Nutritional; Fatty Acid and Microbiological Profile of Jew's mallow (*Corchorus olitorius*; Family Tiliaceae) that grow in Egypt

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Abstract: :

Corchorus olitarius L leaves either fresh, frozen or dried is an important leafy vegetable in Egypt. It is a leafy summer vegetable that grows in tropical regions. The aim of the present study is to evaluate the nutritional content of the leaves of the Egyptian Jew's mallow. It was collected from local markets in Cairo, Egypt. Proximate, vitamin and mineral composition analysis were carried out using standard methods of food analysis. Also fresh leaves were subjected to microbiologial investigation. The leaves are nutritious, rich in beta-carotene (40.3), phenolics (15.45 mgGAE/g), total flavonoids (110.56 mgQE/g), minerals, protein (26.8 g/100g), vitamins, fatty acids especially ω_3 and dietary fiber (37.6%). Mineral analysis (mg/100g) revealed that it contains potassium, Calcium (1400 each). It also contained appreciable concentrations of Na (72.3), P (350), Fe (14.1), Mg (270.3) and Zn (3.7). It was found to be very rich in ω3- fatty acid (47.23%) and it contains also ω9- fatty acid 14.45%.

Conclusion: The present result revealed that *Corchorus Olitorius* leaves are rich sources of potassium, Calcium, iron and very rich in ω3- and ω9 fatty acid. Jew's mallow can be used an inexpensive source of ω3, protein and dietary fiber due to its high nutritional value.

Keywords: Jew's mallow, phenolics, flavonoids, Fatty acids, nutritional value

Introducton

Worldwide, a low intake of vegetables and fruit is among the top ten risk factors contributing to mortality **(1)**. The World Health Organization (WHO) recommends a daily intake of more than 400 g of fruits and vegetables per person to protect against diet-related non-communicable diseases **(2).** Jew's mallow (*Corchorus olitorius L.*) belongs to the family Tiliaceae known as Jew Mallow, Bush okra, Jute, Jute mallow. It is a tropical, leafy, green, fast-growing summer herb (vegetable**) (3)**. It is a traditional dish in Egypt. The Egyptian pharaohs was from the first who eaten Jew's mallow, it was called the "food of the king" after an Egyptian king drank it in soup to treat from a disease **(4)**.

The plant contains triterpenes, intones, steroids, acidic polysaccharide, phenolics, polysaccharides, carotenoids, minerals, sugars, proteins, and the vitamins B_1, B_2, C, and E **(3; 5 & 6).** The leaf is one of the best sources of folate (folic acid: 32 ppm) which may aid in infertility and may prevent spinal birth defects **(7).**

Its leaves consumed as a folk remedy for treatment of pain, gonorrhoea, chronic cystitis, tumors, diuretic and tonic **(8 & 9)**. The leaves has antioxidant, anti-tumor, hypoglycemic, antiobesity and wound healing effects **(10 & 11)**.

Phytochemicals are substances found naturally in plant foods. Increased consumption of vegetables rich in phytochemicals protects against cardiovascular disease, cancer and Alzheimer's disease. Phenolic compounds are a category of phytochemicals that exert strong antioxidant properties **(12).**

People as children and elderly are at high risk of contracting food-borne illnesses and are more likely to be subject to developing infections from pathogens that comes from contaminated vegetables. In USA and Europe S*almonella* spp. and *Escherichia coli* are among the most common pathogens that occur in leafy green vegetables (LGV) **(13).** Raw vegetables have been reported as be as a source of *E. coli*, that might cause diarrhea **(14).**

To the best of our knowledge information in the literature is little regarding the nutritional, microbological evaluation, fatty acid profile of Jew's mallow leaves in Egypt. Therefore, the aim of the present study is to

evaluate the nutritional content, fatty acid profile of the leaves of the Egyptian Jew's mallow to be used as an inexpensive source of ω3, protein and fiber due to its high nutritional value.

Materials and Methodsa

Preparation of sample

Fresh jew's mallow were purchased from 10 different local markets (Cairo, Egypt), pooled then destalked to separate the edible portions (the green leaves) except for microbiological analysis where 10 samples were analyzed. The leaves were thoroughly washed with tap water followed by distilled water, allowed to drain at room temperature and the excess water was removed using paper towel. The moisture content of the fresh leaves was immediately determined according to the **AOAC** (**15)** and found to be 86.3g /100 g sample. The leaves were well mixed, and then left to dry at RT, grind and the powder was kept frozen at -20C° until analysis.

