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Effect of packaging material and storage conditions on potato (*Solanum tuberosum* L.) microtuber storability

Murlidhar Sadawarti*, R. K. Samadhiya, K. K. Pandey, R. K. Singh, S. P. Singh, S. Roy and Y. P. Singh

ICAR-Central Potato Research Station, Gwalior -474020(MP), INDIA
ICAR-Central Potato Research Institute, Shimla- 171001(HP), INDIA
ICAR-Indian Institute of Vegetable Research, Varanasi -221305(UP) , INDIA
*Corresponding author. E-mail: murlidharsada@gmail.com

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Abstract: An experiment was conducted at the ICAR-Central Potato Research Station, Gwalior (MP) during 2012-13 to study best packaging material and storage conditions for short term storage of potato microtubers of important varieties. Ten Micro tubers each of three popular varieties *viz* Kufri Sindhuri, Kufri Lauvkar and Kufri Chandramukhi (KCM) were packed in 5 packaging materials/ storage containers *viz* polythene without ventilation, polythene with ventilation, conical flask with cotton plug, conical flask with plastic cap and petri plates and kept in three storage condition *viz* ambient temperature, refrigerator (4^0C) and plant growth chamber (3^0C). After 45 days of storage of potato microtubers, at 5 per cent level of significance both *percent* overall weight loss and driage/ rottage was significantly low in polythene without ventilation (13.19 and 10.37 respectively) among packaging material and among storage conditions, at 5 per cent level of significance both *percent* overall weight loss and driage/ rottage was significantly low in growth chamber condition of 4^0C (12.77 and 12.44 respectively) over other two storage conditions. Kufri Sindhuri recorded significantly lowest overall *percent* weight loss (17.95) and driage/ rottage (8.00) at 5 *percent* level of significance over KCM and Kufri Lauvkar. Kufri Sindhuri has better storability under growth chamber condition at 3^0C in polythene without ventilation packaging up to 45 days.

Keywords: Microtuber, Packaging material, Potato weight loss, Storage

INTRODUCTION

Potato microtubers are produced *in vitro* in different growing systems with varying environment, media constituents, and storage intervals. (Badoni and Chauhan, 2009; Nistor *et al*., 2012). Microtubers are also important components, along with plantlets and minitubers, for seed tuber production programs in Europe, North America and some South American countries, China and India. Microtuber production systems have contributed to improved self-sufficiency, reduced number of field generations in seed tuber production, and reduced disease incidence in commercial plantings (Donnelly *et al*, 2003).They are used to solve the problems of transplanting the plantlets from *in vitro* to *in vivo* conditions. *In vitro* microtuber production is very important for the production and storage of a potato valuable stock. Mass production of potato microtuber is likely to revolutionize the world potato production (Kanwal and Shoaib, 2006 and Liljana *et al*., 2012).

Potato microtubers production dependent on size and number of microtubers produced per cycle. Induction of microtubers in potato dependent on combination of growth regulators of cytokines and auxins (Hossain, 2005).Microtubers are utilized for minituber (small tubers produced from *in-vitro* produced propagules) production in greenhouses or screen houses and, less commonly, are directly field planted (Donnelly *et al*., 2003). Microtubers and minitubers (nuclear tubers) has biological potential and could be integrated with success on seed potato production program (Struik and Wiersema 1999; Pruski*et al*, 2003). Microtuberof 0.5g is enough to use as seed material (Park *et al*., 2009). Use of potato microtubers (MT), small potato tubers weighing less than 5 g fresh weight and produced *in vitro* can be a potential alternative to conventional imported seed because they are typically pathogen-tested and can be produced in any region (Kawakami *et al*., 2003).

