Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 1710-1715
Received: 15-06-2020
Accepted: 13-08-2020

Bakam Himabindhu
PG Scholar, Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Dr. Suma Divakar
Professor, Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Dr. Shalini Pillali P
Professor, Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Dr. Brigit Joseph
Professor, Department, Agricultural Statistics, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Dr. Krishnaja U
Assisstant Professor, Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Corresponding Author:
Bakam Himabindhu
PG Scholar, Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India

Quality evaluation of Tuberless colocasia (*Colocasia esculenta*) leaves cultivated through aquaponics

Bakam Himabindhu, Dr. Suma Divakar, Dr. Shalini Pillali P, Dr. Brigit Joseph and Dr. Krishnaja U

Abstract
Nutrient, nutraceutical analysis and shelf life studies were carried out on Tuberless colocasia (*Colocasia esculenta*) leaves to determine the differences in the leaves cultivated on aquaponics and conventional one. Tilapia fishes were grown along with the plants. Leaves cultivated in aquaponics showed higher yield and sensory qualities. Significant difference was found in many of the nutrient and nutraceutical components among both the treatments. Anti oxidant property was also seen to be higher with significant difference statistically (T value-2.10).

Keywords: Tuberless colocaisa leaves, aquaponics, soil, sensory qualities

1. Introduction
Today's Indian farmer is exposed to many challenges resulting from low agricultural growth, sustainability concerns and land degradation. Large areas of farmland have become fragmented and have also become infertile due to the overuse of fertilizers and pesticides. Large usage of fertilizers in the conventional method of growing crops has degraded the quality of the soil, that has increased the nitrogen level in the local water. The increase of nitrogen level in water has become harmful to the ecosystem. Along with this, the lack of rainfall has decreased the groundwater level, which has also affected the traditional farming system (Savci, 2012) [30].
In this context, advanced farming methods are needed to overcome these challenges. The technological and scientific advancement in the area of agriculture has started a new regime of cultivation for the landless households, especially in urban areas. Integrating hydroponics, that is the method of raising plants without soil (Savvas, 2003) [31] and aquaculture has assumed additional importance in the current agricultural scenario (Subasinghe *et al.*, 2009) [36].
"Aquaponics" farming is another option, which can prove to be feasible, if the farmers are able to manage the system through proper maintenance combined with technical support. There is rising attention to Aquaponics, as it is a system of aquaculture that involves hydroponics to raise fish and edible plants and can be accomplished in non-traditional localities; for example inside warehouses and also on marginal lands. It can also make available locally grown products without using synthetic pesticides, chemical fertilizers, or antibiotics. The benefits of aquaponics system includes the proficient use of water, reduced waste, organic-like management, co-location for making "two" agricultural products (i.e., edible fish and plants) and there is increased density of crop production, and it also supports the interest of "locally grown food products" (Somerville *et al.*, 2014) [34].
Aquaponics is a combined method of growing fish besides crops in a re-circulating system. In other words, it is an integrated system of hydroponics and re-circulating aquaculture in one production system. The water from fish tank includes fish excreta, that become nutritious for the plants. Plants in turn purify the water emerging into the fish tank to keep the fish healthy (Diver and Rinehart, 2006) [9].
The key components used for aquaponics are the Fish tank and Grow beds with a small pump that purifies water among the two. The success of aquaponics system depends on proper maintenance of the plants, fish and the nutrients that contributes a well-balanced and interdependent relationship (Ebeling and Timmons, 2012) [10].
Since aquaponics has the potential to be a sustainable, approach for safe food production and studies on aquaponics operations and products are scarce, this study attempts to compare the quality of leafy vegetables grown in this system to the conventionally cultivated ones, to serve as a reference for prospective farmers and consumers.

2. Materials and Methods

The experimental site was selected at a farmer's field at Ulloor, Thiruvananthapuram, where there was a well established aquaponics unit. The conventional cultivation was also laid out in the same plot. All plants of both treatments were placed inside the poly house to protect them from pests.

2.1 Selection of vegetables

Colocasia esculenta leaves are reported to possess vital nutritive and nonnutritive components in significant amounts, but are underutilized, and lesser explored. Their chemical composition varies significantly depending upon climatic conditions and other agronomical factors of the location of cultivationand variety (Gupta *et al*., 2019) [13].

