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Price Comparison of Moringa in the Greater District of Columbia Area, United States of America

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ABSTRACT

Introduction

Moringa oleifera (MO) is a nutritional herbal supplement that grows in many subtropical and tropical regions of the world including India, Africa, North and South America, and Asia. The purpose of this study is to review recent clinical studies regarding the health benefits of MO as well as investigate the availability and relative pricing of MO among retail local and online stores for the various Moringa dosage forms.

Method

In this study, price variations and availability of MO in 18 retail companies that serve the District of Columbia, Maryland, and Virginia region were investigated. Price comparisons of the three major formulations of MO-powder, capsules, and tea-were performed through store-to-store and online searches.

Results

This investigation on retail selling pricing of Moringa has shown that Moringa is a very affordable and accessible product in the greater District of Columbia, Maryland, Virginia region. However, we found a major gap and range in prices among the dosage forms and among the 18 stores included in our study. The average selling price per day for all dosage forms is $0.39, ranging from $0.31 to $0.55. The powder is the most commonly carried dosage form of the supplement, and also has the greatest variation in pricing among the stores. In addition, it was noted that the capsule is the most expensive dosage form ($0.55 *vs.* $0.31 for the powder and tea forms) for daily dosing. A comparison of cost per gram per day dosing was done and shows that there are significant differences in the selling price among the three dosage forms with a *p*-value of less than 0.05.

Discussion

MO has many health benefits and is an excellent value as a nutritional supplement. Numerous studies have shown Moringa to have excellent anti-inflammatory, antioxidant, and antimicrobial activity. In the evaluation of dosage price per day, it was found that for over half of the stores (56%; n=16) the Moringa powder was under $0.50, while for three-fourths of the stores (75%; n=12) it was under $1.00. Moringa is readily available in most stores. Over two-thirds (67%; n=11) of the stores carry all three dosage forms. However, there is a major gap range in the price per day and the daily dose quantity of the herb for each dosage form. The powder dosage form was found to be the most readily available form of the supplement and the least expensive.

Conclusion

It was found that Moringa is relatively inexpensive and is a great value for the health benefits obtained. The powder dosage form is the most readily available form while the capsule is the most expensive dosage form. It is important to emphasize in pharmacist counseling sessions that patients should shop around and compare prices when choosing their desired Moringa product.

Keywords
Moringa; Price comparison; Retail; Dietary supplement; Herbal medicine; Retail price.

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INTRODUCTION

Moringa oleifera (MO) is a tree that grows widely in many subtropical and tropical regions of the world. It is grown commercially in many areas including India, Africa, South America, Central America, Mexico, Hawaii, Asia, and Southeast Asia.[1] A literature search was performed *via* Medline and Scopus databases for articles discussing research on MO and the many uses of this plant. However, this thorough search failed to reveal data on pricing and market availability of Moringa. There is scant research on herbal supplement sales data in various regions of the world in general. One article discussed the supply of medicinal plants in village markets in northern Peru.[2] Unfortunately, Moringa was not discussed in this paper. There was another research article, again not involving Moringa, on the cost comparison of purified isoflavonoid products in Washington State.[3] Thus, in an attempt to help provide this important sales information on the popular herbal supplement MO, data was collected on the availability and pricing of this herbal product in the greater Washington D.C., Maryland, and Virginia region of the United States It is hoped that this study will help to pique interest in medicinal plants and their marketing aspects and generate further studies in the future.

MO has been long used in traditional medicine for its many medicinal properties including anti-inflammatory, antioxidant, and antimicrobial characteristics. The most commonly used constituents of the MO plant are the leaves either in powder form or as aqueous or alcoholic leaf extracts. Other parts of the plant including seed pods, stems, bark, roots, and oil extracts of the seeds are also often used.[4,5]