Storability and sprouting characteristics of *in vitro* tubers could be improved if the size of tubers could be increased (Tábori *et al*., 1998).Suitable and qualitative packaging has a major role in maintaining the quality of the product and also in the convenience of customer use (Ahvenainen, 2003).Packaging is essential for products intended for long-term storage because storage time and temperature significantly affect the appearance, aroma, taste and structure (Clark *et al*., 2002). Plastic packaging can help to increase the stor-

age life of perishables and processed products (Suryawanshi, 2008).Different storage areas experience different temperature and relative humidity conditions; it has a great role in the quality of the stored potato tubers (Abeygunawardena *et al*., 1964). Perforated polythene covers are generally used for storage in a refrigerator for 4-5 months until planting (Pandey, 2014). The inability to properly cool potatoes will result in increased weight loss and elevated potential for pathogenic decay and collectively resulting in higher losses of the stored crop (Olsen, 2014). Storage of microtubers in ambient condition causes significant weight loss during the first few hours after harvesting results in deterioration of seed quality and poor sprout emergence (Hossain *et al*, 2017). There is very scanty information about short term storability of potato microtubers. Considering the above facts, an experiment was planned to study the effect of different packaging material and storage conditions on potato microtuber storability.

MATERIALS AND METHODS

An experiment was conducted at the ICAR-Central Potato Research Station, Gwalior (MP) during 2012-13.Micro-tubers of potato were produced in the laboratory at CPRI, Shimla from *in-vitro* raised virus free micro-plants following standard protocol. Microtubers were stored in cold stored under 4^0C and taken out and sent to CPRS, Gwalior for present study. Ten microtubers each of three varieties *viz.* Kufri Sindhuri, Kufri Lauvkar and Kufri Chandramukhi were packed in 5 packaging materials/ storage containers *viz* Polythene without ventilation, polythene with ventilation, conical flask with cotton plug, conical flask with plastic cap and petri plates and kept in three storage condition *viz* ambient condition, refrigerator (4^0C) and plant growth chamber at 3^0C. Experiment with 45 combinations replicated three times in completely randomized block design. Experiment was started on 19th November 2012 and physiological weight loss and driage/rottage by number was recorded at 15 day interval up to 45 days. Data was analyzed statistically by analysis of variance (ANOVA) with factorial Completely Randomized Design and means were calculated and separated using F-test at 5% level of significance. *Percent* draige/ rottage (by number) were transformed into square roots ($\sqrt{x}$ +0.5) and analyzed as per the statistical methods proposed by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Physiological weight loss (PWL): After 45 days of storage *per cent* weight loss was significantly lowest in polythene without ventilation (13.19) followed by conical flask with plastic cap (13.25) at 5% level of significance over other packaging materials and highest was recorded in conical flask with cotton plug (27.44) (Table 1). Weight loss was minimum (58.6%) in cloth bag at the end of storage period of 306 days in Kufri Giridhari aerophonic potato minitubers when stored in five packaging material *viz* yellow cloth bag, muslin cloth bag, plastic net bag and gunny bag in culture room (non-hermetic)at 22 ± 1^0C temperature with 16 hours of light and 8 hours of darkness under Shimla conditions (Pandey *et al*., 2014). When three grades of microtubers of Kufri Chandramukhi and Kufri Megha stored for 8 months at 4^0C in perforated poly bags and then kept for 3 months in 5 different packaging materials *viz*, plastic bag, butter paper, muslin cloth, brown paper and paper box at ambient temperature at Shimla. The plastic paper bag and butter bag found to be best packaging material with minimum weight loss for all the grades and varieties (Sharma *et al.,* 2014). This confirms the present finding of polythene bag is best packaging material for potato microtubers.

Among storage conditions *per cent* weight loss was significantly lowest when microtubers stored in growth chamber at 3^0C (12.77) at 5 *percent* level of significance over ambient condition (27.94) and storage in refrigerator at 4^0C (18.84) Table 1.Microtubers can be stored at room or in refrigerator (4^0C) temperatures for many months (Dodds 1988). When Freshly harvested mini-tubers of Kufri Giridhari of four grades, *viz.* >20g, 10-20g, 3-10gand <3g packed in perforated polythene and stored in ambient temperature both in kharif and *autumn* season for 210 and 120 days respectively, Loss in weight in all the grades of mini-tubers at the end of storage period in both the season were observed and can be attributed to the degradative and natural senescence on account of respiration and other metabolic processes in the living tissues of potato mini-tubers during storage (Sharma and Pandey, 2016). This confirms the result of the present study as higher weight losses were reported in ambient conditions in all the packaging material.

