IL, USA) version 18 was used for statistical analysis of the Kashar cheeses and the corresponding sample replications. The Duncan test was used for comparison of the means.

Results And Discussions

Proteolysis of Kashar cheese

The nitrogen fractions are important parameters in the determination of the extent of proteolysis. The average fractions of nitrogenous compounds in Kashar cheese are presented in Table 1. Nitrogenous compounds increased significantly ($P < 0.05$) during storage. The 12% (v/v) TCA-SN fractions contain small peptides which were free amino acids, between two to twenty amino acid residues, ammonia and other minor compounds. The 5% (v/v) PTA-SN indicated the levels of small peptides to be <600 to 700 g mol^{-1} (di-, tri- and tetra- peptides) and free amino acids. For the cheeses, the soluble nitrogen content was expected to increase with the time of cheese ripening.

Total free amino acids were determined by the spectrophotometric method. The free amino acid content (FAA) changed from 0.45 to 4.9 mg Lys 100 g^{-1} during ripening ($P < 0.05$). The trends in the levels of total FAA in the cheeses were in agreement with the PTA-SN values.

Table 1. Fraction of nitrogenous compounds in Kashar cheese

	WSN	TCA –SN 12%	PTA-SN 5%	RI %	FAA mg Lys/ 100g
1st day	0.133±0.04	0.122±0.03	0.025±0.03	7.18	0.45
3.month	1.260±0.004	0.434±0.003	0.048±0.001	52.86	4.9

WSN:Water soluble nitrogen; TCA-SN:trichloroacetic acid-soluble nitrogen; PTA-SN: phosphotungstic acid-soluble nitrogen; RI: Ripening index; FAA: Free Amino Acid content

Results for RP-HPLC of cheese samples

To monitor the changes in peptide profiles during the storage of the water soluble extract (WSE) of cheese, WSE from day 1 and day 90 of storage were analyzed by RP-HPLC. Figure 1 and Figure 2 show the RP-HPLC profiles obtained from day 1 and day 90 of the cheese WSE. The peak number and peak height provide important knowledge about the ripening of cheese and proteolysis. The chromatograms of the cheese samples had different peaks (Fig. 1–2). The peaks for month 3 of the Kashar cheese samples had the highest amount of peptide peaks. The peaks increased in height significantly, changing the chromatographic profile.

Antioxidant activity in Kashar cheese

Antioxidant activity was determined using the ABTS method. In the ABTS method, the ability of the sample to quench a radical is measured. Caseins potentially have a high content of antioxidative amino acids such as tyrosine, tryptophan and lysine. The ABTS method is a sensitive and appropriate method for the measurement of antioxidant activity in cheese (Apostolidis, Kwon and Shetty, 2007).

ABTS radical scavenging values, the reported % inhibition value and TEAC (free radical and superoxide anion scavenging activity) were noted. Antioxidant activity was found to be 41.09 mM g^{-1} Trolox in the Kashar cheese. In terms of antioxidant activity, a significant difference was observed between day 1 and day 90 of storage ($P < 0.05$).

Fractions were collected at 10-minute intervals, and their TEAC values were obtained from the capacity of each sample to scavenge ABTS to Trolox, and the results were given in mM g^{-1} of Trolox of protein. The 3rd, 4th, 5th and 14th fractions with high values (Fig.2) were lyophilized, and the TEAC values of the fractions were examined. The fractionated peptide extracts were analyzed for antioxidant activity. Three different ratios of peptide extract (30, 40 and 50 µL) to ABTS were examined to determine if the percentage of inhibition increased with higher concentrations of peptide. The inhibition value percentages of the fractions collected before lyophilization were examined, and the results are given in Figure 3. The 3rd fraction showed (920.72 mM Trolox g^{-1}) the highest activity. The antioxidant activity of the peptide fractions are shown in Figure 4. The changes in the antioxidant activity of fractions were related to the rate of proteolysis in all the samples of cheeses up to the third month of ripening. In this study, when the proteolysis was compared with antioxidant activity, it was observed that changes in the antioxidant activity correspond to the rate of creation of proteolysis in the Kashar cheeses.

Other researchers have showed that similar Kashar cheese (cheddar cheese) has antioxidant activity and their activity was dependent on the ripening stage of the cheese (Apostolidis et al., 2007; Gupta et al., 2009; Pritchard et al., 2010; Meira et al., 2012). Biochemical processes were occuring in proteins during cheese ripening by hydrolysis of casein, by rennet activity, by plasmin, lactic acid bacteria and nonstarter bacterial proteinases (Mc Sweeney, 2004; Sousa et al., 2001).

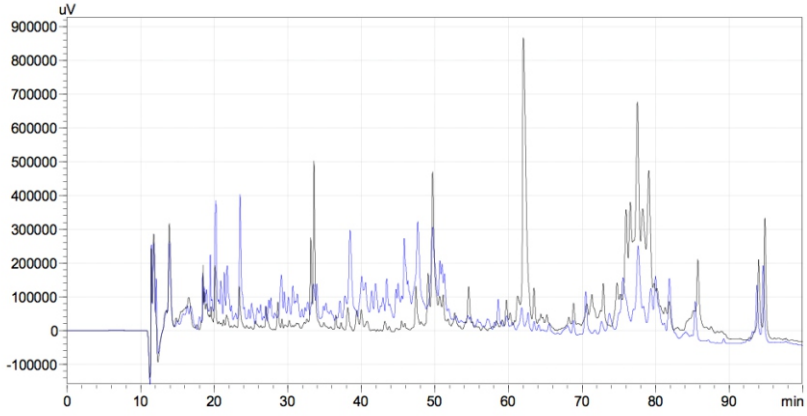

Figure 1. Shows the chromatogram of peptide in Kashar cheese 0- 3rd months. Blue peak: 0.month (1st day), Black peak: 3rd month of Kashar cheese

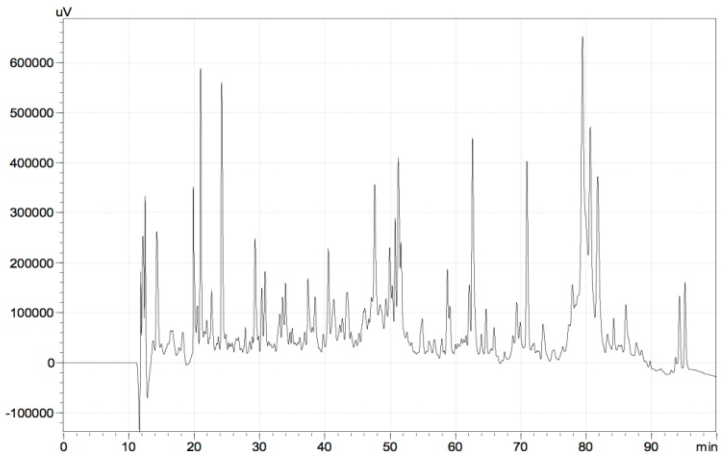

Figure 2. RP-HPLC chromotogram peaks of kashar cheese

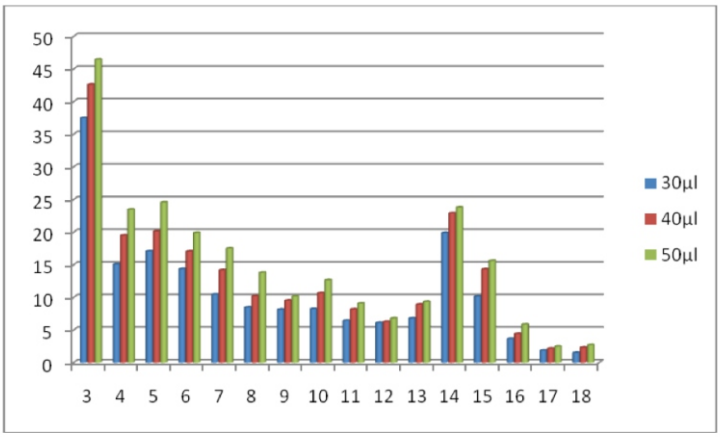

Figure 3. Inhibition ratio of water soluble extract of kashar cheese fraction collected by RP-HPLC

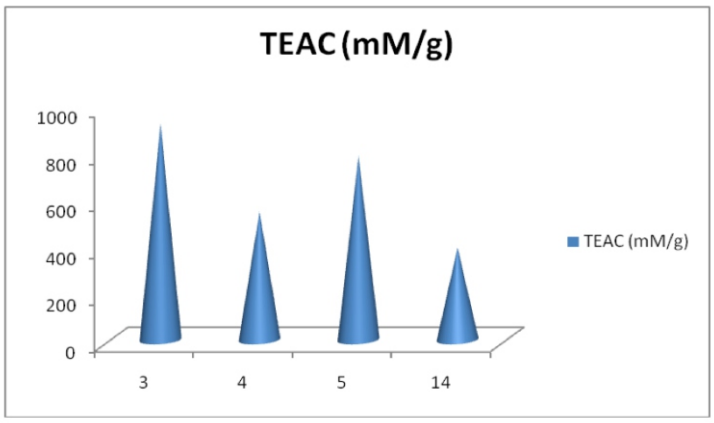

Figure 4. Antioxidant activity (TEAC) expressed as mM g^{-1} of Trolox of Kashar fractions which have higher inhibition activity

Peptide extraction of Kashar cheese and sequence analysis

After the chromatograms of the Kashar cheese had been taken, MALDI-TOF MS-MS was applied for peptide sequence analysis of the F3 and F5 fractions depending on the antioxidant activity results. Whether the samples contained peptides was determined by the one-dimensional SDS-polyacrylamide gel electrophoresis (1D SDS-PAGE), and MS spectrums were obtained by washing with ZipTip. Mascot database scanning was used. The MS/MS spectrum of 875 g mol^{-1} m/z signal matched up to α_{s1}-casein, and it showed that 1012 g mol^{-1} (875+137) histidine can be a part of 1140 (1012+128) glutamine amino acid. Peptide sequences were matched to 875:RPKHPIK-H-Q peptide 1012:RPKHPIK+H peptide and 1140:RPKHPIKH+Q peptide.