Treatments

T_1- Plants cultivated through aquaponics

T_2- Plants cultivated through conventional practices (Organic POP)

The two treatments were compared for their physical characteristics, sensory qualities, nutrient composition, nutraceutical components and shelf life.

Therefore, the experiment had:

Treatments – 2,

No. of plants – 10

2.2 Analysis of physical characters: Number of harvests and Total dry matter production were analysed. The leaves were harvested for two months when they attained an edible size. The observations were recorded. Mature plants were uprooted from each experimental plot. All samples were dried to a constant weight in the hot air oven at 55 ºC for 24 hours and their dry weights were then recorded using an electronic digital balance and expressed in grams.

2.3 Sensory evaluation: A semi-trained panel of 10 members from college of Agriculture, Vellayani, KAU evaluated using 9point hedonic scale appearance (Raw vegetable), Color (Raw vegetable), Flavor (Raw and Cookedvegetable), Texture (Raw and cooked vegetable), Taste (Cooked vegetable) of tuberless colocasia leaves. The scores on hedonic scale of 1 to 9 where: 1 = I dislikeextremely (very bad) and 9 = I like extremely (excellent). The panellists in individual booths wereprovided with samples in plates code with numbers and were asked to test each sample (Swaminathan, 1995) [37].

2.4 Evaluation of Nutrient Composition

Nutrients analyzed in this experiment are moisture (g) by A.O.A.C(1990), Fibre (g) (Sadasivam and Manikam, 1992) [27], Total minerals (g) A.O.A.C (1995) [2], Acidity (%) A.O.A.C (1984), Soluble sugars (mg) Dey (1990) [8], Vitamin C (mg) (Sadasivam and Manikam, 1992) [27], Beta carotene (µg) Srivastava and Kumar (1998) [35], Calcium(mg) (Jackson, 1973) [15], Iron (mg) Jackson (1973) [15]. The results are presented in the following tables.

2.5 Evaluation of Nutraceutical composition

Phenol content was estimated by the procedure defined by Sharma (2001) [33].

Phyticacidcontentwasdeterminedbythemethodwhichwasrecommended by Wheeler and Ferrel (1971) [38]. Tannins were determined as per the procedure defined by Ranganna (2001) [22]. Oxalate content of green leafy vegetables was estimated by the procedure which was suggested by Day and Underwood (1986) [7]. The radical scavenging activity of the samples was determined by 2,2- diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay to assess level of antioxidants (Lim *et al*., 2007) [18].

2.6 Shelf life evaluation

Duration with respect to onset of visible marks of deterioration was noted for green leafy vegetable samples grown through aquaponics and conventional methods for 6 days in 2 types of packagings -newspaper and PP covers. Shelf life in ambient and refrigerated conditions were noted.

Physiological loss of water (PLW)

Under ambient and refrigerated conditions the weight of the GLV was taken on a daily basis and the percentage of loss of water was recorded for each of the samples. They were packed in 2 types of packagings; PP covers and newspaper to compare the quality. This evaluation was carried on for 6 days and physiological changes like wilting and yellowing were noted

PLW of vegetables was determined by using the following formula: Percentage PLW= (Initial weight – Final weight / Initial weight) ^{x}100.

2.7 Statistical Analysis

The mean value of the two treatments were compared through "t-test "and sensory evaluation of panel members were analyzed through "Man Whitney test".

Fig 1: Aquaponics unit setup

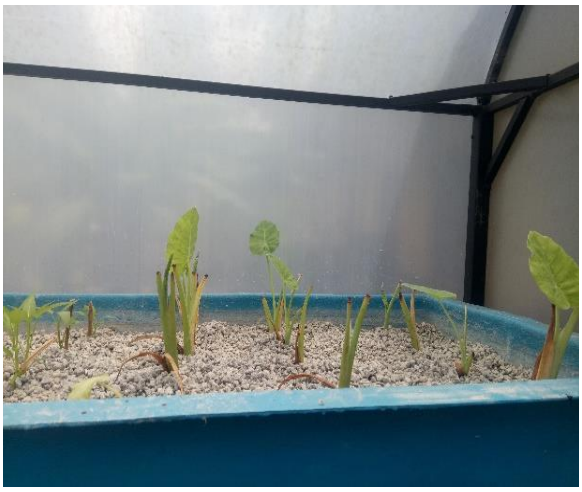

Fig 2: Tuberless colocasia growth after 15 days of planting on aquaponics

Fig 3: Tuberless colocasia growth after 15 days of planting in soil

Fig 4: Mature tuberless colocasia leaves grown on aquaponics

Fig 5: Mature tuberless colocasia leaves grown in soil.

