Original Research Article

Study of pre-storage plant extract application on sprouting, rot and weight loss of two cultivars of frafra potatoes [*Solenostemon rotundifolius* (Poir.)] from Upper East Region, Ghana

ABSTRACT:

Present study conducted to determine the effect of pre -storage plant extract treatments (ginger rhizome extract, neem bark extract and pawpaw leaf extract) on sprouting, rot (decay) and weight loss of two cultivars of frafra potatoes (*Solenostemon rotundifolius*).

The total percentage sprout at the end of the storage period (week 21) did not show significant differences in all extract treated tubers. The cultivar and interactive effect did not also show any significant effect. However, neem bark extract treated tubers recorded the least sprouting in both cultivars at the end of the storage period.

The extracts had no significant effect on weight loss after the storage period. However, the cultivar effect and the interactive effect of extracts and cultivars on weight loss showed significant variation ($P < 0.05$).

There were no significant differences on percentage rot among the extract treated tubers. Also, the cultivar effect and interactive effect were not significant. However, the percentage rot recorded was very low in all extract treated tubers when compared to the control.

Present result suggested that higher concentrations of neem bark extract effect on sprouting should be investigated since its sprout suppressing ability was prominent on both cultivars at the end of the storage period.

1. INTRODUCTION

Solenostemon rotundifolius is a herbaceous perennial which is normally cultivated as an annual [1]. According to [2], *Solenostemon rotundifolius* belong to the family Labiatae (lamiaceae). The plant is known by the following scientific names: *Coleus parviflorus* (Benth) [3], *Coleus rotundifolius* [4], *Coleus esculentus*, *Coleus dazo* [5] and *Coleus dysentericus* (Baker) [6]. According to Peter [7], *Solenostemon rotundifolius* is also known by the following vernacular names: Hausa potato, frafra potato, Sudan potato, pomme de terre du Soudan, frafra-salaga, saluga, tumuku, fabirama and China potato.

In Ghana, *Solenostemon rotundifolius* (frafra potato) is mainly grown in the Guinea and Sudan Savannah agro-ecological zones [8], specifically in the Builsa, Kassena-Nankani, Bolgatanga, Lawra-Nandom, Jirapa-Lambussie, Nandawli and Wa districts of the Upper East and West Regions [9]. It has however been observed that the crop also does well in the moist semi deciduous forest ecology of Ghana [8].

The tubers of frafra potatoes are mostly boiled before consumption. However, they can also be roasted, baked, or fried. Indeed, frafra potatoes can probably replace potato (*Solanum tuberosum*) in each and every recipe, even potato salad [1].

Frafra potatoes also have some medicinal importance. Apabol [10] revealed that frafra potato is used in the treatment of dysentery, blood in urine and eye disorders in Africa. Apabol [10] further indicated the crop also has a lot of socio-cultural importance such as presentation as gifts to in-laws, served as food to mourners at funerals, and snacks at child naming ceremonies. According to Tetteh [9], a local alcoholic drink has also been brewed from frafra potato. It is also believed that one can stay for a long time without food after a meal of frafra potatoes. For this reason, it is the favourite dish served to hunters or persons engaged in strenuous activities which demand that they stay off food for long periods of time.

Frafra potato is particularly used as a food security crop and is usually harvested and stored for use during the long dry season [11]. This implies that the importance of frafra potato in the fight against food insecurity cannot therefore be downplayed. According to NRC [1], frafra potatoes are clonal crops that are easy to handle and propagate. They are found in the areas of low agricultural potential across the neediest regions of the continent. They occur in locations where a shortage of suitable vegetable crops now results in endemic malnutrition and they are capable of producing large amounts of nutritious food from a small land area. NRC [1] further indicates that taken all round, frafra potatoes could prove good tools for reducing malnutrition and hunger while improving farm profitability and providing African families with greater food security.

Due to its relatively low starch content, when compared with other tropical tuber crops such as cassava and sweet potato, frafra potato is a crop with export potential to places such as Europe and the Middle East where non-fattening foods are in high demand [12].

In spite of the importance of frafra potatoes as a food security crop and its potential as an export crop, its cultivation appears to be declining in areas of its production in Ghana. The decline in production is as a result of problems encountered by farmers in the production of the crop. According to [9, 13], spoilage (rot) in storage, pest and diseases are some of the chief problems contributing significantly to the current poor state of production of the crop in Ghana.

