Botany

Explore – Journal of Research
ISSN 2278 – 0297 **(Print)**
ISSN 2278 – 6414 **(Online)**
UGC Approved List of Journals No. - 64404

http://www.patnawomenscollege.in/journal

Different Treatments on Germination and Processing Methods and their Effect on Nutritional and Anti-Nutritional Compositions of Lentils (*Lens Culinaris)*

• **Trisha Tejeswini** • **Puja Rani** • **Vinita Kumari**
• **Pinky Prasad**

Received **:** November 2017
Accepted **:** March 2018
Corresponding Author : Pinky Prasad

Abstract: *The present investigation was aimed at finding suitable treatments to improve germination of lentil seeds, one of the most important crops, to increase the yield. Seeds were treated with different priming solutions viz. osmo, halo, nutrient and hydropriming at different temperatures (5,15, 25 and 35°C). The seeds were treated with UV-radiation and microwave-radiation to see their effects on germination of seeds. The effect of microwave cooking and other traditional cooking methods such as boiling, microwave and autoclaving on the nutritional and anti-nutritional factors of lentils were studied. It was found that hydro-priming at 15°C was found optimum (100%), root and shoot length was found to be maximum, 7.0 cm and 13.5 cm, respectively. On the basis of results obtained from microwave treatment on lentil seeds, it can be concluded that stimulation is stronger for the treatment at shorter exposure time of 30 s than for 90 s and 120 s. The positive effect of stimulation is better expressed for later stages of development on the 15th day. Exposure of hydrated seeds to UV-radiations for 20 and 30 min significantly reduced germination, though the speed of germination was increased. It not only suppressed root and shoot development but also caused curling and twisting of seedlings. From the results obtained from processing methods, it was clear that the microwave cooking caused slight loss in minerals, while boiling and autoclaving caused significant loss. All processing methods caused reduction of tannins and phytic acids. It is quite clear that cooking lentils by microwave not only saves time but also retains nutritive value the most.*

Keywords: Lentils, osmo-priming, nutrient-priming, halo-priming and hydro-priming.

Trisha Tejeswini
B.Sc. III year, Botany (Hons.), Session: 2015-2018,
Patna Women's College, Patna University, Patna,
Bihar, India

Puja Rani
B.Sc. III year, Botany (Hons.), Session: 2015-2018,
Patna Women's College, Patna University, Patna,
Bihar, India

Vinita Kumari
B.Sc. III year, Botany (Hons.), Session: 2015-2018,
Patna Women's College, Patna University, Patna,
Bihar, India

Pinky Prasad
Assistant Professor, Deptt. of Botany,
Patna Women's College, Bailey Road,
Patna–800 001, Bihar, India
E-mail : dr.pinky.prasad@gmail.com

Introduction:

Lentil is one of the most ancient crops, first cultivated 7,000-8,000 years ago (Cubero, 1980; Lev-Yadun *et al*, 2000). Lentil is an important source of protein, minerals & vitamins in human diet (Karakoy *et al*., 2012; Muehlbauer *et al*., 2006; Solanki *et al*., 1999). It contains 36% protein, 90% folate, 330% molybdenum, 21% vitamin B6 and many mineral components.

Seed germination is of primary importance for optimizing seed production of any plant. Pre-sowing seed treatment i.e. seed priming has been reported to have a positive effect on many field crops (Saglam *et al*., 2010). Seed priming treatments are widely used to reduce time between the planting date and the seedling formation period, and to provide uniform plant growth (Parera and Contliffe, 1994).

A number of studies have demonstrated that UV-radiations have significant impact on growth, development, biomass accumulation, yield and metabolism of plants (Rozema *et al.,* 1997; Gao *et al*., 2003). Some studies have also shown the inhibition of stem growth thereby altering the shoot morphology (Kim *et al,* 1998; Kobzar *et al*, 1998).

Microwaves are high frequency electromagnetic radiations, ranging from 300 MHz to 300GHz, wavelengths between 1m &1mm. The microwave irradiations can be used for a short period of time for obtaining significant changes in quality and some properties, like distribution of triglycerides, catalase and peroxidise activities (Oprica, 2008), germination of cereals and other plants (Panomarev *et al*., 1996; Aladjadjiyan and Svetleva, 1997).