The extract was prepared according to **Antolovich *et al.,* (16).** Total phenolic content was determined according to **Kaur and Kapoor (17)** using a colorimetric method with Folin-Ciocalteu reagent and was expressed as milligrams of gallic acid equivalent per gram of dry weight (mg GAE/g DW)**.** Total flavonoids content was determined using a colorimetric method **(18)** and were calculated as quercetin equivalents (mg QE/g DW). All analyses were run in triplicate.

Analytical methods

Proximate analysis Moisture, crude protein, crude fat, crude fiber, dietary fiber and total ash were determined according to the standard methods of the **AOAC (15).**

Sugars were determined calorimetrically using di-nitro-salicylic acid at 540 nm. Glucose was used as a standard **(19 & 20).** Total carbohydrates content was determined by difference **(15)** using the equation: %Total carbohydrates content = 100 − (% protein +% fat + % ash).

Fatty acid was determined using Agilent application note for Agilant GC-Mass **(21)**. Minerals were determined using **AOAC** (**15)** method. Microbiological investigation according to **ICMSF (22)**

All the results were calculated as % of dry weight basis. All the results were mean of triplicate and expressed as mean±SEM.

Results and Discussion

I-Macronutrients

Table 1: Proximate chemical composition of raw Jew's mallow leaves (on dry weight basis)

Chemical Comp		Conc (g/100g DW)
Moisture of Fresh		**86.3±0.40**
Protein		**26.8±0.55**
Fat		**5.4±0.18**
Ash		**8.11±0.11**
Moisture		**2.3±0.06**
Carbohydrate		**57.39±0.86**
Total sugars		**6.2±0.15**
Total solids		**97.7±0.06**
Fibre	**Crude**	**12.2±0.17**
	Dietary	**37.6±0.14**
Calories (Kcal/100g)		**385±0.19**

Table 1 reveals proximate chemical composition of raw Jew's mallow leaves (on dry weight basis). Our result for protein and fat content is higher than that reported by **Ndlovu and Afolayan (5)** (26.8 vs 16.2 **&** 5.4 vs

1.72 respectively), while crude fiber and ash content shows lower content (12.2 vs 20.3 **&** 8.11 vs 10.5 respectively). Our results agree with **(23)** for fat content and disagree for protein and total dietary fiber content (26.8 vs 20; 37.6 vs 45.61 respectively). Our results agree **(23)** for fat content and disagree for protein and total dietary fiber (26.8 vs 20; 37.6 vs 45.61 respectively) content. Also our results disagree with **24 & 25** where their *C. o.* was grown in Tunis and Nigeria respectively. This difference found in the composition can be explained by the variability in the cultural practices, climatic, type of soil, growing conditions, and use of natural or artificial fertilizers and the period of analysis as well as the maturity status of plant **(26; 27 & 28)**.

The high level dietary fiber helps in optimizing the digestive process by eliminating constipation, reducing cramping, and increasing nutrient uptake efficiency, and helps in reducing from blood cholesterol stream as fiber binds itself to the bad cholesterol and removes it from the body.

II-Minerals

Table 2: Proximate mineral composition of raw Jew's mallow leaves (on dry weight basis)

Minerals	**Ca**	**K**	**Fe**	**P**	**Zn**	**Mg**	**Na**
Conc (mg/100g)	**1400±10.41**	**1400±10.4**	**14.1±0.11**	**350±3.03**	**3.7±0.07**	**270.2±3.32**	**72.3±0.6**

Table 2 reveals proximate minerals composition of raw Jew's mallow leaves (on dry weight basis). Mineral analysis revealed that calcium and potassium (1400 mg/100g) were the predominant elements. It also contained appreciable concentrations of P, Mg (350 & 270.2 mg/100g), Fe (19.53±0.09 mg/100g). Our results disagree with **Ezz El-Arab (23)** for: Ca (1400 vs 1760); K (1400 vs 5120); Na (72.3 vs 80.1); Fe (14.1 vs 53). The present result confirmed that *Corchorus olitorius* leaves are rich sources of Ca, K, P, Mg and Fe.