3.Results and Discussion

Table 1: Details of harvest of Tuberless Colocasia

Sequence of harvest	Yield(g/plant)	
	T_1	T_2
1st	25	20
2nd	30	28
3rd	22	25
4th	18	15
5th	26	21
6th	20	24
7th	24	22

(Values depicted are mean of 10 plant units)

Seven harvests were conducted in two months for the Tuberless colocasia plants. From table no.1, it is observed that the yield of T_1 was higher than T_2, the yield of each harvest was however comparable. Yield of T_1 ranged from 18-30g, while that of T_2 ranged from 15-28g.

Saha *et al*. (2016) [28] reported better yield in basil plants under soilless systems than conventional systems. Rakocy *et al*. (2004) reported that aquaponic basil produced higher yield (1.8 kg m^{-2}) than field basil (0.6 kg m^{-2}).

For plant vegetative growth, nitrogen is a key component (Evert and Eichhorn, 2013) [11], and it is the most vital nutrient for crop yield (Blumenthal *et al*., 2008) [4]. So, it is logical to assume that additional nutrients, particularly N that were accessible to aquaponic basil, resulted in their 14% greater plant height and 56% more fresh weight.

Total dry matter production for T_1 was 119.5 (g/plant) and for T_2 was 45.25(g/plant).

Table 2: Sensory evaluation of Tuberless Colocasia

Sensory parameters	T_1		T_2		
	Sum of ranks	U-value	Sum of ranks	U-value	Z value
Appearance (raw vegetable)	114.5 - (I)	40.5	95.5 -(II)	59.5	0.680
Color (raw vegetable)	113- (I)	97	42- (II)	58	0.566
Flavor (raw vegetable)	116.5- (I)	38.5	93.5- (II)	61.5	0.831
Flavor (cooked vegetable)	133- (I)	22	77- (II)	78	2.078*
Texture (raw vegetable)	117.5- (I)	37.5	92.5- (II)	62.5	0.907
Texture (cooked vegetable)	76.5- (II)	78.5	133.5-(II)	21.5	2.116*
Taste (cooked vegetable)	112- (I)	43	98- (II)	57	0.491

(Values indicated are sum of rank values of ten members) (I), (II) – are ranks obtained by the treatments.

From the table no.6, it is observed that sum of ranks for all parameters of Tuberless colocasia grown on aquaponics -T_1- scored more than T_2. Scores of flavour and texture of the cooked vegetable showed significant difference among the two treatments (Z = 2.078 and 2.116 respectively).

Sensory ingredients such as sugars, acids, flavor substances as well as vitamins and secondary plant compounds can be affected by changing the climate conditions in the greenhouse (Gruda, 2005) [12]. Khandaker and Kotzen (2018) [16] indicated that the aquaponically grown bitter gourd was preferred and better in taste than the traditionally grown and imported bitter gourd.

Nutrient Composition

Table 3: Nutrient composition of Tuberless colocasia leaves

Sl.no	Parameters	T_1	T_2	P value
1	Moisture content (g)	88.00	86.80	0.065
2	Fibre content (g)	0.798	0.799	0.96
3	Total mineral content (g/100g)	11.1	8.7	0.018
4	Acidity (%)	1.56	1.10	0.0006
5	Soluble sugars content (mg/100g)	6.67	4.88	9.171-E
6	Vitamin C content (mg/100g)	31.79	14.55	1.221E-15
7	Beta carotene(µg/100mg)	7.66	6.56	7.45E-09
8	Calcium content (mg/100g)	215.92	187.62	1.63362E-08
9	Iron content (mg/100g)	56.13	33.53	1.94991E-14

(Values indicated are mean of 10 replications) Tvalue-2.10

Statistical analysis revealed there was no significant difference in the moisture content and fibre content between two treatments. Nutrient analysis revealed significantly higher values for total minerals, acidity, soluble sugars, vitamin C, beta carotene, calcium and Iron for T_1 at 0.5% significance level.