This research work therefore has the overall objective of determining the effect of three pre-storage plant extracts treatments (ginger rhizome extract, neem bark extract and pawpaw leaf extract) on sprouting, rot (decay) and weight loss of two cultivars of frafra potatoes (*Solenostemon rotundifolius*).

2. MATERIALS AND METHODS

2.1 Geographical location of experiment

The experiment was carried out in the laboratory of the Department of Horticulture, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

2.2 Source of cultivars and botanicals

Black and Brown cultivars of Frafra potato tubers were used for the experiment. These tubers were all obtained from a single farm in Bongo-soe, in the Bongo district of the Upper East Region of Ghana. The farm was monitored from planting to harvest. The tubers were obtained on the day of harvest and transported on that same day to the location of the experiment. In all, eight hundred tubers were used for the study. This comprised of four hundred (400) black cultivar tubers and four hundred (400) brown cultivar tubers. The botanicals from which the extracts were prepared from were pawpaw (*Carica papaya*) leaves, neem (*Azadirachta indica*) barks, and rhizomes of Ginger (*Zingiber officinale).*

Plate 1: Botanicals (Neem bark, ginger rhizome and pawpaw leaves) used for the experiment

Plate 2: Brown cultivar of Frafra potatoes   Plate 3: Black cultivar of Frafra potatoes

2.3 Extract preparation and application

Fresh leaves of pawpaw and neem barks were obtained from trees on KNUST campus. However, the rhizomes of Ginger, *Zingiber officinale,* were bought from the Ayigya market in Kumasi. All the botanicals were washed and then dried aseptically. Each tested part (1kg) was taken and separately made into fine paste and were added into four litres of water, respectively, and then stirred thoroughly so it is evenly mixed. The prepared extracts were then allowed to settle for eighteen hours. After that, the tubers (black and brown cultivars) were soaked in the prepared tested extracts for 30 minutes respectively while tubers soaked in water was taken as control for comparison.

2.4 Measurement

Data was collected on the following parameters during the experiment:

2.4.1 Temperature and relative humidity of storage room

Daily temperature and humidity readings were taken at different time intervals (9.00 am, 12.00 pm, 6.00 pm and 12.00 am) during storage. The "Acurite" indoor digital humidity and temperature Monitor (00325) was used to take the readings.

2.4.2 Weight of tubers

The weight of tubers was recorded every two weeks. The measurement was done in grammes with Kern electronic Precision Scale PCB 350-3. Weight loss of tubers (WL) was calculated by subtracting final weight of tuber (W_2) from initial weight of tuber (W_1) as shown below:

$WL = W_1 - W_2$ …………..Equ. 1

2.4.3 Number of decayed tubers

Counting and recording of decayed tubers (tubers showing visible signs of rot) was done every two weeks. Percentage rot was calculated as shown below:

Percentage rot (%) = Number of decayed tubers at the end of the storage period / Total number of tubers stored X 100…………….Equ. 2

2.4.4 Number of sprouted tubers

Counting and recording of sprouted tubers was done every two weeks. This was done by visually observing and recording tubers showing signs of sprouting. Percentage sprout of tubers was calculated as shown below:

Percentage tuber sprout (%) = Number of sprouted tubers / Total number of tubers stored X 100…………….Equ. 3

2.5 Experimental design and analysis

A 2 x 4 factorial in a completely randomized design was used with two cultivars and four treatments which were replicated three times. Data resulting from individual parameters were subjected to analysis of variance using Statistix Student version 9.0 and means separated at 5 percent ($p=0.05$) least significant differences.

3. RESULTS

3.1 Temperature and humidity of the storage room

Temperature readings over the storage period showed significant variations ($p<0.05$) only in the evening and at mid night. Week 15 recorded the highest average temperature of 30.5 °C in the evening while the lowest was recorded at week 4 (24.8 °C). Midnight temperatures readings showed week 17 recording the highest of 26.6 °C and week 12 having as low as 20.3°C. Both morning and afternoon temperatures did not vary significantly ($p>0.05$) with temperature readings ranging from 24.0 °C to 27.3°C in the morning and 28.0°C to 30.1°C in the afternoon.

The highest temperature over the whole period was record in the evening while the lowest was recorded at mid night.