Jew's mallow has a significant role in controlling blood pressure due to its high potassium content, which is a vasodilator and arteries relaxation. The significant levels of iron present in jew's mallow helps the body to produce RBC thus reduces anemia and improves circulation. Jew's mallow contains high levels of magnesium, which can help in curing sleep disorder as insomnia as it helps in relaxing and calming the nerves.

III-Fatty acids

Table 3: Proximate fatty acid composition of raw Jew's mallow leaves (on dry weight basis)

Fatty Acids	**%**
Tetradecanoic (Myrestic) acid (C14:0)	**1.41±0.03**
Hexadecanoic (Palmitic) acid (C16:0)	**24.35±0.14**
Palmitoleic acid (C16:1)	**2.14±0.07**
Stearic acid (18 : 0)	**2.81±0.04**
Octadecenoic (Oleic) acid ù-9 C18:1	**14.45±0.13**
Octadecadienoic (Linoleic) acid ù-6 C18:2	**5.81±0.10**
Octadecatrienoic (á-linolenic) acid ù-3 C18:3	**47.23±0.29**
Eicosanoic (Arachidic) acid C20:0	**0.47±0.03**
Docosanoic (Behenic) acid C22:0	**1.33±0.03**
SFA	**30.37±0.10**
USFA	**69.63±0.10**
SFA/USFA	**0.44 (1: 2.3)**
ù-3 C18:3	**47.23±0.29**
ù-6 C18:2	**16.45±0.13**

The results of table 4 showed that dry leaves are extremely rich in ω-3 and then ω-9 fatty acid with a relative concentration of 47.23 & 14.45 % respectively. The second most popular fatty acid was Hexadecanoic (palmitic) acid (C16:0) with a relative percentage of about 24.35%. Docosanoic acid C22:0 (behenic) was the lowest one (1.33%) which disagree with **(29)** where they found in their analysis that Stearic acid (C18:0) was the lowest. Our results disagree with **(30)** where they found that %SFA and USFA were 96.46 & 3.54 vs 30.37 & 69.63respectively in our results. The order of abundance of the fatty acids is Palmitic > Stearic > Myrestic > Behenic > Arachidic for SFA and á-linolenic > Oleic > Linoleic > Palmitoleic for USFA.

α-linolenic acid C18:3 (ω-3), found in green leafy vegetables have beneficial effects in health and in the control of chronic diseases. It elongates in the human body to EPA and DHA **(31)**. Myristic acid is a saturated fatty acid used in cosmetic. Palmitic help in synthesizing longer fatty acids **(32).** Both (α-linolenic & Palmitic) have specific roles in acylation of membrane proteins and covalently modify a number of proteins involved in cell signaling **(33 & 34)**. High USFA (69.63) of jew's mallow may reduce the probability of aiding heart diseases. Linoleic and linolenic acids are essential fatty acids, which cannot be synthesized in the body. They promote the reduction of both total and LDL- cholesterol. Oleic acid is associated with biosynthesis of arachidonic acid which is essential for cell growth and maintenance **(35).**

A proper balance of essential fatty acids maintains and improves health **(36).** The ratio of linoleic acid (LA) to α-linolenic acid (ALA) of jew's mallow is 8.13 which fell within the WHO/FAO recommended ratio of between 5:1 and 10:1 **(37).** The ratio of TUSFA to SFA or (P/S ratio)] was 2.29. The higher the P/S ratio, the more nutritionally useful the oil is. This is because the severity of arteriosclerosis is closely associated with the proportion of the total energy supplied by saturated fats and polyunsaturated fats **(27).** Fatty acid profile of jew's mallow may differ according to land where it is cultivated and genus/species (data under publication).

IV-Total phenolic and Flavonoids

Table 4: Total phenolic and flavonoids content of raw Jew's mallow leaves (on dry weight basis)

Parameter	**Conc.**	
Total phenolic	**15.45**	**mg GAE/g DW**
Total Flavonoids	**110.56**	**mg QE /g DW**
GAE: Gallic Acid Equivalent; QE: quercetin equivalent		

Table 4 shows total phenolic and flavonoids content of raw Jew's mallow leaves. According to **Panche *et al.,* (38)** flavonoids are secondary compounds with antioxidant capacity, and the efficiency of that relies upon the quantity and position of free OH groups. **Racha *et al.,* (24) and (39)** stated that content of phenolic and flavonoids compounds differ greatly with the type of extraction solvent used and its polarity**.** They found that absolute ethanol give higher content (extract) than aqueous ethanol or water. Our results agree with **(40).** Our results for total phenolic agree with **(41)** where they found that *C. o.* polyphenolic compounds content was 194.4 mg/100 g FW (Their C.o. were cultivated in glasshouse in Italy).