A similar case was observed in the 5th Kashar fraction for the 1535, 1664 and 1763 signals. The difference between the 1535 and 1407 signals corresponds to 128, which is the mass of lysine or glutamine amino acid; the difference between the 1664 and 1535 signals corresponds to 129, which is the mass of glutamic acid amino acid, and the 99-dalton difference between the 1763 and 1664 signals corresponds to the mass of valine amino acid. When the MS/MS spectrums of these signals were compared, the presence of some similarities strengthened the probability that one missing amino acid /extra peptide signal of the same peptide sequence was seen in the MS spectrum.

1D SDS-PAGE method was used Testing whether the samples contained protein was based on in-gel screening using the. For the peptide analysis, the highest number of peptide signals was observed with ZipTip, and the MS/MS spectrums were obtained by digesting those in sufficient amounts. Results within a confidence interval were not obtained from the Mascot database scanning, and since the sources showed similarity with that of the specimens (milk, α_{s1}-casein), the probability of matching within a confidence interval being true is in question. This similarity is the MS/MS spectrum of 875 g mol^{-1} m/z signal encountered in the Kashar 3 fraction samples. The 1012 g mol^{-1} (875+137) and 1140 (1012+128) g mol^{-1} m/z signals observed in the same spectrum can be an addition to the peptide N-terminal of histidine (137) amino acid and the continuing terminal of glutamine amino acid [18]. When it is compared by overlapping the digestion spectrums, the similarity shown strengthens this possibility (Figure 5).

875:RPKHPIK>gi|999048|gb|AAB34797.1| α_{s1}-casein A long form [ovine, skimmed milk, Peptide, 199 aa]
RPKHPIK-H
QGLSSEVLNENLLRFVVAPFPEVFRKENINELSKDIG
SESIEDQAMEDAKQMKAGSSSSSEEIVPNSAEQKYI
QKEDVP
SERYLGYLEQLLRLKKYNVPQLEIVPKSAEEQLHSM
KEGNPAHQKQPMIAVNQELAYFYPQLFRQFYQLDA
YPSGAWYYLPLGTQYTDAPSFSDIPNPIGSENSGKIT
MPLW
1012:RPKHPIK+H
1140:RPKHPIKH+Q

A similar case is observed in the 1535, 1664 and 1763 signals in the Kashar 5 fraction sample (Figure 6). The difference between the 1535 and 1407 signals corresponds to 128, which is the mass of either lysine or glutamine amino acid; the difference between the 1664 and 1535 signals corresponds to 129, which is the mass of glutamic acid amino acid, and the 99 g mol^{-1} difference between the 1763 and 1664 signals corresponds to the mass of valine amino acid. When the MS/MS spectrums of these signals are compared, the presence of some similarities strengthens the probability of observing one missing amino acid /extra peptide signal of the same peptide sequence in the MS spectrum. However, these results are empirical and not reliable since they do not match within a confidence interval for the database scan. Thus, they are only considered as a probability at this stage.

Proline and histidine showed lipoprotein peroxidation inhibiting peptide activity. The properties of these amino acids may be explained by phenolic and indol groups (Hernandez et al., 2005).

Conclusions

The results have shown that Kashar cheese and its peptide fractions demonstrated antioxidant activity. The Kashar cheese was matured for three months; therefore bioactive peptides may have been created during this time. It was found that Kashar cheese has some bioactive peptides. Further studies are now in progress to determine the peptides and identify the exact amino acid sequences conferring the bioactivities, which could enable the synthesis and purification of bioactive peptides for their application in food production and pharmaceuticals.

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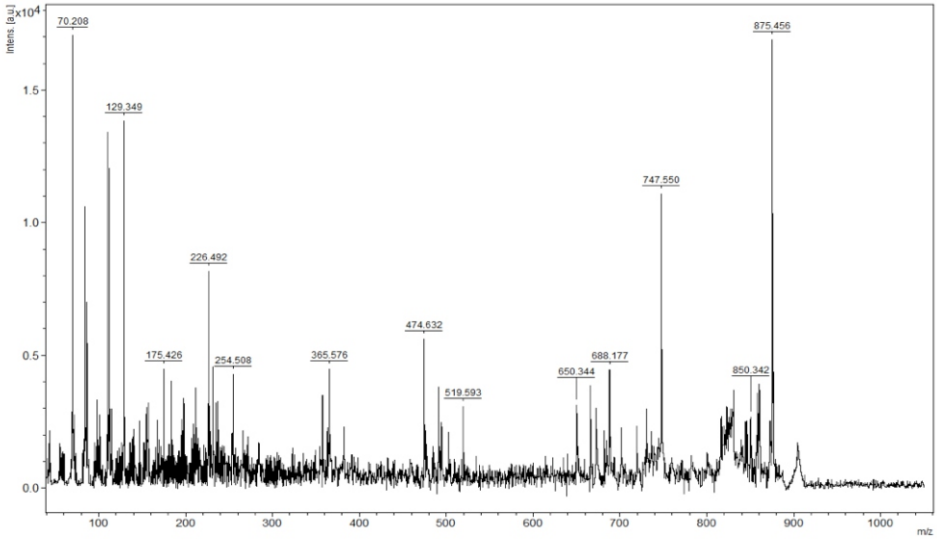

Figure 5. Kashar 3-875

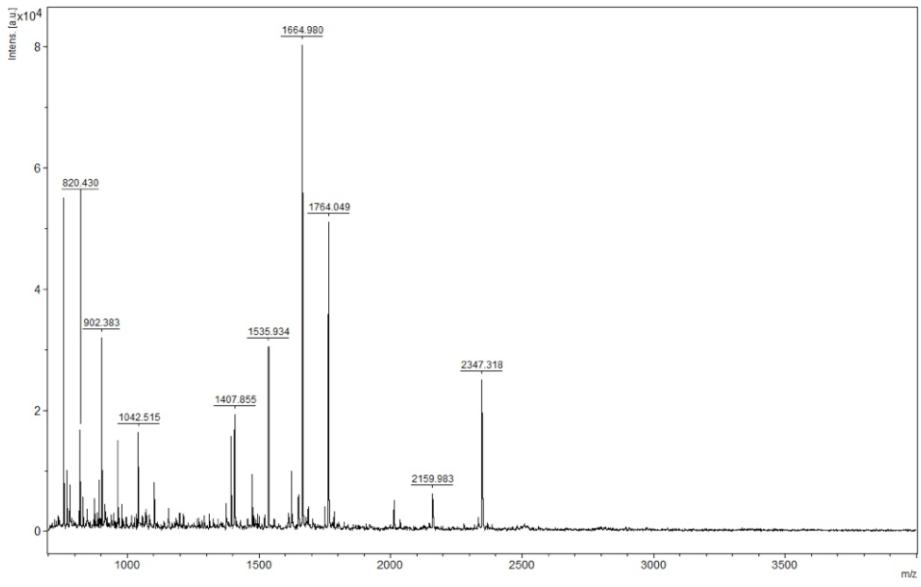

Figure 6. Kashar 5-Ziptip

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Research Article

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The design, fabrication and performance evaluation of solar sustained batch type maize dryer for valuation addition

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Abstract

Drying is the taking away of water from agricultural product thus at the same time provide extended period of shelf life. In this study, an innovative solar sustained maize dryer along with screw conveyor for unloading the grain and central air perforated duct (throughout aeration chamber length) has been developed. High drying rate was achieved due to central air distribution model of the dryer during the drying process. Using 758-kg of freshly harvested maize at moisture content 24% (wet basis), dryer was evaluated. The average aeration rate of the solar sustained maize dryer was 3.67 kilogram per hour. 60% saving in drying time was also achieved by using the solar sustained maize dryer. From 24% to 13% moisture content for drying the whole maize, solar sustained maize dryer took 27 hours. It is economical and environment friendly drying method. Cost analysis was also done and it was found by using this drying method, at very low cost we can dehydrated better quality maize. At community level, marketable size of the solar sustained maize dryer can be better and formed for revolution of agriculture in the country-side areas.

Keywords: Moistness, aeration rate, even drying, central air perforated duct model

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Introduction

Due to ruthless global industrialization energy demand is constantly growing. For most of the world fossil fuel remains the main source of energy; however, consumption is harming the environment and reserves are diminishing. Heating process requires burning of extensive fossil fuels. Due to increasing energy demand and severe energy crises, alternate energy resources such as Solar Energy is used to minimize the load from the fossil fuels.