Yirankinyuki *et al.* (2013) [39] reported that the ash content of Tuberless colocasia leaves was 10.00 per cent. Liao *et al.* (2019) [17] observed that accumulation of metabolites like organic acids was closely related to nitrogen concentration.; nitrogen has a role in limiting glucose, required for synthesis of ascorbic acid. The content of vitamin C in fruits and vegetables can be influenced by many factors such as genotypic differences, preharvest climatic conditions and cultural practices, maturity and harvesting methods and postharvest handling procedures. The enhancement of water and soil nutrient uptake through water could have enhanced photosynthetic performance which in turn triggers an increase in synthesis of carotenoid pigments (Schopfer and Brennicke, 2006) [32]. The leaves of *Xanthosomas agittifolium* grown on aquaponics, revealed higher levels of minerals -iron (Fe), potassium (K), calcium (Ca) and manganese (Mn) (Cardoso *et al.*, 2019) [5]. Analysing the differences due to media of cultivation, Roosta and Hamidpour (2013) [26] reported that the concentrations of Mg, Na, Fe and Zn were higher in the leaves of aquaponic-grown plants as compared to those of hydroponics.

Nutraceutical composition

Table 4: Nutraceutical composition of Tuberless colocasia leaves

Sl.no	Parameters	T_1	T_2	P value
1	Phenol (mg/100g)	37.46	45.78	2.08E-06
2	Phytic acid (g/100g)	5.17	9.09	6.2E-15
3	Tannin (mg/100g)	96.04	90.01	0.00059
4	Oxalates (mg/100g)	74.8	83.6	0.1387
5	Antioxidants (mg/100g)	95.90	89.56	1.11E-17

(Values indicated are mean of 10 replications) Tvalue-2.100

In nutraceutical profile analysis, except for oxalate content there was significant differences among the treatments at 0.5% significance level.

Ibrahim *et al*. (2018) [14] observed that Total plant phenolic contents were affected by nitrogen fertilization. As the levels of nitrogen improved, the total phenolics content was seen to decrease. Raghuvanshi *et al.* (2001) [20] reported that the phytic acid content of the analysed GLVs was found to be in the range of 0.92–13.06 mg/100 g fresh vegetable. Chabeli *et al*. (2008) [6] reported that condensed and hydrolysable tannins increased in a quadratic fashion in response to N nutrition, perhaps representing the higher tannin content in aquaponically Vs cultivated leaves. Accumulation of oxalate seems to be related to nitrate nitrogen assimilation and cation–anion imbalance (Rinallo and Modi, 2002) [24]. Ren *et al*. (2017) [23] had observed higher flavonoid and phenol contents in organic treatments, which eventually affects anti-oxidant activity. This is likely to be the cause for plants in aquaponics showing higher antioxidant activity.

Shelf life

Duration with respect to onset of visible marks of deterioration

Table: 5 shows that shelf life of 7 days was observed for tuberless colocasia when leaves are packed in newspaper. Evaluation of the shelf life of fresh vegetables is very important and there is a requirement for rapid non-destructive methods for the determination of freshness and spoilage during their commercial life (Riva *et al*., 2001) [25].

Table 5: Shelf life of Tuberless colocasia leaves

Tuberless colocasia	Shelf life(days) at ambient temperature		
	Control	PP covers	News paper
T_1	6	6	7
T_2	5	5	6
	Shelf life(days) at Refrigerated temperature(days)		
T_1	8	7	8
T_2	8	6	8

The water content of most of fruits and vegetables is higher than 80%, which limits their shelf-life and makes them more susceptible during storage and transport conditions (Santos and Silva, 2008) [29]. Weight loss during storage has been seen to vary with the packaging conditions and storage temperature of spinach (Pandrangi and Laborde, 2004) [19].