Generally, legumes have been reported to have low nutritive value because of low amounts of sulphur containing amino acids, low protein digestibility and the presence of anti-nutritional factors. Legumes are usually cooked before being used in the human diet. This improves the protein quality by destruction or inactivation of the heat labile anti-nutritional factors (Chau *et al*., 1997; Vijayakumari *et al.,* 1998). However, cooking causes considerable losses in soluble solids, especially vitamins and minerals (Barampama and Simard, 1995).

Considering the role of lentils as an important source of protein, minerals and vitamins, the present investigation was aimed at studying the overall effect on nutrients and different priming treatments at different temperatures on the qualitative and quantitative parameters of lentils. Also, the effects of different cooking processes on the nutritional and anti-nutritional composition of lentils were investigated.

Materials and Methods :

Seeds were collected from the local market, small seeds were eliminated and large sized seeds were selected for the present study.

Application of different priming treatments to the lentil seeds at different temperatures: Seeds of lentils were treated with 1% $HgCl_2$ for surface sterilization. 1% KH_2PO_4, 1% KNO_3, 1% $ZnSO_4$, solutions were prepared in distillled water for Osmo-priming, Halo-priming, and Nutrient-priming, respectively. Seeds were kept in distilled water for Hydro-priming. Then the seeds were soaked in above mentioned priming solutions for six hrs at four different temperatures, 5°C, 15°C, 25°C and 35°C, respectively. Twenty seeds from each of the priming treatments were germinated in petri dishes on wet cotton in darkness. The seeds were observed regularly and the germinated seeds were counted after two days. A seed was considered to have germinated when the emerging radical was 1 mm in length. Germination percentage was evaluated by counting the number of normal seedlings at the end of the germination test. The germinated seeds were then grown in pots filled with soil. It was calculated as time between 10% and 90% of germination. After 15 days the lentil plants were taken out of the pots and the length of root and shoot were recorded.

Application of UV radiations on lentil seeds for different periods of time: - Seeds of lentils were first sterilized with 1.0% of mercuric chloride for two minutes, rinsed and soaked in distilled water for 2 hrs. Ten seeds were placed in four petri plates and exposed to UV rays for 0 min (control), 10 min, 20 min and 30 min, respectively. Each of the four sets of treated seeds was grown on wet cotton at room temperature and the observations were noted down daily for a period of 15 days. A small amount of distilled water was added periodically to keep the cotton moist. At the end of the experiment root and shoot lengths of the seedlings and their fresh weights were recorded.

Application of microwave radiation on lentil seeds for different periods of time:- Lentil seeds were initially soaked in distilled water for 1hr. Seeds were distributed in five sets each comprising 10 seeds. Seeds were exposed to the microwave radiation for 0s (control), 30s, 60s, 90s and 120s. The treated seeds were then grown separately in petri plate on wet cotton. A small amount of distilled water was added periodically to keep cotton moist. The influence of the microwave treatment on the following parameters of lentil seeds was studied and recorded:

1. Germination (G) of seeds in percentage (%), determined on 7th day as a ratio of the number of germinated seeds to the total number of seeds
2. Length of stems and roots in cm on the 15th day
3. Total weight (TW) in mg determined on the 15th day

Application of different processing methods on lentils:- 100g of seeds were taken for each of the processing methods and for control (uncooked seeds). They were soaked in distilled water (1:10, w/v) for 12 hrs at room temperature. The seeds were drained and rinsed three times with distilled water, then cooked by microwave cooking, boiling and autoclaving. Uncooked and processed lentils were ground separately using mortar pestle.

Results and Discussion :

Effect of priming treatments on lentil seeds at different temperatures:- From priming treatment it was found that the highest percentage of germination of lentil seeds were obtained by treatment with hydro-priming solution at 15°C (100%) and lowest by treatment with halo-priming solution at 35°C (81.9%). It was evident that the priming treatment of the seeds increased the germination percentage when compared with the control. The data are tabulated in Table 1.

Table 1.

The effect of different priming treatments and temperatures on shoot length and root length was observed and calculated. The data are shown in Table 2. It was found that maximum shoot length (13.5 cm) and root length (7.0 cm) was observed in hydro-priming treatment at 15°C followed by nutrient-priming for shoot length (13.2 cm) and osmo-priming for root length (6.0 cm) at 15°C.