In Pakistan mean global solar irradiation ranges between 200-250Wm^{-2} per day. It is equal to 1,500-3,000 sunshine hours per year. Pakistan is receiving on an average 5.3 kWh m^{-2} per day. Pakistan lies between longitude 62.0 and 75.0 degree east and latitude 24.0 and 37.0 degrees north. Pakistan is located ideally to get maximum available solar radiation and possess abundant capacity to overcome its energy crises.

Solar energy is used by the solar air heaters to heat air and it can be engaged in many applications demanding moderate to low temperature lower 60°C, for example heating of spaces and drying of fruits vegetables and crop material (Kurtbas and Turgut, 2006).

Drying is the taking away of water contents from agricultural product. The drying carries out in two processes. In first process, the vaporization of moisture hooked on the atmosphere from surface of the substance at stable rate of drying. In second process, drying rate decreased because drying rate decreases with moisture content or decreases with increases in air humidity. Solar dryers are the machines that organize the drying practice and prevent the agriculture product from destroy by insect pest, rain and dust. Grains are the main food items in agriculture. Grains like maize, wheat and rice are accounted for 43% of all food calories and 87% of all grain production Worldwide. Maize is the most consumed food in the World. Over 42% of the world's population depends on maize to fulfill its food requirements. About 87% of the whole output of maize is consumed and produced in developing countries (FAO, 2002).

Hanif et al. (2012) designed and developed the solar collector for air heating and evaluated the energy requirements for the drying of grains. Blower was used to thrown the air that strike with the grains. With the bin in which grains were kept solar collector was joined. Solar collector 6m in length, 4 m in width and 0.3 m in depth. The material used for absorber plate was steel metal sheet. For glazing a single glass with 6 mm thickness was used. They used plywood as an insulating material for the body of the solar collector. They were tested the performance at seven different convective air flow rates. They found that drying efficiency of solar collector was 10% higher than all previous conventional methods. Statistical analysis was also done to check the performance of solar collector and showed that the flow rate of hot air increased the performance of solar collector (Hanif et al., 2012).

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Pakdaman et al. (2011) designed and develop the natural convection air solar heater and evaluated the performance of this system. On absorber plate, rectangular fins were mounted. The objective of this study was to achieve an empirical model for natural convection solar air heaters which forecasts several important features. In this study Nusselt number correlations for such devices were also obtained. Maximum efficiency for the system were also determined through exergy analysis. Solar collector frame 2000 mm in length, 1000 mm in width and 150mm in depth. The material used for absorber plate was black tinted galvanized-iron with a thickness of 1 mm. A total of 46 rectangular fins was 20 mm apart from each other which were attached to the absorber plate. The dimensions of attached fins were 2000x10mm with a thickness of 1 mm. For glazing a single glass cover with a thickness of 4 mm was used. It was concluded that heat transfer rate enhanced by longitudinal rectangular fin arrangement of air solar heaters. In this study, the heat transfer was increased by 20% approximately whereas heat transfer area was increased by 66%.

Soysal et al. (2009) compared the drying methods of microwave by air and commercial drying. The main purpose was to establish favorable drying conditions for good quality products. The main quality parameters were color and stiffness as well as sensory analysis for overall acceptance. They used to microwave dryers for drying actions. The output power for both microwave dryers was 597.20W and 697.87W. Two different modes like continuous and intermittent were used for actions in microwave dryers. The continuous mode showed power result of drying time as compared to commercial drying. Whereas the intermittent type showed good result of drying as compared to commercial dryer. So, they concluded that convective microwave uses 35^0 C - 38^0 C temperature and use 597.20W of energy of drying method was gentle also. They also resulted that products were good in quality like in color and teste.

Zomorodian et al. (2007) designed, fabricated and evaluated solar drier of semi-continuous type for cereals (Maize, etc.). Active mode type maize dryer was efficient timer assisted semi-continuous discharging system. The dryer consisted of: an inlet bin, an outlet bin and a plenum chamber and a drying chamber ended with a discharging valve. Mass flow rate and discharge interval time was the two parameters on which they conducted an experiment. They evaluated the drier capacity, efficiency of collector and overall efficiency of the drying. They found that 21.24% maximum overall efficiency of drying with 55^0 C of temperature. The dryer drying capacity was about, maize of 132 kg with MC 27% (d.b) dried to 13% (d.b) final MC in 3 h of drying time. Keeping in view the above stated problems of energy crisis and the opportunity of utilizing solar energy potential in Pakistan, this research was focused on design and fabrication of the solar sustained batch type maize dryer.

Methodology

To develop a solar sustained maize dryer for farm practices on farm, the subsequent possessions and parameter were calculated.

Design Process and Scheming

For the development of solar sustained batch type maize dryer, the dimensions of the dryer were calculated with the bulk density of the maize grain. The drying temperature was established by using ambient temperature. For the better aeration without evolving the stresses inside the maize the maximum temperature calculated. Relative humidity and mean average temperature is 70% and 29 ^{0}C respectively. The maximum drying temperature was maintained up to 45 ^{0}C for the drying of maize. With the assistance of grain moisture meter initial and final moisture content for the harmless storing of maize was measured that was 24% (w.b) and 13% (w.b) respectively. From the psychometric chart others intended values like moistness, enthalpy and air movement rate was resolute. The subsequent possessions and parameters were resolute for the designing purpose.

Initial Moisture Content of Maize

Initial moisture content of the maize was resolute to find the total of water required to take away from maize. Sample grains was dried in an electric oven for 16 hours at 130 ^{0}C (Ratti, 2001). When sample achieved the constant weight then the sample was taken out from oven and permitted to air quiet. By using the electric balance, the weight of sample was measured. By using Eq.1 moisture content was determined.

$$M.C = \frac{w_1 - w_2}{w_1} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.1)$$

Bulk Density

Bulk density of a material is the mass per total volume of the material. The bulk density of maize was about 824 kg/m^3.

Design of Aeration Compartment

Bola et al. (2013) designed the aeration compartment with the expectations that; formation is cylinder-shaped and mass of maize is 758 kg. Maize bulk density was about 824 kilograms per m^3. So, 1 kilogram's maize inhabits 0.00123 m^3 and 758 kilograms will inhabit 0.92 m^3.

The volume of drying chamber was 0.92 m^3. Since the extents of cylinder-shaped aeration compartment was calculated using equation given as above and were found to be 1.240 m in height and 0.94 m in diameter. At the bottom of the cylinder cone was also mounted which is 0.23 m in height and 0.94 m in diameter.

Mass of moisture to be removed

By using the Eq.3 we can find quantity of moisture required to take away from the maize which is intended as (Henderson and Perry, 1980).

$$M_w = \frac{W(Mo-Mf)}{Mo} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.2)$$

Where,

M_w = Quantity of water required to remove in kilograms

W = Mass of the maize in kilograms

M_o = Initial moisture content of the maize in % w.b

M_f = Desired moisture content of the maize in % w.b

W=758 kilograms, M_o=24% (w.b), M_f =13% (w.b) and M_w = 99.25 kilograms.

Amount of Air Required for Drying of Maize

By using Eq. 4 air quantity required for aeration the maize was intended (Ichsani and Dyah, 2002).

$$m_w = (mC_p \frac{T_b - T_a}{Lw}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.4)$$

Where,

m_w = Air quantity (kilograms)

L_w = Free water latent heat of evaporation (Joule/kilogram)

C_p = Air specific heat at constant pressure (Joule/kilogram °C)

T_a = Ambient temperature (°C)

$T_{b=}$ Ultimate temperature (°C)

From psychometric chart required air quantity was intended. If the relative humidity is the 70% and ambient air at temperature Ta is the 29 ˚C is heated up to the temperature of T_b is the 45 ˚C, for maize is the safe drying temperature (Hall, 1980), then from initial relative humidity 70% will reduce to 20%. 0.0160 kilograms of water per kilograms of dry air was measured as absolute humidity. Until an equilibrium relative humidity is reached, the warmed air is used to take away water, 99.25 kilograms from maize of 758 kg. Absolute humidity was increased from 0.016 to 0.0220 kilograms of water per kilograms of dry air when the temperature of the aeration air was reduced. Transformation in humidity ratio was determined, which was equal to ΔW =0.0060 kilograms of water per kilograms of dry air. By using Eq.5 required quantity of air was determined (Ichsani and Dyah, 2002).

$$M_a = \frac{M_W}{\Delta W x\, n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.5)$$

Where,

Ma = Required quantity of dry air in kilograms

Mw = Quantity of water required to remove in kilograms

ΔW = Difference in absolute humidity

n = Pick-up factor per (Axtell, 2002).

Hence, from the psychometric chart, ΔW = 0.0060 kilograms of water per kilograms of dry air, using n = 0.250 than tapping all values in the Eq. 5 the required quantity of air is intended that was started to be 66166.68 kilograms. 27 hours per batch drying time was considered, Hence, M_a = 3676 kilograms/hour which is equivalent to 1.021 kilograms/second.

Volumetric Flow Rate

By using Eq.6 volumetric flow rate was measured (Axtell, 2002).

$$Q_v = M_a \times V_a \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.6)$$

Where,

Q_v = Drying air volumetric flow rate in m^3/second

V_a = Drying air specific volume in m^3/kilograms

From the psychometric chart, the value of V_a is 0.872 m^3/Kg and from the equation (5) the value of the required quantity of air is 1.021 Kg/s, hence, Q_v = 53.35 m^3/min or 1880 cfm.