Table 6: Physiological loss of water during storage of Tuberless colocasia leaves (0-6 days)

Storage in Ambient Conditions (%)		
Packing material	T_1	T_2
PP covers	25.42	24.60
Newspaper	60.12	59.07
Nil	52.82	53.84
Storage in Refrigerated Conditions (%)		
PP covers	10.99	10.91
Newspaper	16.77	15.76
Nil	33.98	33.77

.

Table no.6 – reveals no significant changes in the extent of physiological loss of water among both the treatments, when stored in ambient conditions and refrigerated conditions in PP covers. The moisture loss was higher when they were packed in newspaper and control when compared with PP covers. This loss was to a greater extent in ambient conditions.

Conclusion

From the analysis carried out on Tuberless colocasia leaves which were grown on aquaponics and soil, it could be concluded that the yield, total dry matter production was higher for aquaponics leaf samples than conventional ones. The scores for sensory evaluation was higher for T_1 samples than T_2 ones. Higher nutrient and nutraceutical components showed significant differences among the two treatments suggesting that aquaponics samples are better when compared with conventional ones.

Acknowledgement

The research team places on record their gratitude for the facility rendered by "Rose garden", Ulloor, Thiruvananthapuram, towards the conduct of the study. The technical and financial support of Kerala Agricultural University is also thankfully acknowledged.