Table 2.

Germination synchrony was affected by priming treatments. The best result was obtained from hydro-priming treatment at 15°C (20 hrs) as compared with other treatments and control. Nutrient-priming, osmo-priming and halo-priming treatments increased the time to reach 50% germination. The effect of different seed priming treatments at different temperatures on Germination synchrony is given in Figure 1.

Figure 1.

In terms of percentage of germination, it was found that hydro-priming was more effective than osmo-priming, nutrient-priming and untreated seeds. This may be related to rapid water uptake in priming treatment with hydro-priming. Similar results were obtained by Yari *et al*. (2010) in wheat, Saglam *et al*. (2010) in lentil and Dezfuli *et al*. (2008) in maize. Furthermore, Ghassemi-Golezani *et al*. (2008) reported that lentil seeds priming with $ZnSO_4$, KH_2PO_4 and KNO_3 also gave higher percentage of germination. Similar results were obtained by Elkoca *et al*. (2007) and Dursun and Ekinci (2010), who reported that percentage of germination at different temperatures, were significantly affected by priming treatments. There was not much effect on germination shown by $ZnSO_4$ but Faruk-Toklu (2015) revealed through his study that $ZnSO_4$ treatment on lentil seeds increases the number of pods per plant and grain yield and he also reported that $ZnSO_4$ treated plants exhibit greater resistance to the disease. However, more research is needed on this topic.

Effect of UV radiations on lentil seeds for different periods of time:- Ten seeds each were placed in four petri plates and the moistened seeds were exposed to UV rays for 0 min (control), 10 min, 20 min and 30 min, respectively. 5 ml distilled water was added to each petri plate. Each of the four sets of treated seeds was grown on wet cotton at room temperature and the length of root and shoot and weight of root and shoot were measured after 15 days. The percentage of germination [G (%)] was calculated. The observations are listed in Table no. 3 and Table 4, respectively. It was found that the maximum shoot length (9.2 cm) and root length (5.8 cm) were observed in control. The longer the exposure to UV radiation, the shorter the shoot length and the root length which were observed, showing adverse effect of UV radiation on lentil plants. Final germination in percentage was found to be maximum in 10 min exposure.

Table 3.

Table 4.

Studies on the effects of UV radiations on plants had consistently demonstrated that increasing of UV radiations induce several morphological characteristics. In the present study, UV exposure of hydrated seeds of lentils for 20 and 30 min significantly reduced the final percentage of germination (Table 4). Noble (2002) investigated the effect of UV-radiation on the seeds of four species and observed that germination was not affected. However, he showed that the speed of germination was increased. Shaukat ***et al***. (2013) reported that in ***Vigna mungo*** the germination velocity was substantially increased but the final percentage of germination remained significantly suppressed by UV-irradiation which is in accordance with the present investigation.

Effect of microwave radiation on lentil seeds for different time periods:- Highest value of percentage of germination (96%) was observed in 30 sec exposure and lowest value was observed at 120 sec exposure as no seed germinated. The percentage of germination was also calculated and is shown in Table 5.

Table 5.

After 15 days of growth root length, shoot length and total weight of the plant were calculated. The root length and the shoot length of lentil plants at different microwave exposure time are shown in Figure 2 and the total weight of the plant is shown in Figure 3.

Figure 2.

Figure 3.

It was found that maximum shoot length (8.1 cm) was observed in 30 sec exposure and maximum root length (4.4 cm) was observed in 60 sec exposure. Total weight of the lentil plant was highest (2.7 g) in 30 sec exposure.

A controversy with the data about RL could be noticed. This controversy could be due to the fact that the RL only of the main root is measured; but there are lateral roots that contribute to the weight and are not accounted for RL. The results obtained in the investigation harmonize well with the investigations on bean seeds and perennials by Anna Aladjadjiyan (1997).

Effect of different processing methods on nutritional and anti-nutritional components of lentils:- The lentil seeds were processed by boiling, autoclaving and microwave cooking. One set was kept uncooked. The nutritional and anti-nutritional compositions of these seeds were calculated. It was found that total protein content was highest (26.2 g/100g) followed by autoclaving and microwave cooking (26.1 g/ 100g in both). Non-protein Nitrogen content was highest (2.2 g/100g) in microwave cooking followed by boiling (2.1 g/100g) and autoclaving (2.0 g/100g). Moisture content was highest (8.63 g/100g) in boiling and minimum (8.4 g/100g) in microwave cooking. The data are shown in Table 6.