V-Microbiological investigation

Table (5): Mean of microbial count of the fresh jew's mallow samples (in CFU: colony forming units).

	Microbial count cfu / ml
Total bacterial count	**1.0×10^2**
Coliform	**-ve**
Staphylococcus aureus	**1.0×10^2**
E. Coli	**- ve**
Salmonella	**-ve**
Enterobacteriaceae	**-ve**

Mold and yeast	**1.0×10^2**

Table (5) shows the microbial profile of the fresh jew's mallow samples. Usually, several factors contribute to microbial contamination of fresh produced vegetables as use of contaminated irrigation water, soil and seed quality, inappropriate fertilizers and harvesting workers with poor hygienic practices **(14).**

In the current study, the microbial quality of Jew's mallow sold in some local markets of Cairo was investigated. The counts for *Enterobacteriaceae* and total coliform were determined. Also, the possibility for the presence of contaminating E. coli, Salmonella spp. was also investigated. The results reveal that it contains no Coliform; *E. Coli; Salmonella* or Enterobacteriaceae.

None of the investigated samples was found to contain *Salmonella* spp., or *E. coli*. which agrees with the results of the FDA survey which indicated that 99% of the local fresh produced sampled in the USA to be free of *Salmonella*, and *E. coli* **(42).** Also it agree with **(43)** where they found 900 samples of fresh produced in Norway were free of *Salmonella* spp., or *E. coli*. The absence of such pathogens (*Salmonella* spp., or *E. Coli)* possibly because some natural microflora on jew's mallow may pose competitive or inhibitory activity against some pathogens that might contaminate it **(44).**

Conclusion

The present result revealed that *Corchorus Olitorius* leaves are rich sources of potassium, Calcium, iron as well as high energy values essential in human and animal nutrition and very rich in ω3- and ω9 fatty acid. Jew's mallow can be used as an inexpensive source of ω3, protein and fiber due to its high nutritional value.

References:

1. Ezzati M, Lopez AD, Rodgers A, van der Hoorn S, and Murray CJL. 2002. Selected major risk factors and global and regional burden of disease. Lancet 360, 1347-1360. https://doi.org/10.1016/S0140-6736(02)11403-6
2. WHO, 2003. Diet, nutrition and the prevention of chronic diseases. Report of a Joint FAO/WHO Expert Consultation. WHO Technical Report Series No. 916. World Health Organization, Geneva, Switzerland.
3. WVC 2017: World Vegetable Center. Jute mallow (Corchorus olitorius). https://avrdc.org/jute-mallow-corchorus-olitorius/. Updated August 23,
4. Cumo C. 2013. Encyclopedia of Cultivated Plants: From Acacia to Zinnia [3 Volumes]: From Acacia to Zinnia. Santa Barbara, CA: ABC-CLIO; 2013.
5. Ndlovu J, and Afolayan AJ. 2008. Nutritional analysis of the South African wild vegetable Corchorus olitorius L. Asian J Plant Sci.; 7(6): 615-618. https://doi.org/10.3923/ajps.2008.615.618
6. Consolacion YR, Julius LAV, Maria CST, and Chien-Chang S. 2016. Chemical constituents of Corchorus olitorius (Linn.). Inter J Pharmacognosy Phytochem Res 2016; 8: 2085-2089.
7. Duke JA. 2003. The Green Pharmacy: Herbal Remedies for Common Diseases and Conditions from the World's Foremost Authority on Healing Herbs. London: Rodale; 2003.
8. Bhawana Dayal and Neetu Singh 2015. Molokhia- the wealth for a better health. International Journal of Research; 2(2): 658-661.
9. The Canon of Medicine, Vol. II: Natural Pharmaceuticals by Avicenna, translated and compiled by Laleh Bakhtiar, pp. 596 – 599. @ 2012 by Laleh Bakhtiar, published by Great Books of the Islamic World, Inc., Distributed by Kazi Publications, Inc., Chicago, IL, USA
10. Wang L, Yamasaki M, Katsube T, Sun X, Yamasaki Y, and Shiwaku K. 2011. Antiobesity effect of polyphenolic compounds from molokheiya (Corchorus olitorius L) leaves in LDL receptor-deficient mice. Eur J Nutr 2011, 50: 127-133. https://doi.org/10.1007/s00394-010-0122-y; PMid:20617439
11. Barku VYA, Boye A, Quansah N. 2013. Antioxidant and wound healing studies on the extracts of Corchorus olitorius leaf. World Essays J.; 1: 67-73.