The MO plant has many health benefits. The plant is used as an important superfood and is cultivated and harvested in many parts of the world. The dried leaves have a crude protein content of 30% and contain 19 amino acids. The leaves have the following mineral contents: calcium, phosphorus, magnesium, potassium, sodium, sulfur, zinc, copper, manganese, iron, and selenium. There are seventeen fatty acids, with alpha-linolenic acid having the highest concentration. Vitamin E, carotenoids, ascorbic acid, flavonoids, and phenolics are also found in the leaves. The amino acids, fatty acids, vitamins, and minerals show a desirable nutritional balance.[6] The MO plant is a rich source of many bioactive compounds and incorporating MO in the diet can improve the nutritional status of nursing mothers and help to combat malnutrition and iron deficiency anemia among children.[7] A study was done aimed at exploring the effects of MO leaves supplementation on the quality-of-life (QoL) of HIV-positive adults in Nigeria. The study found that MO leaves increased the physical, psychological, level of independence, and social relationship domains of a survey on Quality of Life as compared to placebo. It was concluded that MO leaves can be used to improve treatment outcomes by improving nutritional intake and QoL in People Living with Human Immunodeficiency Virus in resource-constrained settings.[8]

MO also shows many health benefits as an herbal nutritional supplement. The leaf part of the plant is most commonly used. The MO supplement is taken in the form of leaf powder, capsules, or leaf extracts. MO has been shown to express anti-inflammatory properties. Chronic inflammation may lead to chronic inflammatory associated diseases such as arthritis, colitis, diabetes, and cancer.[9,10] Inflammatory cytokines, such as tumor necrosis factor-alpha, and interleukin-1-beta can upregulate prostaglandin E-2 and nitric oxide thereby enhancing the activity of inducible NO synthase, microsomal Prostaglandin synthase-1, and cyclooxygenase-2 in target cells and thus increasing inflammation. MO has been shown to inhibit the production of tumor necrosis factor-alpha and interleukins in response to stimulated human macrophages, and also inhibit the expression of Re1A, a gene in nuclear factor signaling during inflammation.[9,11]

A number of studies have demonstrated the antioxidant properties of MO. A study of an aqueous extract of MO leaves using in vitro systems showed the free radical scavenging ability of MO, and also its ability to inhibit oxidative damage to DNA.[12] The aqueous leaf extract was shown to exhibit the most antioxidant activity and to have the highest concentrations of phenolic, flavonoid, and ascorbic acid antioxidants.[1] Another study by Siddhuraju and Becker showed that MO leaf samples from three different agroclimatic origins have very high free radical scavenging activity.[13] Here, these naturally occurring antioxidant compounds decrease oxidative damage in tissues by scavenging harmful free radicals and by cell enhancement.[14]

Many studies also show the anti-microbial properties of MO. A study on the control of coliform bacteria detected from diarrhea-associated patients showed that the organic leaf extracts of MO exhibited a remarkable antibacterial effect against the tested bacterial pathogens including *Escherichia coli*, *Shigella dysenteriae*, and *Salmonella species*.[15] Another study showed the antibacterial activity of bark extracts of MO against *Staphylococcus aureus*, *Citrobacter freundi*, *Bacillus megaterium*, and *Pseudomonas fluorescens*.[16]

There was a study done using paper disks soaked in MO leaf extracts to determine the susceptibility of gram-positive and gram-negative bacteria. While some of the gram-negative bacteria showed resistance, the disks were most efficient and showed good inhibition against *S. aureus*, *Vibrio parahaemolyticus*, *Enterococcus faecalis,* and *Aeromonas caviae*.[17]

An additional study carried out in Ethiopia evaluated the antimicrobial capability of MO leaf ethanol extract. The extract exhibited good antibacterial activity against *Pseudomonas aeroginosa*, *Proteus vulgaris*, *Bacillus subtilus*, *Staphylococcus epidermidis*, and *Streptococcus mutans*.[18]

There was also a study done by Singh and Tafida in Nigeria on the antibacterial activity of MO leaf extracts against *S. aureus*, *Escherichia coli*, and *P. aeruginosa*. The aqueous, ethanol, and methanol extracts all exhibited large zones of inhibition against each of these bacteria.[19]

Reviews of the safety and untoward effects of MO show MO to be a very safe herbal medicine. Based on human, animal, and *in vitro* studies, various preparations of MO leaves including aqueous and organic extracts appear to be exceedingly safe at the doses commonly utilized.[1]

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The purpose of this study is to review the most recent clinical studies regarding the health benefits of MO as well as to investigate the availability and relative pricing of MO among retail local and online stores.