With respect to the relative humidity of the storage environment during the storage period, significant differences ($p<0.05$) were observed between the weeks. Morning readings in Week 17 recorded the highest humidity of 82.0% while week 9 recorded a lower relative humidity value of 38.1 %. Afternoon readings observed week 17 having as high as 73.0 % relative humidity value while week 9 recorded as low as 20.7%. Week 4 had a higher relative humidity value of 77.7 % in the evening while week 9 recorded the lowest of 27.8 %. During the midnight humidity readings, week 4 recorded the highest humidity of 89.0 % as against the lowest recorded in week 9 (54.0 %). At Week 9, the harmattan season was at its peak and might have contributed to the low humidity recorded. The harmattan season is normally associated with low humidity.

The overall highest humidity value was recorded at midnight while the lowest was recorded in the evening.

The average temperature reading over the storage period ranged from 24.0°C and 29.0 °C. The highest average temperature recorded over the storage period was 29.0°C. This was recorded during midday and in the evening at 6:00 pm. The lowest was recorded at (12:00 am).

Average relative humidity reading during the storage period ranged from 58.0 % at 12:00 noon and 6:00 pm and 78.0 % at 12:00 midnight. This reading was inversely proportional to that of the temperature reading thus relative humidity increased with decreasing temperature.

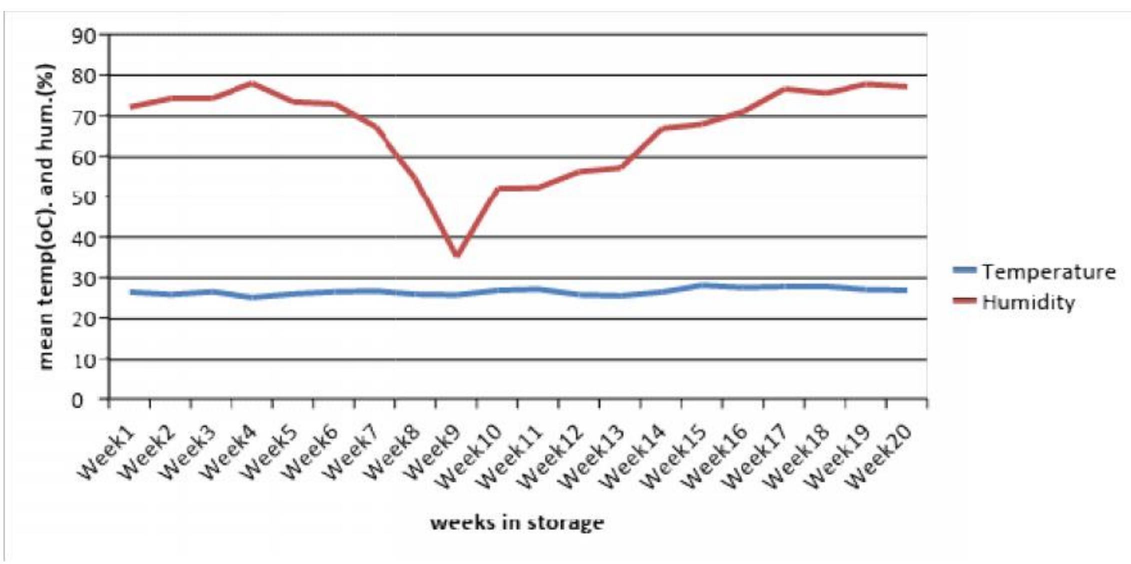

Figure 1: Average temperature and Relative Humidity values over the Storage Period.

3.2: Effect of the extracts on percentage sprouting

The results in Table 1 below show the effect of the extracts on sprouting of frafra potato. From the results in the table, sprouting was observed to have started from the 11week onwards with percentage of sprouted tubers increasing with duration of storage.

From the results, the control recorded significantly higher sprouting as compared to the extracts. At week 11, the control recorded significantly higher percentage sprout of 1.74 % as against 1.55 % by neem bark extracts, 1.40 % by Ginger rhizome extract and 1.54 % by pawpaw leaf extract. Week 13 also showed the control recording a higher sprouting of 2.39 % which was significantly higher than that recorded by the ginger rhizome extract (1.72 %), Pawpaw leaf extract (1.93%) and neem bark extracts (1.95 %). The control still recorded significantly higher percentage sprout of 3.68% at week 15 which was statistically different from that recorded by the neem bark extract (3.21 %), ginger rhizome extract (2.83%) and pawpaw leaf extract (3.16 %). Week 17 however saw the control recording a lower percentage sprout of 4.47 % which was not statistically different from that of the Pawpaw leaf extract (4.71 %), ginger rhizome extracts (4.83 %) and neem bark extract (4.62 %). Also, there was no significant difference between the extracts at week 19 and 21. Thus, the total percentage sprout after the storage period did not show significant differences.