Total weight loss in potato varieties determines the longevity of their storage and also their keeping quality. Among varieties, *per cent* weight loss was significantly low in Kufri Sindhuri (17.95) and Kufri Lauvkar (19.89) at 5 per cent level of significance over Kufri Chandramukhi (21.70). Among 7 genotype stored at 4-6^0C for 6 months, minimum (8.25 %) and maximum (13.00 %) storage loss was observed in genotypes MF-II and TPS-67, respectively(Kale and Kothekar,2006).Physiological weight loss was least among 6 varieties in *Kufri* Surya and the highest was in Kufri Pukhraj in all the grades of micro-tubers of potato when stored in Polythene bags in a refrigerator under continuous darkness at a temperature of 4^0C and relative humidity of 85-90%, for three months and shifted to incubation (culture) room at a temperature of 22 + 2°C for 2 weeks followed by storage for 2-weeks at room temperature (about 18^0C) for sprouting (Sharma *et al* 2012).Significantly higher PLW in Kufri Pukhraj than Kufri Chipsona-1 was observed during storage of

Table 1. Effect of packaging material/storage conditions and their interactions on microtuber storability.

Packaging material/ storage conditions	Physiological weight loss (%)				Rottage/ driage of microtubers (%)			
	Ambient temperature	Refrigerator (4^0C)	Growth chamber (3^0C)	Mean	Ambient temperature	Refrigerator (4^0C)	Growth chamber (3^0C)	Mean
Polythene without ventilation	19.33	12.75	7.50	13.19	14.44 (3.42)	12.22 (3.02)	4.44 (1.76)	10.37 (2.73)
Polythene with ventilation	28.32	21.40	15.16	21.63	22.22 (4.57)	5.56 (2.17)	21.11 (3.70)	16.30 (3.48)
Conical flask with cotton plug	36.85	29.46	16.00	27.44	26.67 (4.86)	16.67 (3.96)	10.00 (2.56)	17.78 (3.79)
Conical flask with plastic cap	19.62	10.51	9.62	13.25	40.00 (5.90)	16.67 (3.98)	16.67 (3.53)	24.44 (4.47)
Petri plates	35.58	20.07	15.55	23.74	30.00 (5.20)	16.67 (4.01)	10.00 (2.51)	18.89 (3.91)
Mean	27.94	18.84	12.77	19.85	26.67 (4.79)	13.56 (3.43)	12.44 (2.81)	17.55 (3.68)
LSD (0.05)	Packaging material		1.81				0.82	
	Storage conditions		1.40				0.64	
	Interaction		3.31				NS	

* Data in parenthesis are square root transformed values

Table 2. Effect of packaging material/varieties and their interactions on microtuber storability.

Packaging material/ Varieties	Physiological weight loss (%)				Rottage/ driage of microtubers (%)			
	KCM	K Sindhuri	K Lauvkar	Mean	KCM	K Sindhuri	K Lauvkar	Mean
Polythene without ventilation	16.16	13.26	10.16	13.19	6.67 (2.31)	1.11 (1.26)	23.33 (4.64)	10.37 (2.73)
Polythene with ventilation	24.00	19.33	21.55	21.63	18.89 (3.59)	7.78 (2.26)	22.22 (4.60)	16.30 (3.48)
Conical flask with cotton plug	27.06	20.65	34.60	27.44	28.33 (4.83)	10.00 (3.06)	15.00 (3.48)	17.78 (3.79)
Conical flask with plastic cap	14.93	16.16	8.65	13.25	20.00 (4.22)	10.00 (2.82)	43.33 (6.37)	24.44 (4.47)
Petri plates	26.33	20.36	24.51	23.74	30.00 (5.49)	11.11 (2.96)	15.56 (3.27)	18.89 (3.91)
Mean	27.70	17.95	19.89	19.85	20.78 (4.09)	8.00 (2.47)	23.90 (4.47)	17.55 (3.68)
LSD (0.05)	Packaging material		1.81				0.82	
	Varieties		1.40				0.64	
	Interaction		3.13				1.43	

* Data in parenthesis are square root transformed values

Table 3. Effect of storage conditions/ varieties and their interactions on microtuber storability.