METHOD

The study was done to determine the price variation and availability of different dosage forms of MO among stores in the District of Columbia, Maryland, Virginia region of the United States. A total of 18 retail companies were analyzed based on the cost of dosage per day, weight of dosage per day and the cost per gram of different formulations of Moringa. The 3 major formulations that were analyzed in this study include powder, capsules, and tea. Only 3 formulations were selected, although there are other less popular types including extracts and oil, because of the wide availability of these dosage forms among the stores. A price comparison between the three major Moringa formulations was also conducted. The prices of the different formulations of Moringa products were obtained through the website of each retail company and the location was set within the Washington Metropolitan Area. The quantity and formulation of each product was found on the product label. The price comparison was done using cost per gram per day since there was variation among the products in dosage frequency. The data was then analyzed through statistical package for the social sciences (SPSS) software.

RESULTS

A price comparison among the various dosage forms of Moringa is shown below (Table 1). For more uniformity, the retail prices per day for each of the dosage forms were calculated and variations examined. Of all the dosage forms, the powder has the greatest variation in pricing. About one third (30%, n=18) of the Moringa powder has a 2- fold difference in price in comparison to the capsules. About 94% (n=18) of the retail companies have a lower retail price of the powder in comparison to the capsules (n=15) and tea (n=14). The overall average price for all the stores is less than fifty cents ($0.41). The retail store that has the lowest price per day for all the products is Walgreens which is $0.19. The retail store that has the highest price for all products per day is CVS which is $1.83.

The average retail price was also calculated for each of the dosage forms across all the stores (Table 2). The powder followed by the capsules are the most carried dosage forms in the stores studied (100% *vs.* 83% and 77% for the capsule and tea respectively). The average cost of capsule dosage form is over 77% greater than powder or tea ($0.31; SD $0.20 *vs.* $0.55; SD $0.70). There is a wide range in pricing. For example, the powder is over 10- fold in price between the highest and the lowest. The tea form has the lowest price per day and the least price variation among the stores with a 2- fold difference in price between the highest and lowest. There were also some differences in the minimum price of the different Moringa products. The lowest price of the Moringa tea is about twice the price of the lowest price of the powder.

Table 1. *Price Comparison of Moringa Products (in dollars)*

Store	Powder	Capsule	Tea	Average
Giant	0.22	-	0.20	0.21
Hmart	0.30	0.30	-	0.30
GNC	0.35	1.46	-	0.91
CVS	0.95	2.70	-	1.83
Safeway	0.73	0.72	0.15	0.53
Target	0.17	0.45	-	0.31
HarrisTeeter	0.25	0.15	0.28	0.23
Kroger	0.24	0.44	0.28	0.32
VitaminShoppe	0.46	0.33	0.28	0.36
eVitamin	0.11	0.50	0.44	0.35
SproutFarmersMarket	0.19	0.21	0.32	0.24
Amazon	0.08	0.30	0.47	0.28
Walmart	0.17	0.22	0.35	0.25
Vitacost	0.37	0.23	0.19	0.26
iHerb	0.18	0.12	0.33	0.21
Walgreens	0.13	0.12	0.33	0.19
Wegman	0.24	-	0.33	0.29
Whole Foods	0.35	-	0.39	0.37
Average	0.31	0.55	0.31	0.41

Table 2. *Cost of Dosage forms Per Day with the Average Cost Per Store (in dollars)*

	Powder	Capsule	Tea	Average Cost
Count(# stores)	18	15	14	16
Average	0.31	0.55	0.31	0.39
Max	0.95	2.70	0.47	1.83
Min	0.08	0.12	0.15	0.19
Range	0.80	2.60	0.30	1.60
SD	0.2	0.7	0.1	0.4

Table 3. *Weight of Dosage Per Day of Moringa Products (in grams)*

Store	Powder	Capsule	Tea	Average Amount
Giant	7	-	1.88	4.44
Hmart	4	3.6	-	3.80
GNC	4	3.6	-	3.80
CVS	10	3.36	-	6.68
Safeway	8	2.8	1.1	3.97
Target	2	0.56	-	1.28
HarrisTeeter	7	0.5	1.8	3.1
Kroger	2	1.4	1.5	1.63
VitaminShoppe	5	2	2	3
eVitamin	10	2	1.28	4.43
SproutFarmersMarket	4	0.7	2.8	2.50
Amazon	3	2.4	1.25	2,22
Walmart	2	1.6	1.2	1.60
Vitacost	5	5	1.89	3.96
iHerb	4	1.2	1.96	2.39
Walgreens	10	2	-	6
Wegman	4	-	1.5	2.75
Whole Foods	4	-	1.5	2.75