Table 1: Extract effect on percentage sprouting.

Extracts	**wk11**	**wk13**	**wk15**	**wk17**	**wk19**	**wk21**
Pawpaw leaf	1.54	1.93	3.16	4.71	6.32	7.00.
Ginger rhizome	1.40	1.72	2.83	4.83	6.47	6.99
Neem bark	1.55	1.95	3.21	4.62	6.27	6.88
Water (control)	1.74	2.39	3.68	4.47	6.28	6.93

Lsd	0.33	0.32	0.34	0.54	0.31	0.16
CV (%)	17.13	12.92	8.59	9.36	3.93	1.80

3.3 Effect of cultivar on percentage sprouting

The results in Table 2 show the effect of the cultivars on the sprouting of the frafra potato tubers over the storage period. From the table, there were significant differences (P>0.05) between the two cultivars from the week 11 through to the 19th week. However, there was no significant difference between the cultivars on the 21st week. The Black cultivar recorded significantly higher percentage sprout of 1.72 % on the 11th week. However, from the 13th to 19th week, the brown cultivar recorded significant higher percentage sprouting of 2.26 % on the 13th week, 4.05 % on the 15th week, 5.64 % on the 17th week and 6.60 % on the 19th week. The Brown cultivar also recorded the highest percentage sprouting on the 21st week. However, the difference between the cultivars was not statistically significant. Thus, there was no significant difference between the two cultivars with respect to the total percentage sprout after the storage period.

Cultivars	wk11	wk13	wk15	wk17	wk19	wk21
Black	1.72	1.74	2.39	3.67	6.06	6.93
Brown	1.40	2.26	4.05	5.64	6.60	6.97
Lsd	0.23	0.23	0.24	0.38	0.22	0.11
Cv %	17.13	12.92	8.59	9.36	3.93	1.80

Table 2: Effect of cultivar differences on percentage sprouting (%)

3.4 Interactive effect of extracts and cultivars on sprouting frafra potato

Table 3 below shows the interactive effect of the extracts on sprouting of two cultivars of frafra potato. There were significant differences ($p<0.05$) between the interactive effect of the cultivars and the organic extracts over the weeks. By the 11th week, there was significant difference between all the interactions and the control. However, there was no significant difference among the interactions between the brown cultivar treated with water and brown cultivar treated with pawpaw leaf extracts. The brown cultivar treated with pawpaw leaf extracts recorded the highest percentage sprouting (2.08 %) followed by the brown cultivar treated with water (2.00 %). The black cultivar treated with pawpaw leaf extract recorded the least sprouting (1.00 %) as at the 11th week. The brown cultivar treated with water (control) record the highest percentage of sprouts with 2.87 % sprout in week 13 while the black cultivar treated with pawpaw leaf extracts recorded the lowest sprout of 1.49 % followed by black cultivar treated with ginger rhizome extracts (1.73 %). By the end of the 15th week, the brown cultivar treated with water (control) still recorded a higher sprouting percentage of 4.47 % while the black cultivar treated with ginger extract also recording the lowest sprouting of 1.99 %. Week 17 saw the brown cultivar treated with neem bark extract and brown cultivar treated with pawpaw leaf extract both recording 5.37 % sprout while the black cultivar treated with water recording the lowest sprout of 3.34 %. Black cultivar treated with neem bark extract recorded the lowest percentage sprout of 5.92 % as at week 19 with the brown cultivar treated with ginger rhizome extract recording the highest sprouting of 6.81 %. At week 21, the black cultivar treated with pawpaw leaf extract recorded the highest sprouting of 7.05 % while the black cultivar treated with neem bark extract recorded the lowest sprouting of 6.83 %. Also, the brown cultivar treated with ginger rhizome extract recorded the highest sprouting of 7.02 % while the brown cultivar treated with neem bark extract recorded the lowest sprouting of 6.93 %. At the end of the storage period, the total percentage of sprouted tubers did not show significant differences (p>0.05) among the treatments however both cultivars treated with neem bark extracts recorded the lowest sprouting.