Table 6.

Effect of different cooking methods on some selected mineral contents is tabulated in Table 7. It was found that maximum mineral contents were retained in microwave cooking (K 520 mg/ 100g; P 488 mg/ 100g; Na 75 mg/ 100gm; Fe 7.0 mg/ 100g and Zn 3.9 mg/ 100g) followed by autoclaving (K 512 mg/ 100g; P 480 mg/ 100g; Na 73 mg/ 100gm; Fe 6.9 mg/ 100g and Zn 3.8 mg/ 100g) and then boiling (K 420 mg/ 100g; P 462 mg/ 100g; Na 72 mg/ 100gm; Fe 6.1 mg/ 100g and Zn 3.4 mg/ 100g).

Table 7.

After different processing methods, it was observed that tannins were reduced by cooking. The highest reduction was noted after autoclaving (0.81 g/100g) followed by microwave cooking (0.84 g/100g) and then boiling (0.90 g/100g). The highest reduction of phytic acid was noted in microwave cooking (2.4 g/100g) followed by autoclaving (2.5 g/100g) and then boiling (2.6 g/100g). The observations are listed in Table 8.

Table 8.

Different processing methods show different effects on chemical composition of lentils. No significant difference in total protein and moisture contents was observed in different cooking treatments of lentil seeds. These observations are in agreement with those reported by Barampama and Simard (1995) for cooked beans (***Phaseolus vulgaris***). Also, Khatoon and Prakash (2004) and Wang (2005) reported that microwave cooking and pressure cooking do not affect the nutrient composition of eight legumes. Cooking treatments decreased the non-protein nitrogen content as shown in Table 6. This decrease might be attributed to their diffusion into cooking water.

However, microwave cooking resulted in the greatest retention of all minerals, followed by autoclaving, and then boiling (Table 7). Haytowitz and Matthews (1983) reported that cooking in boiling water caused great losses of K (30%) and Fe (10%). Longe (1983) reported losses of 30% Cu and 23% Mg from mature cowpeas when cooked by autoclaving.

Cooking treatments significantly affect the anti-nutritional factors of lentil seeds. Tannins and Phytic acid in lentils were significantly reduced by cooking as shown in Table 8. Similar results were obtained by Vijaykumari ***et al.*** (1998) and Wang ***et al*** (2009).

Conclusion:

It has been observed that hydro-priming at 15°C is optimum for the germination of lentil seeds followed by nutrient-priming, osmo-priming and halo-priming. On the basis of results obtained from microwave treatment on lentil seeds, it can be concluded that stimulation is stronger for the treatment at shorter exposure time of 30 s than 90 s and 120 s. The positive effect of stimulation is better expressed for later stages of development on the 15th day. Exposure of hydrated seeds to UV-radiations for 20 and 30 min significantly reduced germination, though the speed of germination was increased. It not only suppressed root and shoot development but also caused curling and twisting of seedlings. From the results obtained from processing methods, it was clear that the microwave cooking caused slight losses in minerals, while boiling and autoclaving caused significant losses. All processing methods caused reduction of tannins and phytic acids. It is quite clear that cooking lentils by microwave not only saves time but also retains nutritive value the most.

LIST OF TABLES

Table 1. Effect of priming treatments and temperatures on germination percentage of the lentil seeds

Priming solutions	Temperature			
	5°C	*15°C*	*25°C*	*35°C*
Osmo-priming	*86.9%*	*96.9%*	*97.5%*	*84.4%*
Nutrient-priming	*91.3%*	*98.8%*	*97.5%*	*92.5%*
Halo-priming	*97.5%*	*90.0%*	*90.0%*	*81.9%*
Hydro-priming	*93.8%*	*100%*	*98.1%*	*98.1%*
Control	*68.8%*	*82.5%*	*83.8%*	*78.1%*

Table 2. Effect of different priming treatments and temperatures on root length and shoot length of lentil plant