Storage conditions/ varieties	Physiological weight loss (%)				Rottage/ driage of microtubers (%)			
	KCM	K Sindhuri	K Lauvkar	Mean	KCM	K Sindhuri	K Lauvkar	Mean
Ambient temperature	29.48	28.71	25.63	27.94	34.00 (5.67)	8.67 (2.73)	37.33 (5.98)	26.67 (4.79)
Refrigerator (4^0C)	21.03	14.06	21.43	18.84	10.67 (3.05)	11.67 (3.07)	18.33 (4.16)	13.56 (3.43)
Growth chamber (3^0C)	14.58	11.09	12.63	12.77	17.67 (3.54)	3.67 (1.61)	16.00 (3.27)	12.44 (2.81)
Mean	27.70	17.95	19.89	19.85	20.78 (4.09)	8.00 (2.47)	23.90 (4.47)	17.55 (3.68)
LSD (0.05)	Storage conditions		1.81				0.64	
	Varieties		1.40				0.64	
	Interaction		3.13				1.10	

* Data in parenthesis are square root transformed values

tubers of these cultivars at room temperature (Kumar *et al*., 2005). Under ambient storage conditions of three years up to 75 days of storage, Kufri Sindhuri recorded minimum weight loss (8.1%) followed by Kufri Chandramukhi and Kufri Lauvkar when studied for 44 indigenous varieties of potato and also reported that storability varied according to climatic conditions during the years (Gupta *et al* , 2015). Hossain *et al* (2017) reported that at 90 days of storage the maximum weight loss was observed in microtuber of variety Granola followed by Diamant and the minimum in Asterix under refrigerator (4^0C).This confirms the varietal difference in storage behavior.

Interaction: In interaction study between packaging material x storage condition, polythene without ventilation under growth chamber conditions (7.50%), conical flask with plastic cap under growth chamber condition (9.62%) and conical flask with plastic cap under (10.51 %) recorded significantly lower PLW over all the interactions at 5 *percent* level of significance and highest was recorded in microtuber stored in conical flask with cotton plug under control condition (36.85%) table 1.

In packaging material x variety interaction, potato microtuber of Kufri Lauvkar stored in conical flask with plastic cap (8.65%) and microtuber of Kufri Lauvkar stored in polythene without ventilation (10.16%) recorded significantly lower PWL over all the interactions at 5 *percent* level of significance and highest was recorded in microtuber of Kufri Lauvkar stored in conical flask with cotton plug (34.60%) table 2.

In storage conditions x variety interaction, potato microtuber of Kufri Sindhuri stored in growth chamber (11.09 %) recorded significantly lower PWL at 5 *percent* level of significance and highest was recorded in microtuber of KCM stored under control conditions (29.48%) table 3

In packaging material x storage condition x variety interaction, significantly lowest weight loss was recorded in microtuder of Kufri Lauvkar stored in polythene without ventilation under growth chamber condition at 3^0C (6.89%) at 5 *percent* level of significance and highest was recorded when microtuber of Kufri Lauvkar stored in petriplates under control condition (42.96%). Storage conditions and containers/ packaging materials have influence on storability of potato microtubers. When three grades (4, 6 and 8 mm) of microtubersof Kufri Chandramukhi stored for 8 months at 4^0C in perforated poly bags and then kept for 3.5 months in plastic petriplates, ventilated culture bottles and perforated plastic bags under ambient conditions, non-hermatic and hermetic culture rooms at Shimla, weight loss was higher in 4 mm as compared to 6 &8 mm. The weight loss varied from 14.9-75.3%. Ventilated culture bottles were found to be better container/ storage material than plastic petriplates and perforated plastic bags (CPRI, 2013).