Table 3: The interactive effect of the extracts on sprouting of two cultivars of frafra potato

Source of Variation	wk11	wk13	wk15	wk17	wk19	wk21
CV1/T1	1.00	1.49	2.32	3.69	6.13	7.05
CV1/T2	1.52	1.73	1.99	3.94	6.13	6.95
CV1/T3	1.58	1.82	2.35	3.72	5.92	6.83
CV1/T4	1.49	1.91	2.88	3.35	6.07	6.88
CV2/T1	2.08	2.37	3.99	5.73	6.50	6.95
CV2/T2	1.26	1.72	3.67	5.71	6.81	7.02
CV2/T3	1.52	2.08	4.08	5.73	6.63	6.93
CV2/T4	2.00	2.87	4.47	5.59	6.48	6.98
Lsd (5%)	0.47	0.45	0.48	0.76	0.44	0.22
CV (%)	17.13	12.92	8.59	9.36	3.93	1.80

Note: CV1 = Black cultivar CV2= Brown cultivar T1= Pawpaw, T2= Ginger rhizome T3 = Neem Extract T4= Control (water)

3.5: Effect of extracts on weight loss of frafra potato

From table 4 below, the extracts on their own did not show any significant differences (P>0.05) with respect to weight loss of the tubers. The weight loss of the tubers however ranged from 17.75 grammes for ginger extract and 24.26 grammes for water (control).

3.6: Effect of extracts on rot (decay) of frafra potato

From the results in table 4, there were no significant differences recorded between the different extracts used with respect to the percentage rot. However, the highest percentage rot was recorded by the control (1.85 %) whiles the least was recorded by pawpaw leaf extract (1.45 %).

Table 4: Effect of pre-storage plant extracts on weight loss and rot (decay) of frafra potato

Extracts	**Weight loss (g)**	**Rot (%)**
Pawpaw leaf	23.62	1.45
Ginger rhizome	17.75	1.50
Neem bark	21.02	1.56
Water (control)	24.26	1.85
Lsd	9.01	0.46
CV (%)	33.60	23.48

3.7: Effect of cultivar on weight loss of frafra potato tubers

From table 5 below, the differences between the individual effects of the two cultivars with respect to weight loss were significant (P<0.05). From the table, the black cultivar recorded the highest weight loss of 25.65 grammes while the brown cultivar recorded the lowest weight loss of 17.68 grammes.

3.8: Effect of cultivar on percentage rot

From table 5 below, there were no statistical differences between the two cultivars though the black cultivar recorded 1.73 % rot which was higher than that recorded by the brown cultivar. The brown cultivar recorded 1.45 % rot.

Table 5: Cultivar effect on weight loss and percentage rot of frafra potato

Cultivar	Weight loss (g)	Rot (%)
Black	25.65	1.73
Brown	17.68	1.45
Lsd	**6.37**	**0.33**
CV (%)	**33.60**	**23.48**

3.9: Interactive effect of extracts and cultivars on weight loss

From the results in table 6 below, Weight loss of the tubers treated with the different extracts showed significant variation (P< 0.05). The black cultivar treated with water (control) recorded the highest weight loss of 30.74 grammes significantly different from those recorded by the brown cultivar treated with water (17.78 grammes), neem bark extract (13.67 grammes) and ginger extract (13.51 grammes). However, it was not statistically different (P>0.05) from those recorded by brown cultivar treated with pawpaw leaf extract (25.75 grammes) and black cultivar treated with pawpaw leaf extract, ginger extract, and neem bark extract. The brown cultivar treated with ginger rhizome extract recorded the lowest weight loss.

3.10: Interactive effect of extracts and cultivars on percentage rot

From the results in table 6 below, there were no significant differences (p> 0.05) between the interactions of the cultivars and the extracts. The percentage of rot ranged between 1.28 % for the brown cultivar treated with the ginger extracts and 2.07 % for the black cultivar treated with water (control). The interaction between cultivar and water (control) recorded the highest percentage rot in both the black and brown cultivars.

Table 6: Interactive effect of extracts and cultivars on some quality parameters of frafra potato

Interaction	Weight loss (g)	Rot (%)
CV1/T1	21.49	1.38
CV1/T2	22.00	1.72
CV1/T3	28.38	1.75
CV1/T4	30.74	2.07
CV2/T1	25.75	1.52
CV2/T2	13.51	1.28
CV2/T3	13.67	1.38
CV2/T4	17.78	1.63
Lsd	12.75	0.65
CV (%)	33.60	23.48

Note: CV1 = Black cultivar CV2= Brown cultivar T1= Pawpaw, T2= Ginger rhizome T3 = Neem Extract T4= Control (water)

4. Discussion

Temperature readings were generally low with high humidity between week 1 and week 10 of the storage period as compared to the readings from week 11 onwards. High temperatures are generally associated with increased sprouting which subsequently leads to weight loss of tubers [14, 15]. The general increase in temperatures from week 11 could therefore be a contributory factor to the observed increase in sprouting from the 11th week onwards.