Treatments	Temperatures	Shoot length (cm)	Root length (cm)
Osmo-priming	5°C	12	5.6
	15°C	12.9	6.0
	25°C	11.8	5.5
	35°C	11	4.5
Nutrient-priming	5°C	12.5	4.5
	15°C	13.2	4.9
	25°C	10.8	4
	35°C	9.4	3.3
Halo-priming	5°C	10.8	4.3
	15°C	12.1	5.2
	25°C	11.1	5.5
	35°C	10	4.1
Hydro-priming	5°C	13	6.5
	15°C	13.5	7.0
	25°C	11.5	6.1
	35°C	9.1	5.2
Control	5°C	8.0	4.0
	15°C	9.2	4.3
	25°C	8.1	3.9
	35°C	7.5	3.2

Table 3. Effect of UV-radiations for different time period on root length, shoot length, root weight and shoot weight of lentil plants

UV exposure	Root length (cm)	Shoot length (cm)	Root wt. (g)	Shoot wt. (g)
0 min (control)	5.8	9.2	0.79	1.84
10 min	5.3	7.1	0.62	1.24
20 min	3.4	6.4	0.54	0.90
30 min	2.0	3.2	0.36	0.42

Table 4. Effect of UV-radiations for different time periods on Final germination (%) of lentil seeds

UV-exposure	Final germination (%)
0 min (control)	89.5
10 min	94.7
20 min	70.5
30 min	26.5

Table 5. Effect of Microwave irradiations for different time periods on Germination percentage on lentil seeds

Exposure time (sec)	Germination percentage
Control	92±4.9
30	96±2.5
60	86±8.5
90	14±10.4
120	0

Table 6. Effect of different processing methods on the chemical composition of lentil seeds

Processing method	Total Protein (g/100g)	Non-protein Nitrogen (g/100g)	Moisture (g/100g)
Raw	26.6	2.4	8.52
Boiling	26.2	2.1	8.63
Autoclaving	26.1	2.0	8.55
Microwave cooking	26.1	2.2	8.4

Table 7. Effect of cooking methods on selected mineral contents of lentil seeds (mg/100g dry weight basis)

Processing method	K (mg/ 100g)	P (mg/ 100g)	Na (mg/ 100g)	Fe (mg/ 100g)	Zn (mg/ 100g)
Raw	960	541	78	7.3	4.3
Boiling	420	462	72	6.1	3.4
Autoclaving	512	480	73	6.9	3.8
Microwave cooking	520	488	75	7.0	3.9

Table 8. Effect of different processing methods on the anti-nutritional factors of lentil seeds

Processing method	Tannins (g/100g)	Phytic acid (g/100g)
Raw	1.26	4.11
Boiling	0.90	2.6
Autoclaving	0.81	2.5
Microwave cooking	0.84	2.4

LIST OF GRAPHS

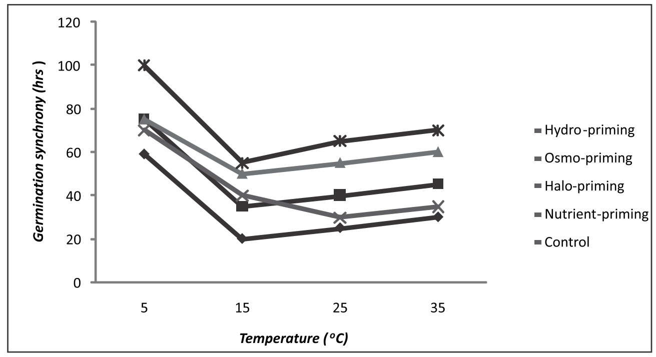


Fig.1. Germination synchrony (h) at different temperatures with different priming treatments

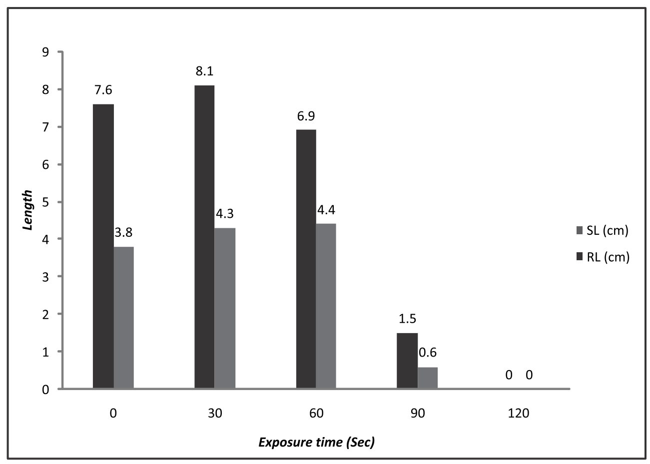


Fig. 2. Effect of microwave irradiations for different time periods on Root Length (RL) and Shoot Length (SL) of lentil plants after15 days