Draige/rottage: After 45 days of storage *per cent* driage/ rottage by number was significantly lowest in polythene without ventilation (10.37) over conical flask with cotton plug (24.44) at 5% level of significance.

Among storage conditions *per cent* driage/ rottage was significantly lower in growth chamber at 3^0C (12.44) and in refrigerator at 4^0C (13.56) over control condition (26.67) at 5% level of significance (Table 1). Among varieties, *per cent* draige/ rottage was significantly lower in Kufri Sindhuri (8.00) over Kufri Lauvkar (23.89) andby Kufri Chandramukhi (20.88) over 5% level of significance (Table 2).Sharma *et al.* (2012) reported proportions of viable micro-tubers at the end of storage was the highest (68.4%) in Kufri Badshah and the lowest (26.5%) in Kufri Pukhraj, which can be attributed to the better quality of micro-tubers with intact lenticels in Kufri Badshah and vice-versa in Kufri Pukhraj when stored in polythene bags in a refrigerator under continuous darkness at a temperature of 4^0C and relative humidity of 85-90%, for three months and shifted to incubation (culture) room at a temperature of 22 + 2°C for 2 weeks followed by storage for 2-weeks at room temperature (about 18^0C) for sprouting. Viability of micro-tubers was affected significantly by the size of micro-tuber as well as by the potato genotypes (Tabori *et al*., 1999 ; Sharma *et al.,* 2012). Hossain *et al* (2017) reported that maximum decayed micro tubers *percent* were recorded in variety Granola (14.24) over variety asterix and diamant (10.42) when stored in refrigerator (4^0C) up to 90 days. The present study confirms the varietal difference in draige/rottage.

Interaction: In packaging material x storage condition interaction, significantly lowest driage/ rottage was recorded in polythene without ventilation in growth chamber condition (4.44%) and in polythene with ventilation in refrigerator (5.56%) at 5 *percent* level of significance (Table 1). In packaging material x variety interaction, storage of Kufri Sindhuri (1.11%) followed by Kufri Chandramukhi (6.67%) in Polythene without ventilation recorded significantly lowest draige/rottage at 5 *percent* level of significance. Kufri Sindhuri in all the packaging material recorded lower rottage %. Highest rottage was recorded in Kufri Lauvkar when stored in conical flask with plastic cap (40.33%) table 2.In storage conditions x variety interaction, Kufri Sindhuri in all the storage conditions recorded lower rottage and significantly lowestrottage was found in Growth chamber condition (3.67%) at 5 *per cent* level of significance. Higher driage/rottage was found in Kufri Chandramukhi and Kufri Lauvkar in all the storage conditions and highest was recorded in Kufri Lauvkar (37.33%) and Kufri Chandramukhi (34.00) under control conditions (Table 3).

In packaging material x storage condition x variety interaction, lower draige/ rottage was recorded in Kufri Sindhuri in all the packaging material and growth conditions. Significantly highest draige/ rottage was recorded in Kufri Lauvkar stored in conical flask with cap in control condition (70%) followed by Kufri Chandramukhi (50.0%) in Conical flask with cotton plug under control conditions at 5 per cent level of significance. After three

months of storage in vented plastic bags at 4^0C and 85-90% RH in continuous darkness, microtubers of cultivar Kufri Kanchan recorded significantly higher (34.5%) and Kufri Anand (9.8%) lowest *per centt* of dried tubers among 10 cultivars (Venkatasalam *et al*., 2011).

Conclusion

For short term storage of potato microtubers up to 45 days, polythene without ventilation (minimum weight loss and driage 13.19 % and 10.37 % respectively) found to be best packaging material, growth chamber condition at 3^0C best storage condition (minimum weight loss and driage 12.77 % and 12.44 % respectively) and among varieties Kufri Sindhuri had best storability (minimum weight loss and driage 17.95 % and 8.00 % respectively.

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