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Table 3 shows the weight of the daily dose of the different formulations of the Moringa products. The Moringa powder (n=18) has the highest weight of dosage per day in comparison to the capsules and tea among the different stores. About 80% (n=15) of the retail stores have a higher weight per dosage of Moringa capsules in comparison to the Moringa tea (n=14). The tea has the lowest daily dosage weight.

In Table 4, there is a large 5- fold difference in amount between the lowest and the highest weight of the powder per day. The tea products have the least variation in the amount per day. There is nearly a 2- fold difference between the maximum amount of capsule per day in comparison to tea. There is also a 10- fold difference in quantity between the lowest and highest amount of capsule per day.

Table 4. *Weight of Dosage Per Day (in grams) per Store*

	Powder	Capsule	Tea	Average Amount
Count(# stores)	18	15	14	16
Average	5.28	2.18	1.67	3.04
Max	10.0	5.0	2.8	5.93
Min	2.0	0.5	1.1	1.80
Range	8.0	4.5	1.7	4.73
SD	2.7	1.3	0.5	1.50

In Table 5, the average selling prices per gram for each of the dosage forms are listed. As shown, there is considerable variation in the cost per gram for all the formulations. For instance, the Moringa capsules have a 2- fold difference in cost per gram in comparison to the powder. Also, the Moringa powder has a 6- fold difference in cost per gram in comparison to the capsules.

Table 5. *Cost per Gram of Moringa Products with Average Price per Gram (in dollars)*

COST/GM				
Store	Powder	Capsule	Tea	Average Price/Gram
Giant	0.03	-	-	0.03
Hmart	-	0.08	-	0.08
GNC	0.09	0.41	-	0.25
CVS	0.10	0.80	-	0.45
Safeway	0.09	0.26	0.6	0.31
Target	0.09	0.80	-	0.44
HarrisTeeter	0.04	0.30	0.9	0.42
Kroger	0.12	0.31	0.9	0.44
VitaminShoppe	0.09	0.17	1.7	0.65
eVitamin	0.01	0.25	1.8	0.67
SproutFarmersMarket	0.05	0.30	1.1	0.47
Amazon	0.03	0.13	3.8	1.30
Walmart	0.09	0.14	2.5	0.92
Vitacost	0.07	0.05	4.1	1.42

Moringa is one of the more affordable dietary supplements. When estimating the dosage per day, over half of the stores (56%; n=16) sell Moringa powder under $0.50 while three-fourths (75%; n=12) sell the product under $1.00. Moringa is also one of the dietary supplements readily available in most stores. Over two-thirds (67%; n=11) of the stores carry all the three dosage forms. There is a large gap and range in the prices of the dosage forms among the stores. The Moringa tea has the highest cost per gram in comparison to the capsules and powder among the different retail stores. The powder has the lowest cost per gram in comparison to the capsules among the retail stores.

Table 6 shows the average price per gram for each product formulation. The average price per gram per day for all the dosage forms across all the stores is just under seventy cents ($0.68). The Moringa powder and capsules are the most carried Moringa products in comparison to the tea (100% *vs.* 73%). However, there is a major price gap among the three dosage forms compared. The tea is the most expensive product at $2.38 per gram per day which is 2.5- fold higher compared to the average price for all the dosage forms. It is also tea that has the highest price variation among the stores (range $4.92). The Moringa powder has the least variation between the highest and lowest price per gram.