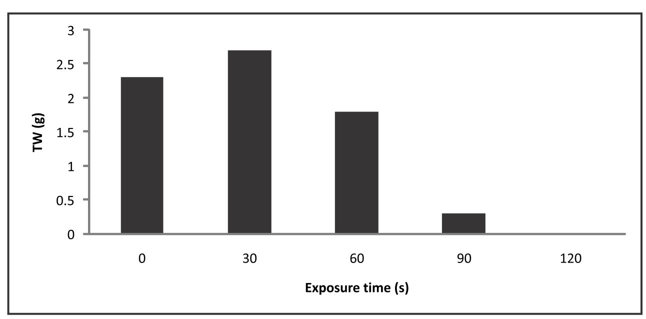
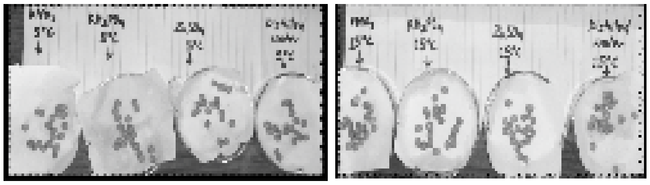
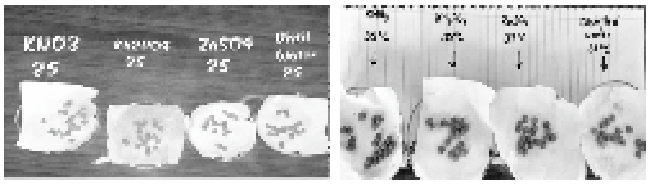


Fig. 3 Effect of microwave irradiations for different time periods on the total weight of lentil plants after 15 days

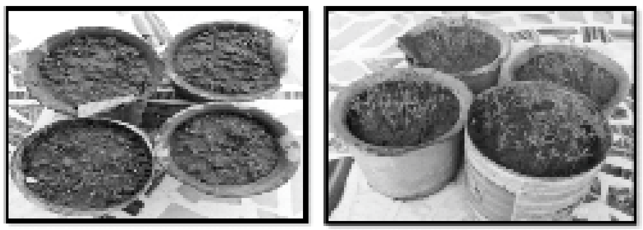


(a) (b)



(c) (d)

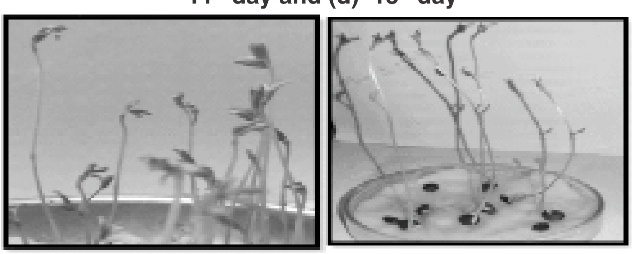
Plate 1. Seeds treated with different priming solutions at different temperatures (a) 5°C, (b) 15°C, (c) 25°C and (d) 35°C



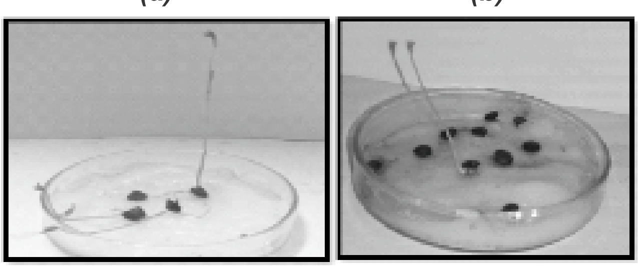
(a) (b)

(c) (d)