References

1. AOAC. Official and Tentative Method of Analysis. Association of Official Analytical Chemists, Washington D.C, 1984, 156.
2. AOAC. Official Method of Analysis « Ash of flour – direct method » in Official Methods of AOAC International, method 923.03, (23.1.05).1995.13.
3. AOAC. Official Method of Analysis. Fifteenth edition. Association of Official Analytical Chemists, Inc., Arlington, V A, 1990, 381.
4. Blumenthal JM, Baltensperger D, Cassman KG, Mason SC, Pavlista AD. Importance and effect of nitrogen on crop quality and health. In Nitrogen in the Environment. Academic Press, 2008, 51-70.
5. Cardoso SB, Bianchini PPT, Alberto J, Pantaleao F, Pereira VM, Okura MH. Aquaponics pilot system: case study. Int. J Adv. Eng. Manag. Sci, 2019; 5:512-517.
6. Chabeli PM, Mudau FN, Mashela PW, Soundy P. Effects of nitrogen, phosphorus and potassium nutrition on seasonal tannin content of bush tea (*Athrixia phyliciodes* DC.) South African J Plant and Soil, 2008; 25(2):79-83.
7. Day RA, Underwood AL. Quantitive analysis 5th ed. Prentice. Hall publication, 1986, 701.
8. Dey PM. Oligosaccharides. In Methods in plant biochemistry, Academic Press. 1990; (2):189-218.
9. Diver S, Rinehart L. Aquaponics-Integration of hydroponics with aquaculture. Attra. A Publication of ATTRA - National Sustainable Agriculture Information Service, 2006; 1-800:346-9140
10. Ebeling JM, Timmons MB. Recirculating aquaculture systems. Aquaculture production syst, 2012, 245-277.
11. Evert RF, Eichhorn SE. Raven Biology of Plants. Freeman, W. H. & Company, New York, NY, 2013.
12. Gruda N. Impact of environmental factors on product quality of greenhouse vegetables for fresh consumption. Crit. Rev. plant sci. 2005; 24(3):227-247.
13. Gupta K, Kumar A, Tomer V, Kumar V, Saini M. Potential of Colocasia leaves in human nutrition: Review on nutritional and phytochemical properties. Journal of food biochemistry. 2019; 43(7):12878.
14. Ibrahim MH, Rahman NYA, Zain NAM. Effect of nitrogen rates on growth and quality of water spinach (*Ipomea aquatica*). Annu. Res. & Rev. Biol, 2018, 1-12.
15. Jackson ML. Soil Chemists Analysis*:* second edition Prentice hall of India (Pvt.) Ltd., New Delhi, 1973, 498.
16. Khandaker M, Kotzen B. Taste testing bittergourd (*Momordica charantia*) grown in Aquaponics. Ecocycles, 2018; 4(2):19-22.
17. Liao L, Dong T, Qiu X, Rong Y, Wang Z, Zhu, J. Nitrogen nutrition is a key modulator of the sugar and organic acid content in citrus fruit. PloS one, 2019; 14(10):0223356.
18. Lim YY, Lim TT, Tee JJ. Antioxidant properties of several tropical fruits: A comp. study. Food chem, 2007; *103*(3):1003-1008.
19. Pandrangi S, Laborde LF. Retention of folate, carotenoids, and other quality characteristics in commercially packaged fresh spinach. J food sci, 2004; 69(9):702-707.
20. Raghuvanshi S, Singh R, Singh R. Nutritional composition of uncommon foods and their role in meeting micronutrient needs. Int. J food sci. nutr. 2001; 52(4):331-335.
21. Rakocy J, Shultz RC, Bailey DS, Thoman ES. Aquaponic production of tilapia and basil: comparing a batch and staggered cropping system. In South Pacific Soilless Culture Conf.-SPSCC. 2003; 648:63-69.
22. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. Second edition. Tata McGraw-Hill, Publishing Company Ltd, India, 2001,112.
23. Ren F, Reilly K, Gaffney M, Kerry JP, Hossain M, Rai DK. Evaluation of polyphenolic content and antioxidant activity in two onion varieties grown under organic and conventional production systems. J sci. food agric. 2017; 97(9):2982-2990.
24. Rinallo C, Modi G. Content of oxalate in Actinidia deliciosa plants grown in nutrient solutions with different nitrogen forms. Biologia plant. 2002; 45(1):137-139.
25. Riva M, Benedetti S, Mannino S. Shelf life of fresh cut vegetables as measured by an electronic nose. Preliminary study. Italian J Food Sci. (Italy). 2001; 13(2):201-212.
26. Roosta HR, Hamidpour M. Mineral nutrient content of tomato plants in aquaponic and hydroponic systems: Effect of foliar application of some macro-and micro-nutrients. J plant nutr. 2013; 36(13):2070-2083.
27. Sadasivam S, Manikam A. Biochemical Methods for Agricultural Sciences Wiley Eastern Limited and Tamil Nadu Agricultural University Publication, Coimbatore, 1992, 11-20.
28. Saha S, Monroe A, Day MR. Growth, yield, plant quality and nutrition of basil (*Ocimum basilicum* L.) under soilless agricultural systems. Ann. of Agric. Sci, 2016; 61(2):181-186.
29. Santos PHS, Silva MA. Retention of vitamin C in drying processes of fruits and vegetables-A rev. Drying Technol. 2008; 26(12):1421-1437.
30. Savci S. An agricultural pollutant: chemical fertilizer. Int. J Environ. Sci. Dev, 2012; 3(1):73.
31. Savvas D. Hydroponics: A modern technology supporting the application of integrated crop management in greenhouse. J food agric. Environ. 2003; 1:80-86.
32. Schopfer P, Brennicke A. Pflanzenphysiologie. Elsevier GmbH, Munich, 2006, 700.
33. Sharma A. A Text Book of Food Science and Technology. International book distributing Co, Lucknow, 2001, 56.
34. Somerville C, Cohen M, Pantanella E, Stankus A, Lovatelli A. Small-scale aquaponic food production:

integrated fish and plant farming. FAO Fisheries and Aquac. Technical Paper, 2014, 589.
35. Srivastava RP, Kumar S. Fruits and Vegetable Preservation – Principles and practices. Second edition. International Book Distribution Co., Lucknow, 1998, 444.
36. Subasinghe R, Soto D, Jia J. Global aquaculture and its role in sustainable development. Rev. Aquaculture, 2009; 1(1):2-9.
37. Swaminathan M. Food Science and Experimental Foods. Ganesh and company, Madras, India, 1995, 293.
38. Wheeler EL, Ferrel RE. A method for phytic acid determination in wheat and wheat fractions. Cereal chem. 1971; 48(3):312-320.
39. Yirankinyuki FF, Lamayi DW, Sadiq BA, Yakubu MU. Proximate and some minerals analysis of *Colocasia esculenta* (TARO) leaves. J Med. Biol. Sci. 2013, 3(2).