12. Tariq A. and Reyaz A. 2013. Significances and importance of phytochemical present in *Terminalia chebula*. Int J Drug Dev & Res.; 5 (3): 256-262. ISSN 0975-9344
13. Tomas-Callejas A, Lopez V, Camacho BA, Artes-Hernandez F and Suslow TV. 2011. Survival and distribution of Escherichia coli on diverse fresh-cut baby leafy green sunder preharvest through postharvest conditions. Int J Food Microbiol.; 151: 216-222. https://doi.org/10.1016/j.ijfoodmicro.2011.08.027; PMid:21924789
14. Fan X, Niemira BA, Doona CJ, Feeherry FE and Gravani RB. (Eds.). 2009. Microbial Safety of Fresh Produce. Wiley-Blackwell, Ames, IA. https://doi.org/10.1002/9781444319347
15. AOAC 2016. Official Methods of Analysis. 16th Edition, Association of Official Analytical Chemists, Washington DC.
16. Antolovich M, Prenzler P, Robards K and Ryan D. 2000. Sample preparation in the analysis of phenolic compounds in fruits. The Analyst, 125: 989-1009. https://doi.org/10.1039/b000080i
17. Kaur C and Kapoor HC. 2002. Anti-oxidant activity and total phenolic content of some Asian vegetables. Int J Food Sci Technol.; 37: 153-161.https://doi.org/10.1046/j.1365-2621.2002.00552.x
18. Piyanete C, Meechai P and Nakbanpotecc W. 2009. Antioxidant activities and phenolic contents of extracts from Salvinia molesta and Eichornia crassipes. Res J Biol Sci.; 4:1113-1117.
19. Miller GL. 1959. Use of Dinitrosalicylic acid reagent for determination of reducing sugar. Analytical Chemistry, 31: 426-428.https://doi.org/10.1021/ac60147a030
20. Souza LD, Wahidulla S, and Devi P. 2010. Antibacterial phenolics from the mangrove Lumnitzera racemosa. Indian J Mar Sci.; 39(2): 294-298.
21. Agilent application note: Analysis of fatty acid in infants formula using an Agilent J & W HP 88 Capillary GC Column.
22. ICMSF 1998: International Commission on Microbiological Specification for Foods: Microbial ecology of foods, V. 6. Micro organisms in food (pp.356-378).
23. Ezz El-Arab AM. 2009. A Diet Rich in Leafy Vegetable Fiber Improves Cholesterol Metabolism in High-Cholesterol Fed Rats. Pakistan Journal of Biological Sciences; 12: 1299-1306. https://doi.org/10.3923/pjbs.2009.1299.1306; PMid:20387744
24. Racha AY, Abdehedi O et al., 2018. Flavonoids, phenols, antioxidant, and antimicrobial activities in various extracts from Tossa jute leave (*Corchorus olitorus L.*). Industrial Crops and Products; 118: 206-213. https://doi.org/10.1016/j.indcrop. 2018.03.047
25. Mohammed G and Mann A. 2012. Evaluation of the nutritional values of dry season Fadama vegetables in Bida, Nigeria. Afr J Food Sci.; 6: 302-307. https://doi.org/10.5897/AJFS11.172
26. Adeleke RO and Abiodun OA. 2010. Chemical composition of three traditional vegetables in Nigeria. Pak J Nutrition; 9 (9): 858-860.https://doi.org/10.3923/pjn.2010.858.860
27. Adeyeye A, Ayodele OD, and Akinnuoye GA. 2017. Comparative study of the proximate and fatty acid profiles of Cola nitida, Cola acuminata and Garcinia kola. Am J Food Sci. & Nutrition; 4 (6): 80-84.
28. Dai ZW, Ollat N, Gomès E, Decroocq S, et al., 2011. Ecophysiological, genetic, and molecular causes of variation in grape berry weight and composition. Am J Enol Vitic Rev.; 62: 413-425.https://doi.org/10.5344/ajev.2011.10116
29. Mahmoud AS, Thao N, and Mario A. 2016. Corchorus Olitorius Linn: A Rich Source of Ù3-Fatty Acids. Pharm Anal Acta.; 7(6): 1-9.https://doi.org/10.4172/2153-2435.1000486 PMid:27722021 PMCid:PMC5053770