The initiation of sprouting generally marks the end of the dormancy period in root and tubers [16]. Initiation of sprouting leads to increased respiration and dry matter loss [17]. Length of dormancy period of *Solenostemon rotundifolius* is about two months (eight weeks) [18]. Significant sprouting was observed in the 11th week, with the sprouting of the black cultivar treated with pawpaw leaf extracts recording the least sprouting. This was not however the case for the brown cultivar treated with pawpaw leaf extracts. This probably meant that the two cultivars responded differently to the treatments. The fluctuation in rate of sprouting between the two cultivars buttresses this observation. According to Babajide [19], characteristics between species vary considerably and this might have been responsible for cultivars responded differently to the treatments.

A significantly high percentage of sprouted tubers were observed from week 15 to week 19. This observation could have been triggered by the higher temperatures recorded from week 11 onwards. According to [14, 15], an increased temperature during storage is associated with increased sprouting which subsequently leads to weight loss of tubers.

Generally, it could be said that all the three extracts exhibited sprout suppressing ability since the control (water treated tubers) recorded the highest percentage sprouting in the week the tubers started sprouting (eleventh week).

At the end of the experiment, neem bark extract treated tubers recorded the least percentage sprouts in both cultivars. This confirmed the observations made by [20]. According to Osunde [20], neem bark treatments on yam tubers affects sprouting rates and can even delay sprouting by up to one month. Neem bark extract treated frafra potato tubers recording the least sprouting may be an indication that it is more anti-sprouting than the other extracts used in this experiment.

Arif et al. [21] attributed moisture loss, respiration and other metabolic activities to be the main cause of weight loss during storage. Sprouting is known to lead to increased respiration and dry matter loss [17]. Weight loss leads to economic loss and also makes produce less attractive to potential buyers when sent to the market [22].

The black cultivar generally experienced greater weight loss as compared to the brown cultivar. This observation could be as a result of cultivar differences that enabled the black cultivar to experience greater moisture loss, respiration and other metabolic processes that promoted greater weight loss in storage. However, research work on the particular aspect of cultivar (tuber) physiology or biochemical activity of frafra potatoes responsible for this observation has not been cited.

The brown tubers treated with ginger extract recorded the least weight loss whiles pawpaw leaf extract also recorded the least weight loss for the black cultivar. This observation could also be as a result of cultivar differences.

Generally, few tubers experienced rot during the experiment. This could be as a result of the antifungal properties of the extracts applied or fewer entry wounds on the tubers thus making it difficult for secondary infections. According to Knoth [23], pathogens can only penetrate the skin of tubers through damaged spots, like injuries, lesions and holes. Injury on tuber skins can occur in the field, during harvesting, transportation or in storage.

In the brown cultivar, ginger recorded the least percentage rot of 1.28 % whiles the control recorded 1.63 %. This may be that ginger extracts were more fungitoxic on the rots of the brown cultivar than the other extracts. A similar explanation could also be given to the observations in the black cultivar which experienced the pawpaw leaf extract treated tubers recording the least percentage rot of 1.38 % as compared to the other extracts.

The fungicidal properties of the extracts in reducing rot generally tend to be good since the control of both cultivars recorded greater rot than the extract treated tubers and this agrees with observations made by several authors; [24, 25, 26, 20, 27]. However, the extracts could not completely prevent rot from occurring as the efficacy may have reduced over time or as a result of tubers being infected already before the application of the extracts. According to Stuart et al. [28], the effect of a fungicide depends on the extent of latent infection, the amount of soil on the tuber and the interval between harvest and application.

5. CONCLUSION

The total percentage sprout at the end of the storage period (week 21) did not show significant differences in all extract treated tubers. The cultivar and interactive effect did not also show any significant effect. However, neem bark extract treated tubers recorded the least sprouting in both cultivars at the end of the storage period. Higher concentrations of neem bark extract effect on sprouting should therefore be further investigated since its sprout suppressing ability was prominent on both cultivars at the end of the storage period.

The extracts had no significant effect on weight loss after the storage period. However, the cultivar effect and the interactive effect of extracts and cultivars on weight loss showed significant variation ($P < 0.05$).

There were no significant differences on percentage rot among the extract treated tubers. Also, the cultivar effect and interactive effect were not significant. However, the percentage rot recorded was very low in all extract treated tubers when compared to the control.

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