Table 6. *Price Per Gram of Moringa Products with Average Price per Gram (in dollars)*

	Powder	Capsule	Tea	Average Amount
Count(# stores)	18	15	14	-
Average	0.06	0.28	2.38	0.68
Max	0.12	0.80	5.50	1.86
Min	0.01	0.05	0.58	0.03
Range	0.11	0.76	4.92	1.83
SD	0.01	0.20	1.60	0.50

Table 7 shows the *p*-values for the various products, and there are significant differences in the cost per daily dose of the powder in comparison to the capsule (p=0.04965). There is also a significant difference in cost per gram in powder compared to capsules (p=0.001403), powder compared to tea (p=0.000389) and capsule compared to tea (p=0.000794). Powder costs significantly less per gram than the other formulations. There is, in addition, a significant difference in the amount in grams of daily dose between powder and capsules, and powder and tea (p=0.0005279).

Table 7. *Significance Determinations for Cost Per Dose, Cost per gram, and Daily Quantities of Moringa*

	Cost per Daily Dose (p value)	Cost per Gram (p value)	Amount in Grams per Daily Dose (p value)
Powder *vs.* Capsule	0.04965	0.001403	0.0005279
Powder *vs.* Tea	0.25247	0.000389	0.0005279
Capsule *vs.* Tea	0.45895	0.000794	0.2843660

DISCUSSION

Overall, the Moringa powder dosage form has the least cost per gram and per day in comparison to the other formulations. A significant difference in pricing was found with a lower cost per daily

dose of powder compared to capsules and tea. We hypothesized that this can be due to the production process for the powders. It involves the drying and grinding of Moringa leaves. However, the production of Moringa capsules involves additional steps such as addition of excipient, and also requires evaluations of friability and disintegration time of the capsules. Additional steps in the production of Moringa tea include packaging of the Moringa leaves into tea bags. This process can lead to an increase in cost of production and require additional materials.

There was some variation in dosage amount for each Moringa product. The greatest amount of product (in grams) per day was the powder form while the tea had the least amount. There was some variation in the availability of the various dosage forms among the stores. The powder and then capsules were the most carried dosage forms. Over two thirds of the retail stores carried the tea dosage form. The average cost of the capsule dosage form was over 77% more compared to that of powder or tea. It is highly recommended for consumers to shop for the cheaper price since there is up to 6-fold difference in price in the studied area.

The Moringa powder also had a significant difference in the weight per dose in comparison to the capsules and tea among the different products (33% *vs.* 13%). The average weight per dose of Moringa is over 2-fold higher for the powder compared to the capsule and over 3- fold compared to the tea (5.28 g, 2.18 g, and 1.67 g respectively). The Moringa powder may include some seed pods and stems in addition to leaves and may thus be a bulkier formulation. Also, the Moringa capsules and tea require additional packaging of the Moringa extracts into tea bags or capsules which can lead to reduction in weight per dose of the products.

There was also variation in the cost per dose of the Moringa products among the different retail stores. CVS had the highest overall average cost for all the products while Walgreens had the lowest among the stores studied. This can be due to the difference in operating costs, overhead costs and delivery of different services among the different retail stores. For instance, CVS provides bonus rewards when purchasing OTC products which can lead to an increase in the retail price of the products. Also, other companies such as Amazon have membership programs such as Amazon Prime which can provide free or reduced cost of delivery of products. Factors such as these may result in cost differences of Moringa products among the retail stores.

CONCLUSION

In this study, wide variations in pricing of Moringa formulations were found among the stores. The Moringa tea had the highest cost per gram in comparison to the capsules and powder. The powder had the lowest cost per gram in comparison to the capsules and tea. There was also variation in cost per dose among the various dosage forms. Moringa powder had a similar average cost per dose in comparison to tea. However, the capsules had the highest cost per dose.

Moringa is a very useful food supplement and herbal medicine. The basis of many of Moringa's medicinal properties lies in its anti-inflammatory and antioxidant activities. Moringa has been shown to counter chronic inflammatory processes and its phenolic and flavonoid compounds reduce oxidative damage in tissues.

Overall, it was found that Moringa is relatively inexpensive and is a great value for the health benefits obtained. This investigation on pricing and costs of Moringa in the greater District of Columbia, Maryland, Virginia region has shown the powder dosage form to be the most readily available form of the supplement and have the least expensive daily dosing. It is hoped that in the future more studies showing Moringa's many health benefits and its pricing and availability will be performed and Moringa will continue to gain in popularity.

INSTITUTIONAL REVIEW BOARD APPROVAL

This study has been approved by the Institutional Review Board (IRB).

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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