Fan Selection

Fan selection was based on the depth of the product bed and the pressure drop for air flow (Brooker et al., 1992). From fan characteristics curve (Stream rate (cfm) vs Resistance of air movement), the static pressure value was measured 43 mm of water. Then pressure drop multiply with a pack factor. The value of pack factor is 1.5 for maize and other crops. 0.5 is also added to the measure total static pressure if air is delivered from duct. Then the full static pressure value was 65 mm of water (Kenneth and Hellevang, 2013).

$$\text{Fan HP} = \frac{\text{Air flow rate} \times \text{Static pressure}}{3814} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.7)$$

Thus, by using Eq. 7 the needed HP is 0.8 hp. Consequently, a one-horse power centrifugal fan is carefully chosen.

Total of Heat Required

By using Eq. 8 for removing moisture from maize, the total of heat energy required was considered as (Hall, 1980).

$$Q = ML + Mh_{fg} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.8)$$

Where,

Q = Total heat energy in Watt

M = 99.25 kilograms is the amount of water need to remove

L = From the steam tables latent heat evaporation = 2.261×10^6 Joule/kilograms

h_{fg} = From steam tables heat coefficient = 43990 kilo-Joule/Kalvin moles of water

Then for drying the total of heat required is 2.3526 kilo-Joule/second.

Area of Solar Collector

For the essential heat, collector area Ac was intended by using Eq.9 (Hall, 1980).

$$Q = A_c(I_t \delta_a - U_L(T_b - T_a)F_R) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.9)$$

Where,

A_c = Collector area

I_t = Solar intensity (Pakistan) = 855 W/m^2 on normal basis

U_L = Overall heat coefficient = 7.38 W/m^2 ^{0}C

$\mathcal{Z}_a$ = Transmissivity = 0.89

F_R = Heat removal factor = 0.9

T_a = Average ambient temperature = 29 ^{0}C

T_b = Average needed temperature = 45 ^{0}C

In conclusion, with equation (9), the collector area is considered as 4 m^2.

Enlightenment of Solar Sustained Maize Dryer

The concept of dryer plan is grounded on batch nature dryers. The working principal of the solar dryer is that when ambient air passing through the solar collector its temperature increase by absorbing the solar energy and then moisture from the moist grains is removed with the use of this heated air. In the workshop of Agricultural Engineering, University of Agriculture, Faisalabad solar sustained batch type maize dryer was developed and constructed. Plane platter collector, blower, aeration compartment and central air perforated duct model are some important parts of solar sustained batch type maize dryer. Plan diagram of the dissimilar parts of the machine are shown in the Figures 1and 2 respectively.

Figure 1 shows the cross-sectional understanding of aeration compartment. Drying bins were used to collect the grains. To maintain static, pressure the depths of grain in the drying bin was selected. For natural air, drying system to keep the static pressure as low as possible, larger diameter, and shallow bins were fabricated. Solid chamber, perforated drying chamber, central vertical duct and plenum chamber were the main parts of aeration compartment.

Figure 2 shows the isometric view of solar flat plate collector. A collector with flat rectangular plate was used which was helped with heat absorbing black sheet of mild steel, glazing glass, and specific amount of space was made for the wind to collect heat from sun. Solar collector intensified the solar radiations towards the heat absorbing plate as the solar radiation reached the glazing glass. Solar radiation heated the absorbing plate up to a specific temperature. By the help of blower, the wind touching absorbing plate was heated up and was forced towards the maize drying chamber. Figure 2 also shows the cross-sectional view of air duct. To remove moisture that was extracted from the maize, the air distribution system was used. It removes moisture to deliver air to the drying zone in the dryer through perforated duct. To maintain the uniform air flow rate over the material air distributors were designed and selected. Figure 3 shows the actual view of solar sustained batch type maize dryer.

Table 1. Design Specification.

Items	Units	Conditions and Assumptions
Location	_	Faisalabad, Pakistan
Crop	_	Maize
Bulk density	Kg/m^3	824
Grain mass per batch	Kg	758
Initial moisture content	% (w.b)	24
Required moisture content	% (w.b)	13
Temperature of ambient air,	^0C	29
Ambient relative humidity	%	70
Maximum allowable temperature [11]	^0C	45
Drying time	hour	27
Incident solar radiation,	W/m^2	850
Collector efficiency, ηc	%	40 - 70
Total heat required for drying of whole maize.	KJ/s	2.3526
Transmissivity	_	0.89

Table 2. Component and material used in the fabrication.

Name of Component	Parts	Fabrication Material
Solar Flat Plate Collector	Frame	Aluminum
	Absorber	Black painted steel sheet
	Insulation	Black tape
	Cover sheet	Glazing glass
	Connection pipe	Rubber
Drying Chamber	Outer chamber	Stainless Steel
	Perforated chamber	Stainless Steel
	Perforated Air duct	Stainless Steel
Centrifugal Blower	Frame, wings	Iron
Unloading Conveyor	Frame, augar	Stainless Steel

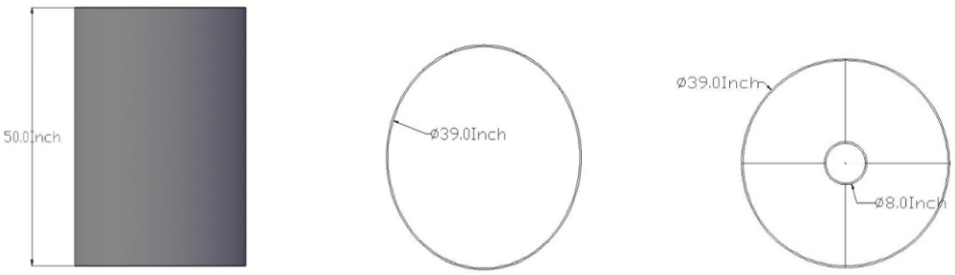

Figure 1. Cross sectional view of aeration compartment.

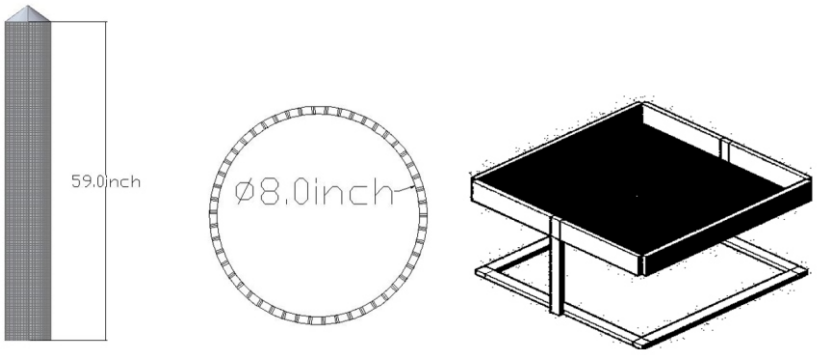

Figure 2. Isometric view of air duct and collector area.

Fabrication of Solar Dryer

All parts of solar sustained batch type maize dryer were fabricated in the workshop of Agricultural Engineering Department University of Agriculture Faisalabad, Faisalabad-Pakistan. The outer chamber was made up of Non-magnet stainless steel material and no perforations were made on this chamber. Single hole was made on this chamber which was used to support the outlet of the maize. Drying bin cover was designed to keep it safe from weathered conditions. Large perforated chamber was used, where the maize was needed to be placed. The amount of maize being dried was based on this chamber. The capacity of the maize dryer was same as the size of this chamber. It was also made with perforations on the surface. Whole surface of this chamber was contained small perforations. The size of perforations in this chamber was such that no maize should get out of the chamber. The air distributors were designed and selected to maintain the uniform air flow rate over the material. It was also fabricated from Non-magnet stainless steel material. The solar flat plate collector frame was made from Aluminum and absorber was made from black painted steel material. The choice of black painted steel material for absorber will help in absorbing all heat that come from sun in the form of radiation. The material used for conveyor construction was Non-magnet stainless. For maize unloading, the conveyor 3 inch in diameter and 24 inches in length was constructed. DC motor was used to run the conveyor with 12V/50W power.

Figure 3. Actual view of solar sustained batch type maize dryer.

Results and Discussions

Figure 4 shows that as intensity of solar radiation increases, heat added to the collector was also increases. Results shows that the average ambient temperature ranged from 24 to 32^{0}C, collector outlet temperature ranged from 38^{0}C to 65^{0}C, ambient relative humidity ranged from 70% to 29% and intensity of the solar radiation ranged from 600 to 924W/m^2.

Figure 5 shows that collector efficiency of the solar assisted maize dryer during the test day was varies from 45 to 57%, which indicating the good performance of the collector. The efficiency values obtained by (Ting and Shove, 1983) for a flat plate collector are like those obtained in this work, with a similar influence of the solar radiation and the air mass flow.

Figure 6 shows the variation in moisture content with respect to drying time of maize. Results shows that for achieving the final desired moisture content up to 13% dryer took 27 hr.

Cost Analysis

Cost analysis is the most important to check the feasibility of machine for farmer point of view to find out the drying cost. However (01 Rs = 0.01 US$), the new solar sustained maize dryer purchase price of was estimated to be US$. 1234.33/- and solar sustained maize dryer useful life is supposed to be 10 years.

The yearly static cost was considered = US$. 159.51/-
Annual drying capacity of maize dryer is assumed = 206 tons/ year
The total fixed cost of the dryer = US$. 0.77/ton
For maize labor charges = US$. 4.75/ton of maize aeration
Energy charges = US$.0.002/kg
The sum of variable charges = US$. 0.63/ton
The total cost is about = US$. 1.40/ton.
Therefore, the drying cost = US$. 0.00147/Kg.