Plate 2. Growth of lentil seeds after hydro-priming at 5°C, 15°C, 25°C and 35°C on (a) 3rd day, (b) 7th day, (c) 11th day and (d) 15th day

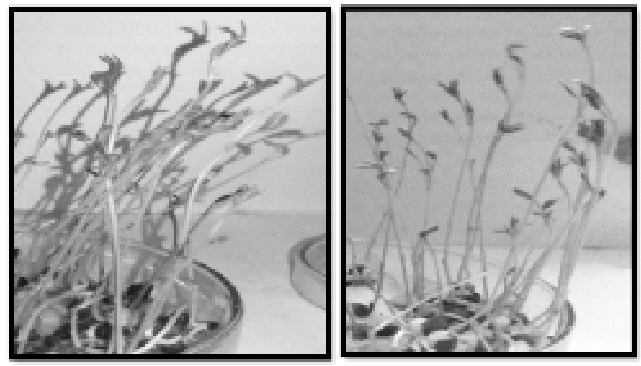


(a) (b)

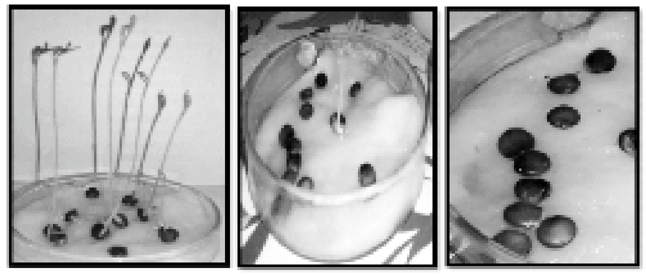


(c) (d)

Plate 3. Growth of lentil plants when seeds exposed under UV-radiation for different time periods at (a) control, (b) 10 min, (c) 20 min and (d) 30 min.



(a) (b)



(c) (d) (e)

Plate 4. Growth of lentil plants under microwave irradiation for different time periods (a) plants grown in control, (b) plants grown at an exposure of 30 seconds in microwave irradiation, (c) plants grown at an exposure of 60 seconds, (d) plants at an exposure of 90 seconds, (e) seeds at 120 seconds exposure in which no growth was observed.

References :

Aladjadjiyan A. andSvetleva D. (1997). Influence of Magnetron Irradiation on Common Bean (***Phaseolus vulgaris*** L.) Seeds, Bulgarian ***Journal of Agricultural Science.*** **3**: 741-747.

Barampana and Simard(1995).Effect of soaking, cooking and fermentation on composition, in-vitro starch digestibility and nutritive value of common beans. ***Plant Food Hum. Nutr.*** **48:** 349-365.

Chau C.F., Cheung P.C. and Wong Y.S. (1997). Effect of cooking on content of amino acids and anti-nutrients in three Chinese indigenous legume seeds. ***Journal of science Food Agriculture***. **75:** 447-452.

Cubero J.I. (1980).Origin, taxonomy and domestication in: Lentils (eds C. Webb & G.C. Hawtin). ***Commonwealth Agricultural Bureau***, Slough, England.15-38.

Dezfuli P.M., Sharif-Zadeh F. and Janmohammadi M. (2008). Influence of Priming Techniques on Seed Germination Behaviour of Maize Inbred Lines. ***ARPN Journal of Agricultueal and Biological Science.*** **3**(3): 22-25.

Dursun A. And Ekinci M. (2010). Effects on different priming treatments and priming durations on germination percentage of parsley seeds. ***Agricultural Sciences***. **1**(1): 17-23.

Elkoca E., Haliloglu K., Esitken A. And Ercisli S. (2007). Hydro-priming and osmo-priming improve chickpea germination. ***Acta Agriculture Scandinavica Section B-Soil and Plant Science.*** **57**:193-200.

Faruk-Toklu (2015). Effects of Different Priming Treatments on seed germination properties, yield components and grain yield of lentil***. Not Bot HortiAgrobo***.**43**(1): 153-158.

Gao W., Zheng Y., Slusser J. R. and Heisler G. M. (2003). Impact of enhanced ultraviolet irradiance on cotton growth, development, yield and qualities under field condition. ***Agri. & For Meteorolo.*** **120**: 241-248.