30. Amal ZH, Maged KGM, Atef GH, András S, Gábor T, and Helmut D. 2009. Phytochemical investigation of Corchorus olitorius and Corchorus capsularis (Family Tiliaceae) that grow in Egypt. Egyptian Pharmaceutical Journal; 18: 123-134.

31. Galli C, Simopoulos AP, and Tremoli E. 1994. Fatty Acids and Lipids: Biological Aspects. World Rev Nutr Diet.; 76:1-152.

32. Muhammad NO, and Ajiboye BO. 2010. Nutrients composition of Rana galamensis. African J Food Sci Technol.; 1 (1): 27-30.

33. Mitchell DA, Vasudevan A, Linder ME, Deschenes RJ. 2006. Protein palmitoylation by a family of DHHC protein S-acyltransferases. J Lipid Res.; 47: 1118- 1127. https://doi.org/10.1194/jlr.R600007-JLR200 PMid:16582420

34. Lin J, Yang R, Tarr PT *et al.* 2005. Hyperlipidemic effects of dietary saturated fats mediated through PGC-1beta co-activation of SREBP. Cell; 120: 261-273.https://doi.org/10.1016/j.cell.2004.11.043 PMid:15680331

35. Thomas A. 2000. Fats and Fatty Oils. Ullmann's Encyclopedia of Industrial Chemistry. https://doi.org/10.1002/14356007.a10_173

36. James HO, Keefe J, Hussam A, Sastre A, David MS and William SH. 2006. Effect of omega-3 fatty acids on resting heart rate, heart rate recovery after exercise, and heart rate variability in men with healed myocardial infections and depressed ejection fractions. Am J Cardiol.; 97: 1127-1130. https://doi.org/10.1016/j.amjcard.2005.11.025 PMid:16616012

37. WHO/FAO, 1994. Fats and oils in human nutrition (Report of a Joint Expert Consultation), FAO Food and Nutrition Paper 57, Rome.

38. Panche AN, Diwan AD, and Chandra SR. 2016, Flavonoids: an overview. Journal of Nutritional Science; 5:.https://doi.org/10.1017/jns.2016.41 PMid:28620474 PMCid:PMC5465813

39. Figueroa-Espinoza MC, Zafimahova A, Alvarado PGM, Dubreucq E, Poncet-Legrand C. 2015. Grape seed and apple tannins: emulsifying and antioxidant properties. Food Chem. 178, 38-44. https://doi.org/10.1016/j.foodchem.2015.01.056 PMid:25704681

40. Youssef KhM, Mokhtar SM and Noha EM. 2014. Effect of Hot Air Drying Variables on Phytochemicals and Antioxidant Capacity of Jew's Mallow (Corchorus olitorius L.) Leaves. Journal of Food Sciences; Suez Canal University; 2: 1-8 https://doi.org/10.21608/scuj.2014.6667

41. Petronia C, Giuseppe C, Christophe El-Nakhel *et al.,* 2019. Biostimulant application with a tropical plant extract enhances Corchorus olitorius Adaptation to sub-optimal nutrient regimens by improving physiological parameters. Agronomy; 9, 249; 19 pages https://doi.org/10.3390/agronomy9050249

42. FDA (United States Food and Drug Administration). 2003. FDA survey of domestic fresh produce [online]. Available at http://vm.cfsan.fda.gov/wdms/prodsu10.html.

43. Johannessen GS, Loncarevic S and Kruse H. 2002. Bacteriological analysis of fresh produce in Norway. Int J Food Microbiol.; 77: 199-204.https://doi.org/10.1016/S0168-1605(02)00051-X

44. Schuenzel K.M. and Harrison M.A. 2002. Microbial antagonists of food-borne pathogens on fresh, minimally processed vegetables. J Food Prot.; 65: 1909-1915. https://doi.org/10.4315/0362-028X-65.12.1909 PMid:12495009