The drying cost by using open sun drying method was 0.02 to 0.03 US$. /kg in Pakistan per literature and survey report. It is economical and environment friendly drying method.

Conclusions

From 24% to 13% moisture content for drying the 758-kg maize, solar sustained maize dryer took 27 hours and mean drying rate was 3.67 kilograms/hour. Against the outmoded open sun aeration method, 60% saving in time was achieved by using solar sustained maize dryer. Furthermore, Cost analysis was also done and it was found by using this drying method, at very low cost we can dehydrated better quality maize because in Pakistan the drying cost by using open sun drying method was 0.02 to 0.03 US$. /kg in Pakistan per literature and survey report. At community level, marketable size of the solar sustained maize dryer can be better and formed for revolution of agriculture in the country-side areas.

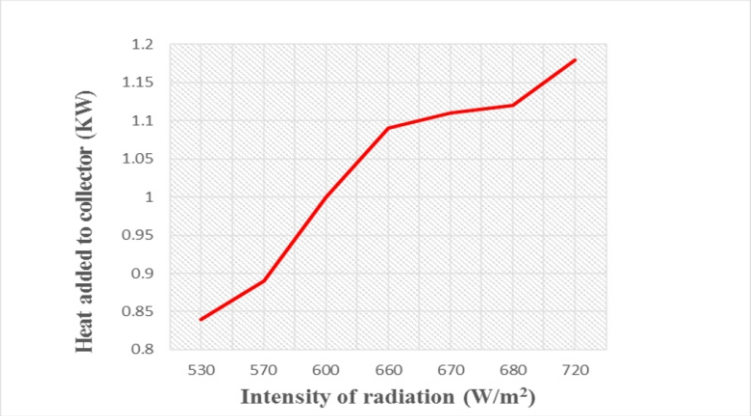

Figure 4: Efficiency of the collector for five typical days.

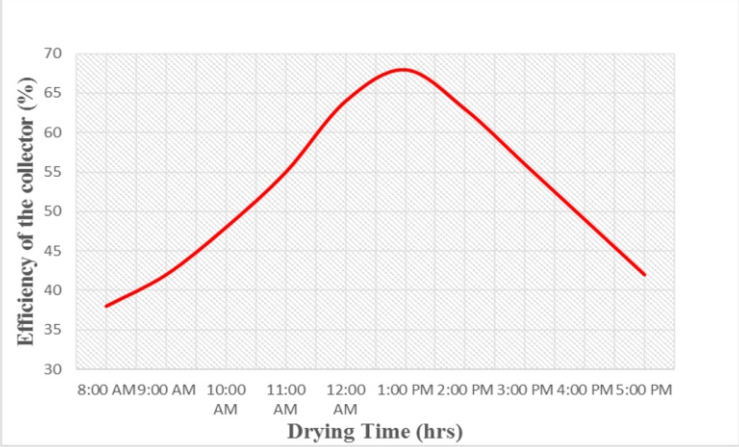

Figure 5. Efficiency of the collector for five typical days

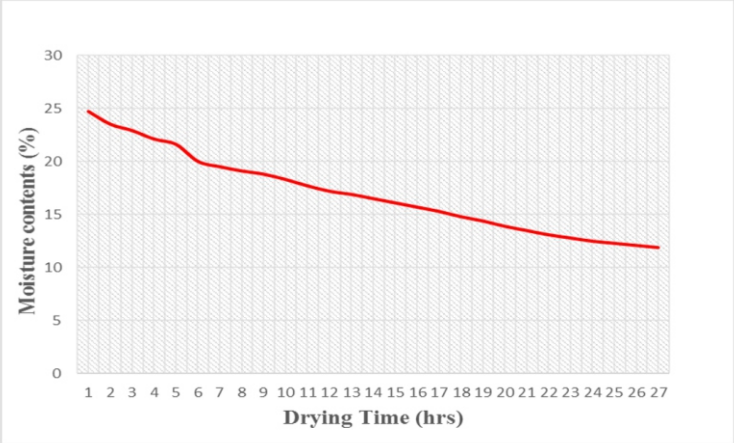

Figure 6. Variation in moisture content with time.

Fixed cost	
Depreciation (US$.)	56.97/year
Interest @ 12% (US$.)	102.54/year
Total fixed cost, (US$.)	159.51/year
Variable cost	
Repair and Maintenance @ 15% (US$.)	34.18/year
Labor @ 300 US$. / day of 9 hours	94.95/year
Total variable cost, (US$.)	129.13/year

Table 3. Drying cost worksheet.

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Research Article

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The first findings on rusty grain beetle, *Cryptolestes ferrugineus* (Stephens, 1831) (*Coleoptera, Cucujoidea: Laemophloeidae*) in pistachio orchard in Siirt province (Turkey)

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Abstract

In this study, Siirt province (Turkey) has been reported as the new distribution area for Rusty Grain Beetle, *Cryptolestes ferrugineus* (Stephens, 1831). In addition, some morphological measures are presented. The measured length of this species varies between 2.19 and 2.22 mm. It was found between May and June in pistachio orchards. In addition to being found in such pistachio areas, for this species; the facultative predator property must be observed. Adults as well as larvae, are cannibalistic and will consume eggs, pupae and prepupae of other species co-habiting with them. For instance, It is important to monitor the relationship of this species with the species belonging to the family Scolytidae, Bostrichidae and Diaspididae family species in this pistachio orchards in future.

Keywords: *Cryptolestes ferrugineus*, Pistachio, Siirt, Turkey

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Introduction

Stored products and food industry arthropod pests present a serious economical and medical risks for stored food, feed commodities and seeds in Turkey, and requires phytoquarantine. The rusty grain beetle, *Cryptolestes ferrugineus* (Stephens, 1831) is a world-wide pest of stored food products. Meanwhile; they are primarily pests of wheat. However, this pest also feed on barley, cacao, capsicum, cassava, chilies, clover, copra, corn, currants, dates, flax, illipe nuts, lucerne, millet, mustard, oats, palm kernels, peanuts, rape, rice, sorghum, soybean, sunflower, and triticale (Throne, 1987). *Cryptolestes* spp. are capable of being hazardous for whole kernels under suitable conditions, but can be associated with primary invaders such as *Rhyzopertha dominica*.

C. ferrugineus generally causes mixed infestations with *Tribolium castaneum*. Larvae and pupae are protected from predation or cannibalism because they develop singly under the seed coat covering the germ of cereal seeds (Suresh et al., 2001). *C. ferrugineus* is one of the most common grain feeding insects found in grain stores in farms in Turkey. It is widely distributed throughout the World. In turkey; It is distributed many different locations. This report has been written about a new locality record of this stored product pest. Also, it is important that this species, which is basically known as stored product pests, has been found in pistachio orchards. Although not active; It has been reported that this species has predator behavior in its habitat. They are also found in the nests of Vespa wasps and under tree barks. They are facultative predators and scavengers and able to feed on many species of storage fungi (Suresh et al., 2001) . Adults as well as larvae, are cannibalistic and will consume eggs, pupae and prepupae of other species co-habiting with them (Suresh et al., 2001). For this reason it is necessary to determine the relations with the bark beetle and scale insects. as they are reported to be related in the literature (Zakladnoi and Ratonova, 1987; Thomas, 1988).

Materials and Methods

Specimens were collected from traps in Siirt Province. The light trap was operated from mid-June to mid-September in years 2008 and 2009. This study was carried out in two pistachio orchards in Siirt province. There was one light trap in each garden. Number of study orchards was changed to 5 within 8 acres (Figure 1). Each orchard was controlled every week. A 20-watt Philips energy saver white day light bulb was used. The specimens are preserved in 70 % ethanol. The collected material is deposited in Bioengineering Department Laboratory of Fırat University, Bioengineering Department, Turkey.

Figure 1. Pistachio orchard in Siirt Provinces, habitat of *Cryptolestes ferrugineus* (Stephens, 1831).

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Results and Discussion

Cryptolestes ferrugineus (Stephens, 1831) (Figure 2).

Distribution in World: Widely distributed (Halstead, 1993)

Distribution in Turkey: Adana, Ankara, Konya, Mersin, Şanlıurfa (Bağcı et. al., 2014; Er et. al., 2016) .

Hosts: Wheat, cotton (Thomas and Ghari, 1988) common important pest of stored grain and grain products in warehouse and field (Rees, 1994).

Material examined: Siirt, Aydınlar, 17.06.2008, 9 exc, 02.08.2008, 15 exc, 08.06.2009, 13 ex., 24.08.2009, 16 exc., pistachio orchard, Siirt, Center, 17.07.2008, 2 exc, 02.08.2008, 5 exc, pistachio orchard, 12.05.2009, 5 exc, 01.06.2009, 6 exc., pistachio orchard, Totally: 68 exc.