Ghassemi-Golezani K., Aliloo A. A.,Valizadeh M. And Moghaddam M. (2008). Effects of Different Priming Techniques on Seed Invigoration and Seedling Establishment of Lentil (Lens culinarisMedik.). ***Journal of Food, Agriculture and Environment.*** **6**(2): 222-226.

Haytowitz D. B. and Matthews R. H. (1983). Effect of cooking on nutrient retention of legumes. ***Cereal Foods world.*** **28**: 382-384.

Karakoy T., Erdem H., Baloch F. S., Toklu F., Ekser S., Kilian B. And Ozkan H. (2012). Diversity of macro- and micronutrients in the seeds of lentil landraces***. The scientific World Journal.*** **10:** 1100.

Khatoon N. and Prakash J. (2004). Nutritional quality of microwave cooked and pressure cooked legumes***. Int. J. Food Sci. Nutr***. **55**: 441-448.

Kim B. C., Tennessen D. J. and Last R. L. (1998). Photo morphogenesis Arabidopsis thaliana***. Plant Journal***. **16**: 823-830.

Kobzar E. P., Kreslavsk V. D. and Muzafarov E. N.(1998). Photomorphogenic responses to UV-radiation and short-term red lighting lettuce seedlings. ***Pl. Grow. Regula***. **26:** 73-76.

Lev-Yadun S. (2000). ***The Cradle of Agriculture Science.*** **288:** 1602-1603.

Longe O.G. (1983). Varietal differences in chemical characteristics related to cooking quality of cowpea. ***J. Food Process. Preserv***. **7:** 143-150.

Muehlbauer F.J., Cho S., Sarker A., McPhee K. E., Coyne C. J., Rajesh P. N. and Ford R. (2006). Application of biotechnology in breeding lentil for resistance to biotic and abiotic stress***. Euphytica.*** **147**: 149-165.

Oprica L. (2008). Effect of microwave on the dynamics of some oxidoreductase enzymes in ***Brassica napus*** germination seeds, ***Scientific Annals of University "AlexandruloanCuza", Section Gnetics and Molecular biology.*** **9** (4): 11-16.

Parera C. A. And Cantliffe D. J. (1994). Pre-sowing seed priming. ***Hortic Rev.*** **16**: 109-141.

Ponomarev L. I., Dolgodvoro V. E., Popov V. V., Rodin S. V. and Roman O. A. (1996). The effect of low-intensity electromagnetic microwave field on seed germination (in Russian), ***Proceedings of Timiryazev Agricultural Academy.*** **2**: 42-46.

Rozema J., Van de S. J., Bjorn L. O. and Caldwell M. (1997). UV- B as an environmental factor in plant life: stress and regulation. ***Trends Ecol.*** **12**: 22-28.

Saglam S., Day S., Kaya G. and Gurbuz A. (2010). Hydro-priming Increases Germination of Lentil under water Stress. ***Not Sci. Biol***. **2**(2): 103-106.

Shaukat S. S., Farooq M. A., Siddiquei M. F. and Zaidi S. (2013). Effect of enhanced UV-B radiations on germination, seedling growth and biochemical responses of ***Vigna mungo. Hepper. Pak. J. Bot.*** **45**(3): 779-785.

Solanki I. S., Kapoor A. C. and Singh U. (1999). Nutritional parameters and yield evaluation of newly developed genotypes of lentils (***Lensculinaris***). ***Plant Food Hum. Nutr.*** **54**: 79-87.

Vijayakumari P., Siddhuraju P., Pugalenthi M. and Janardhan K. (1998). Effect of soaking and heat processing on the levels of anti-nutrients and digestible proteins in seeds of ***Vignaaconitifolia*** and ***Vignasinensis***. ***Food Chem.*** **63**: 259-264.

Wang N. (2005). Optimization of a laboratory dehulling process for lentils. ***Cereal Chem.*** **82**: 671-676.

Wang N., Hatcher D. W., Toews R. and Gawalko E. J. (2009). Influence of cooking and dehulling on nutritional composition of several varieties of lentils. ***Food Sci. Technol***. **42**: 842-848.

Yari L., Aghaalikani M. And Khazaei F. (2010). Effect of seed priming duration and temperature on seed germination behaviour of bread wheat. ***ARPN Journal of Agricultural and Biological Science.*** **5**(1): 1-6.