The length of species was measured to be approximately 2, 19 mm (Figure 2). This measure was given as 2.2 mm in some previous studies (Zaklodnoi and Ratonova, 1987). *Sitophilus granarius*, *S. oryzae* L., *Tribolium* spp., *Oryzaephilus surinamensis* L., *Tenebroides mauritanicus* L., *Rhizopertha dominica* F. and *Trogoderma granarium* Evert. species are distributed in some provinces in the South and the Southeast Anatolia region (Özer, 1957) . Ergül et al., (1972); in their study they have carried out in Southeast Anatolia reported that *Plodia interpunctella* Hb. in addition to the presence of the same species parallel to the previous year's work, is also detrimental to storage. Özar and Yücel (1982); found in the study conducted in the Southeastern Anatolia region that *S. granarius*, *Tribolium* spp., *O. surinamensis*, *R. dominica* are harmful. Number of studies on stored product pests is limited in Southeast Anatolia region. It is estimated that *C. ferrugineus* would be a problem in the province of Siirt and in the neighboring province Batman, if it is not struggled against in wheat and stored products. In addition, this pest was firstly found in pistachio orchards. The behavior of the species should be monitored in pistachio gardens, because it is capable of showing predator behaviors in harmful natural conditions (Zakladnoi and Ratonova, 1987). In these studies, this species has been found in tree barks. In this study, it is necessary to determine the relation with bark beetle with *C. ferrugineus* which is caught by light traps. In these gardens there are Scolytidae family species belonging to this family, characterized by *Chaetophorus (Hylesinus) vestitus* Mulsant & Rey, 1861 (Coleoptera: Scolytidae) significant damage. This pest is a major pest of pistachio gardens in Southeastern Anatolian region of Turkey (Bolu, 2002). In addition, it has also been reported that *Cryptolestes* sp. feed on scale insects species (Thomas, 1988). *Lepidosaphes pistaciae* A. has significant density in gardens where the study has been carried out in (Suresh et al., 2001). It is likely to be associated with this species. Hence; it must be observation of interact pest in orchard to following time.

Figure 2. Habitus of *Cryptolestes ferrugineus* (Stephens, 1831).

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Review Article

Int J Agric Environ Food Sci 2(2):59-66 (2018)

A review on hydroponic greenhouse cultivation for sustainable agriculture

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Abstract

The term 'Hydroponics' was derived from Greek word '*hydro'* means water and '*ponos'* mean labor. Hydroponics is a modern agriculture technique that uses nutrient solution rather than soil for crop production. Humans need water, food and living habitat to endure. As population increases the food demand also increases. The worry is that the existing system of agriculture will not be able to meet the food requirement near future as this system is facing many challenges. The objectives of this review paper are to discuss the hydroponic greenhouse technologies, impact of environmental factors on hydroponic greenhouse cultivation, advantages and challenges of hydroponic greenhouse system. This study revealed that hydroponic greenhouse cultivation is better option in the sense of utilization of inputs and improved crop production.

Keywords: Greenhouse cultivation, Hydroponics, Environmental factors

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Introduction

Humans need water, food and living habitat to endure. These things do not happen in interminable profusion and are resulting both from abiotic and biotic sources, making humans fundamentally hooked on the optimization of land area and the conservation of biodiversity. Within next 40 years human population is projected to increase from 7.0 billion to 9.5 billion people as human population increases. Food production will need to be doubled to compensate the parallel increase in demand for food species. The worry with this turn out to be plain upon the attention of the yield of existing structures of agriculture and fresh water harvesting: even with our energies, 1.0 billion people hurt from malnutrition modernly, and 1.2 billion live in zones with water shortage (Bellona Foundation, 2009).

Usually the most favorable or available medium for crop growth is soil. Soil provides the available the nutrients, air; water, etc. for effective crop growth (Ellis et al., 1974). Presence of micro-organism and nematodes instigating diseases, inappropriate soil response, poor drainage, soil compaction, soil degradation, etc. are the serious limitations of soil for effective crop growth (Beibel, 1960). The need for more land could be decreased by growing crops in towers. Increase in yield with efficient use of inputs (water, fertilizer, and pesticides) can be achieved through protected cultivation. The major advantage of hydroponic greenhouse cultivation is the efficient usage of natural light. Light play an important role in the development of fruit. In hydroponic greenhouse, light fall on both upper and lower part of the plant. Due to equal distribution of light, both upper and lower fruit develop at the same time (Despommier, 2009). Most profitable varieties of crops from cereal, green leafy vegetables, flower and fodder are growing well in the hydroponic systems (RIRDC, 2001). Resh and Howard (2012) studied the advantages of hydroponic systems like minimum use of pesticides, increase in yield, and water conservation. According to literature, many studies have been conducted on hydroponic leafy green, peppers, and tomato (Arias et al., 2000; Buchanan et al., 2013; Koyama et al., 2013).

Open field agriculture, will face some serious problems in near future like availability of land and agricultural productivity, deforestation, and soil erosion. In addition, some areas where, there is an issue of soil fertility, unfavorable topographical conditions, and soil is not available for cultivation of crop like urban areas, under such conditions soil-less culture or protected farming can be introduced successfully (Butler and Oebker, 2006). In the world, 115 countries have commercial greenhouse production (FAO, 2005). Total estimated area in the world for greenhouse crop production is 623302 hectares (Hickman, 2011).

Background

In 1627, the most primitive book on soil-less culture was *Sylva Sylvarum* published by Francis Bacon. In 1859-65, German botanists made developments in the techniques of soil-less culture. In 1929, solution culture was promoted by William Frederick Gerick for agricultural crop production. The word "Hydroponic" was firstly introduced by the William Frederick Gerick in 1937. In 1946, English scientist W.J. Shalto Duglas introduced the Hydroponics in West Bengal India. Nutrient film technique was developed by by English scientist Allen Cooper in 1960.

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In 1960-70, commercial hydroponics farms were developed in many countries of the world. Later, during 1980s many automatic and high-tech hydroponics farms were developed around the world (George, 2010).

Definition of Hydroponics

The term 'Hydroponics' was derived from Greek word '*hydro'* means water and '*ponos'* mean labor (Beibel, 1960). Hydroponics is a modern agriculture technique that uses nutrient solution rather than soil for crop production (Bridgewood, 2003; Hochmuth and Hochmuth, 2001a).

Hydroponic Techniques

Many studies have been conducted on hydroponic techniques. Generally, there are two techniques of hydroponics, named as solution culture method and media culture method. Comparison between both techniques are shown in table below regarding percentage of irrigation water saving, percentage of efficient fertilizer usage, increase in the percentage of productivity, and percentage of water productivity (Van et al., 1991; Van, 1995; Bohme, 1996; Gul et al., 1999; Dhakal et al., 2005; Tuzel et al., 1999; Van, 1999) (Table 1).

Table 1. Comparison between Hydroponic Techniques.

Parameters	Hydroponic Technique	
	Solution Culture	
	Open	Closed
Percentage of irrigation water saving	85	90
Percentage of fertilizer saving	68	85
Percentage of productivity increase	200	300
Percentage of water productivity	2000	3500

Solution Culture Method

It is also known as liquid hydroponics method. In this method plants are grown in solution culture and their roots are suspended directly in nutrient solution (Maharana and Koul, 2011). It can be further categorized into different subsections as below.

Continuous Flow Solution Culture

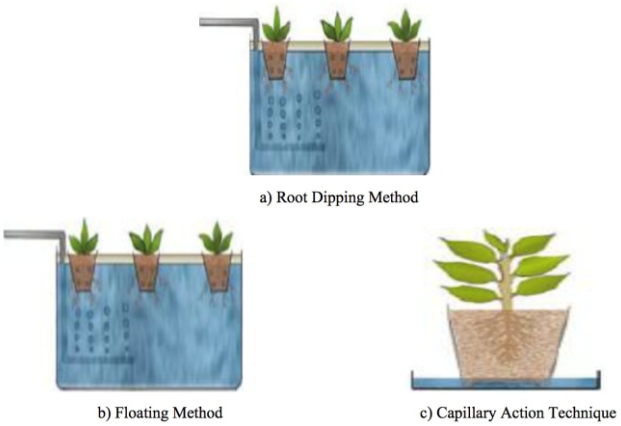
In this system pump is used to circulate the nutrient solution in plant roots and excess solution is collected and reused. Various studies have been conducted on continuous flow solution culture in different countries. This culture has two types of system named as nutrient film technique and deep flow technique shown in Figure 1. In nutrient film technique, the nutrient solution is pumped through the growing tube and flow over the roots of plants, then drain back into the reservoir. In deep flow system, PVC pipes with 10 cm diameter are used. 2-3 cm deep nutrient solution flows through the PVC pipes. PVC pipes have pots and plants are fitted in pots. The bottom of pots is in touch with the nutrient solution and pots contain planting materials. Plants are grown in pots (Maharana and Koul, 2011) (Figure 1).

a) Nutrient Film Technique b) Deep Flow Technique

Figure 1. Continuous Flow Solution Culture.

Static Solution Culture

In this system, nutrient solution is not circulated but provided only once when EC changes. It has three types of systems named as root dipping method, floating method, and capillary action method. In root dipping method, plants are grown in pots that have the growing media. The 2-3 cm bottom of pots is submerged into nutrient solution. Roots of plant are dipped in nutrient solution in this system and some are hanged in air. In floating method, shallow container (10 cm deep) can be used to grow the plants. Container is filled with nutrient solution. Plants are grown in pots that fixed on Styrofoam sheet. This sheet is floated on the nutrient solution. In capillary action technique, seedling/seed are planted in pots of different sizes and shape which is filled with inert medium. Shallow container having nutrient solution is used in this technique and pots are placed in this shallow container. By the capillary action nutrient solution reaches the inert medium. Ornamental, flower and indoor plants can be sown by using this technique (Maharana and Koul, 2011) (Figure 2).



a) Root Dipping Method

b) Floating Method c) Capillary Action Technique

Figure 2. Static Solution Culture.

Aeroponic System

Aeroponics is a method of growing plants where they are anchored in holes in Styrofoam panels and their roots are suspended in air beneath the panel. The aeroponics culture is usually practiced in protected structures and is suitable for low leafy vegetables like lettuce, spinach, etc. (Research News, 2008) (Figure 3).

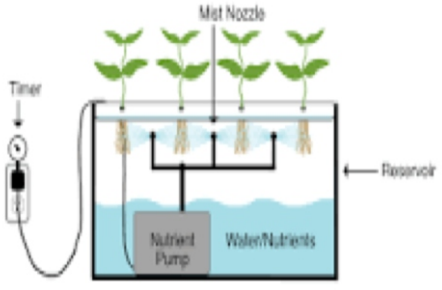


Figure 3. Aeroponic System.

Nutrients for Hydroponic Greenhouse Cultivation

Many studies have been conducted on crop nutrient requirement. Approximately, seventeen elements are required for proper plant growth. These elements are categorized into macro-nutrients and micro-nutrients (Table 3).

These elements are summarized in Table 3. Supply of nutrient solution to the hydroponic crops mainly depends on two parameters named as pH (Resh, 1993) and electrical conductivity (EC). The optimum range of pH of nutrient solution for hydroponic cultivation is 5.8 and 6.5 and good EC range is between 1.5 to 2.5 dS/m.

Crops For Hydroponic Greenhouse Cultivation

Crops need suitable environment for its successful growth. The only condition to achieve suitable environment for better crop production is the protected cultivation or hydroponic greenhouse cultivation. It is possible to grow cereals, vegetables, fruits, fodder, flowers, condiments, and medicinal plant in hydroponic greenhouses (Singh and Singh, 2012). The summary of those crops that are grown in hydroponic greenhouse are shown in Table 4. According to (Singh and Singh, 2012), hydroponic greenhouse yield per area is more than open agriculture yield per area. The yield comparison between hydroponic and open agriculture is shown in Table 5. This comparison showed that there is big difference between both types of method. This difference is due to controlled environment in case of hydroponic greenhouse cultivation and the re-use of nutrient solution.

Table 3. Summary of Nutrients for Hydroponic Crop Growth

Type of Nutrients	Name of Nutrients	Functions in Plants
Macro	Nitrogen	Chlorophyll, amino acids and proteins synthesis
	Phosphorus	Photosynthesis and growth
	Potassium	Enzyme activity
	Hydrogen	Water formation
	Oxygen	Release of energy from sugar
	Carbon	Formation of organic compounds
	Calcium	Cell growth
	Magnesium	Enzyme activation
	Sulfur	Formation of amino acids and proteins
Micro	Iron	Used in photosynthesis
	Boron	Vital for reproduction
	Chlorine	Help roots growth
	Copper	Enzyme activation
	Manganese	Component of chlorophyll
	Zinc	Component of enzymes
	Molybdenum	Nitrogen fixation
	Cobalt	Nitrogen fixation

Table 4. Summary of Crops for Hydroponic Greenhouse Cultivation (Singh and Singh, 2012).

Type of Crops	Name of Crops	
	Common Name	Botanical Name
Cereals	Rice	Oryza sativa
	Maize	Zea mays
	Wheat	Triticum aestivum
	Oat	Avena sativa
	Soybean	Glycin max
	Peas	Pisum sativum
Vegetables	Tomato	Lycopersicon lycopersicum
	Chilli	Capsicum frutescens
	Brinjal	Solanum melongena
	Green bean	Phaseolus vulgaris
	Bell pepper	Capsicum annum
	Beet	Beta vulgaris crassa
	Potato	Solanum tuberosum
	Cabbage	Brassica oleracea var.
	Cauliflower	Brassica oleracea
	Cucumber	Cucumis sativus
	Onion	Allium cepa
	Radish	Raphanus sativus
	Lettuce	Latuca sativa
Fruits	Strawberry	Fragaria ananassa
	Melons	Cucumis melo
Fodder crops	Sorghum	Sorghum bicolor
	Alfalfa	Cynodon dactylon
	Barley	Hordeum vulgare
	Bermuda grass	Cynodon dactylon
	Carpet grass	Axonopus compressus
Flower	Marigold	Tagetes patula
	Roses	Rosa berberifolia
	Carnations	Dianthus caryophyllus
	Chrysanthemum	Chrysanthemum indicum
Condiments	Parsley	Petroselinum crispum
	Mints	Mentha spicata
	Sweet basil	Ocimum basilicum
	Oregano	Origanum vulgare
Medicinal crops	Aloe	Aloe vera
	Coleus	Solenostemon scutellarioides

Table 5. Yield Comparisons between hydroponic and open field cultivation (Singh and Singh, 2012).

Type of Crops	Name of Crops	Hydroponic Yield (kg per ha)	Open Agriculture Yield (kg per ha)
Cereals	Rice	13,456.56	841.03-1,009.25
	Maize	8,971.0	1,682.07
	Wheat	5,606.9	672.83
	Oat	3,364.14	953.18
	Soybean	1,682.07	672.83
	Peas	15,699.32	2,242.76
Vegetables	Tomato	403,335.81	11,203.75-22,407.47
	French bean	47,097.96	-
	Beet	22,427.6	10,092.42
	Potato	156,852.29	17,925.98
	Cabbage	20,184.84	14,577.94
	Cauliflower	33,641.4	11,213.8-16,820.7
	Cucumber	31,398.64	7,849.66
	Lady's finger	21,306.22	5,606.9-8,971.04
	Lettuce	23,548.98	10,092.42

Impact of Environmental Factors on Hydroponic Greenhouse Cultivation

There are important environmental factors which effect the hydroponic greenhouse production e.g., light, temperature, air humidity, and CO_2 concentration. Usually, the level of these factors (too low or too high) adversely affects the hydroponic greenhouse production. The optimum level of temperature (Thompson et al., 1998; Tabatabaei et al., 2008; James et al., 1994; Kim et al., 2000; Kaya et al., 2000; Zornoza et al., 1987), relative humidity (Mathieu et al., 2006; CSUE, 2011; Jayaraman et al., 2011; Prosser et al., 2001; Seginer et al., 1991; Hikosaka et al., 2008), light intensity (Off-Grid-World, 2012; How Stuff Works, Inc., 2014; Simeonova et al., 2004; Chueca et al., 1984; Siddiqi et al., 2002; Nowak, 1980), and pH (Benoit and Ceustermans, 1988; Lieten, 1992; Sonneveld and Voogt, 1999; Jauert et al., 2002; Waisberg et al., 2004; Gibbs and Calo, 1959) for vine crops ranges from 20-24°C, 65-85 %, 100-130 Wm^{-2}, and 5.8-8.2 respectively.

Light Intensity

Several studies have been conducted on effect of low light or intensity on crop production. These studies have shown that low light is a problem in northern latitudes (Benoit, 1987; Grimstad, 1987; Gaudreau et al., 1994; Drews et al., 1995; Drews et al., 1996; Cockshull and Ho 1995; Dorais et al., 2001; Ottosen et al., 2003). The greenhouse structures reduced the amount of daylight received by 30 percent or more (Peet, 1999; Warren et al., 1992). When daylight is low or sub-optimal then greenhouse yield will be low because of the production of relatively small fruit (e.g., tomatoes), early in season (Grimstad, 1987; Cockshull and Ho 1995; Kays, 1999). Low light intensity reduced the leaf carbon assimilation, presumed by Pardossi et al. (2000). In flowers, accumulation of sugar decreased due to low light intensity. Additionally, sugar content and dry matter will be more if tomatoes and strawberries are grown in full sunlight and less in those which are grown in shade (Winsor, 1979; Weston and Barth, 1997; Caruso et al., 2004). According to Caruso et al. (2004), dry matter, sugar, acids, and taste determining compounds are reduced in case of shading effect in strawberry fruit (Caruso et al., 2004). In autumn-grown vegetables, taste is sometime poor due to shading effect of weather. Sign ensues, flavor quality of some crops affected by low light intensity (Winsor and Adams, 1976; Watson et al., 2002; White, 2002).

External and internal quality of vegetables crop is also affected due to excess lighting (Gaudreau et al., 1994; White, 2002; Hao and Papadopoulos, 1999; Dorais and Gosselin, 2002). In medicinal plant excess light increase the content of essential oils and other compounds (Hao and Papadopoulos, 1999; Dorais and Gosselin, 2002). Wide range of crops (tomatoes, bell peppers, eggplants, and pepinos) are adversely affected due to excess of light (Kays, 1999; Geissler, 1985). Cellular death, collapse of tissue, and degradation of the pigmentation are caused by excessive solar energy (Kays, 1999; Prohens et al., 2004).

Temperature

Chemical reaction and physical properties of plant are affected by the different level of temperature. Generally, growth rate of the different vegetable fruit increased with increasing air temperature (Marcelis, 1993; Dorais et al., 2004). According to Marcelis (1993), the biomass provision of the fruit increased with increasing temperature from 18°C to 25°C at the same plant (Marcelis, 1993). Organoleptic properties of vegetable are directly affected by low temperatures. Tomatoes having less juice and mealy taste is the clear indication of low temperature production (Anonymous, 1999; Bruckner et al., 2004). Quality of the most vegetable is affected by different temperature pattern. Marcelis and Baan Hofman-Eijer (1993) studied the effect of temperature fluctuations during crop production and compare the result with crop production at constant temperature. They found that sturdy fluctuation in temperature between day and night need to be avoided, because temperature fluctuation can decrease the quality of crop (Marcelis and Baan, 1993). Moreover, high temperature changes associated with growth factors can cause opening of cucumber (Geissler, 1985). Inspite of ventilation, shade, cooling, greenhouse temperatures arise in summer due to solar radiation. High temperature cause changes in the shape, color, and texture of tomato, cucumber and eggplant fruit (Geissler, 1985; Zipelevish et al., 2000).

Air Humidity

Water status and transpiration (water balance, transpiration cooling, and ion translocation) of hydroponic greenhouse plants is affected by air humidity (Bakker, 1984). Humidity is most difficult environmental factor to control and it is quite economical especially when heating. There are different methods to control the relative humidity. In cool weather, the utmost effective way to control relative humidity is to open the exhaust window slightly. Slightly open window escape heat allied with much of the water vapor. There are many other methods which have been tested but practical solutions have not been provided (Adams, 2002). When the vapor pressure deficits range 0.2 to 1.0 kPa then it has no effect on crop growth and development (Grange and Hand, 1987). Many studies have been done on effect of vapor pressure deficit and it is concluded that when vapor pressure deficit is low in hydroponic greenhouse then there is reduction in the average weight of tomato plant (Bakker, 1990a; Holder and Cockshull, 1990). When vapor pressure deficit increased from 1.0 to 2.5 kPa in hydroponic greenhouse then there is reduction in net accumulation of water in fruit (Guichard et al., 2001). Quality of vegetable is affected by high humidity levels; that cause increase in the diseases by spreading pathogens (Bakker, 1990b; Vonk and Welles 1995; Cockshull, 1998).

CO_2 Concentration

CO_2 concentration is one of the major environmental factors, several times throughout the history agronomy or horticulture the interest in CO_2 enrichment has risen and declined (Mortensen, 1987). Many studies have been done on effect of CO_2 enrichment and it is concluded that dry weight of plant, plant height, number of plant leaves, and lateral branches of plant increases with the increase in CO_2 enrichment in greenhouse (Mortensen, 1987). Moreover, other environmental factor (temperature and light) also increase with the elevated CO_2 concentrations (Mortensen, 1987). There should be a need of more research on CO_2 factor, how CO_2 enrichment affects the optimal levels of light, temperature and air humidity for a better product quality.

Challenges of Hydroponic Greenhouse Cultivation

High Initial Cost

Many studies have been done on the construction of hydroponic greenhouse structures. According to Tyson et al., (2004) the area of hydroponic structure should be able to sustain minimum 40 large plants (tomatoes, banana peppers, and bell-peppers) and minimum 72 small plants (spinach, lettuce, and strawberries). According to Hochmuth and Hochmuth (2001b), there should be an Arduino based climate control monitor system in hydroponic greenhouse to monitor the light intensity, temperature, carbon dioxide concentration, and humidity (Hochmuth and Hochmuth, 2001b). Many factors such as (availability of the system, the efficiency of the system, and transportation cost etc.,) should be kept in mind during installation of Arduino based climate control system and initial cost of this system also based on these factors (Taig, 2012). According to literature survey, the cost of Arduino based climate control system for commercial hydroponic greenhouse ranges from 500-2000 US Dollar (Grewal et al., 2011; Takakura, 2014).

High Maintenance and Running Cost

High maintenance and running cost is one of the major challenges for hydroponic greenhouse cultivation. Narrow and precise temperature range to attain the optimal plant growth is one of the major expenses for maintaining a hydroponic greenhouse (Wells, 2014; Tavassoli et al., 2010). Other expenses like resources to maintain the large concentration of nutrients in the water, energy for pumping the water-mixed nutrients, energy to run exhaust fans, and sensors etc., requires high maintenance and running cost.

High level of management is needed for hydroponic greenhouse. According to Shaw et al. (2001), high management skills are required for commercial production of any crop in hydroponic greenhouse system. The complexity of the system decides the level of management (Higashide et al., 2013). High level of management like production knowledge of different crop, technical skills, and adequate experience in hydroponic greenhouse field are the basic requirements for hydroponic greenhouses (He and Ma, 2010; Cantliffe and Vansickle, 2012). Grower must be committed to meet the entire requirement in an active means to make successful production (Sigrimis et al., 2013). Automatic system for regularly checking and regulating environment condition inside hydroponic greenhouse should be able to provide enough heating during winter season and chilling or shading during the summer season especially in a tropic area where there is extreme seasonal change (Kuennen et al., 2008).

Irrigation Management

Proper management about irrigation should be adopted and water should be free from contamination because there is more chance of diseases if water is contaminated (AI-Amri, 2007). High level of management and special training is required in area of agronomy (germination area for seedling, cultivar, and plant selection) (Othman et al., 2008; Succop and Newman, 2009). Crop selection plays an important role in initial and running cost of hydroponic greenhouse (Alexander and Parker, 2010). Crop production method (continuous flow and static flow) also requires high level of management skills (Stone, 2014). Supply nutrient to the crops is another area which requires high level of management (Peckenpaugh, 2004). Harvesting and storage requires high level of management with skilled labor (Savvas et al., 2007). Thus, modern type of agriculture systems needs high level of management for successful production (Vollebregt, and Brantford, 2014; Rathinasabapathi, 2011). Moreover, hydroponic greenhouse needs special and regular care (Carruthers, 2011).

Disease and Pest Management

Management related to pest and diseases are also a major problem for hydroponic greenhouse system. Detection of diseases in advance needs careful and high level of management because plant share same nutrient solution and this sharing can result in a quick spread of diseases (DeKorne, 2009). High degree of sanitation is the only solution for system to disease frees (Puri and Caplow, 2009; Jensen, 2007). When water mold is introduced into nutrient solution then most of diseases occur in plant and these water mold spread to all plant through circulating system (Silkova et al., 2011).

Advantages of Hydroponic Greenhouse Cultivation

No doubt hydroponic greenhouse system is facing many challenges, despite of all challenges this modern agricultural system is the most productive method for crop production. Hydroponic greenhouse system produced the higher nutritional value crop (Jones, 2012). Hydroponic greenhouse system has more benefits than disadvantages (Banda-Guzman and Lopez-Salazar, 2014).

In case of hydroponic greenhouse system percentage of land requirement, nutrient requirement, water requirement, and growing time is less (Banerjee and Adenaeuer, 2014). The estimated yield of vine crops is more in case of hydroponic greenhouse system (Mattas et al., 1997; Haifa Chemicals, 2014). Plants never come under stress in case of hydroponic greenhouse system because water and nutrient are always available to the plants (Ruth, 2009). The advantages of hydroponic greenhouse cultivation are summarized in Table 6.

Table 6. The summary of advantages of hydroponic greenhouse cultivation.

Sr. No	Advantages
1	Year-round crop grown
2	Crops are protected from extreme weather conditions
3	No or little use of pesticides
4	Water use efficiency is nearly about 90 %
5	Reduce the environmental pollution as no use of mechanical plow and other equipment's so that reduce the burning of fossil fuel
6	Human health friendly
7	Solar energy and wind energy can be used to generate electricity to controlling the hydroponic greenhouse environment
8	Sustainable urban growth
9	Reliable harvest
10	Crop can be grow in cities because soil is not required

Future of Hydroponic Greenhouse Cultivation

Hydroponic greenhouse system can play a vital role for the food production in the future (Butler and Oebker, 2006). The future of this technology is very bright because as world population increases, agricultural land come under colonies so to overcome such situation we will need unique system which produce food with limited inputs, hydroponic greenhouse system is only system which could meet the food requirement according to our needs. Rice is harvested four times annually in hydroponic technique, instead of single harvest in open field agriculture (Van et al., 2002). Hydroponic greenhouse system has an ability to feed millions of people in future in third world countries because water and crops are scarce/threaten in those regions although installation cost is high but in the long run all cost will decline, that will make this technology more feasible and convenient (Maharana and Koul, 2011; De Kreij et al., 1999; Raviv et al., 1998). This technology also has future in space and NASA had started working on this technology (Van et al., 2002). Because of its adaptation anywhere in the world it can be assumed that this technology has a bright future ahead.

Conclusion

The review on hydroponic greenhouse cultivation has been done in this paper. Ecological solutions to answer food requirements are today's extremely apprehension. In the developing countries, hydroponic greenhouse cultivation is rising quickly among other agricultural areas. It is concluded that hydroponic greenhouse cultivation technology can be utilized conveniently and it has the potential to raise the production and quality of crop tremendously year-round and has countless benefits. It may not result in any environmental pollution. The problem for need of more land can be solved by growing crops in towers. Increase in yield with efficient use of inputs (water, fertilizer, and pesticides) can be achieved in protected cultivation. The major advantage of hydroponic greenhouse cultivation is efficient usage of natural light. It can also be concluded that environmental factors have a huge impact on the quality of most of hydroponic greenhouse vegetables discussed above. Environmental factors not only affect the external and internal quality of the products, and physiological processes, but also lead to changes in appearance of products.

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