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RESEARCH ARTICLE

Consumer Knowledge of Garlic for Nutrition Education Programming

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ABSTRACT

Garlic intake has been the subject of research for its many potential health benefits. Consumers have continuing interest in food-related topics, food preparation, and growing their own food in small gardens. Garlic has specific agronomic protocols because it is not grown simply from seed. As a culinary aromatic, garlic use may be somewhat mystifying for some. This research study used an online consumer survey with 558 participants to determine basic garlic consumption habits, knowledge of the research related to health benefits of garlic, experience with and interest in growing garlic, and some basic demographic information. The top reason for using garlic, at 64% of responses, was 'cardiovascular' benefits, followed by 'anti-bacterial' at 45% and 'blood pressure support' at 37%. Only 3% of respondents reported that they were currently taking garlic supplements. The top two preferred garlic forms used at home were 'dried garlic powder' and 'fresh, raw garlic,' at 86% and 83% respectively. We noted a budding interest in growing garlic for home harvest and in educational information, especially when available in online print and video formats. The survey results showed that more programming is needed to emphasize the health benefits of the natural phytochemicals (plant chemicals) contained in garlic as part of an overall balanced diet.

Keywords: garlic, aged garlic extract supplements, plant-based, nutrition, diet, health, Cooperative Extension, gardening

Introduction

Garlic is unique in a class of edible vegetables called alliums that have been the subject of research for their potential medicinal properties. Not only is garlic the most pungent of the allium family of comestibles, but it also is an historically used remedy for ailments since the plant was first discovered and cultivated. Eventually, garlic's unique healing properties lent itself toward the application of dietary supplements in human health. Especially since the pandemic, consumers are eager to learn to grow their own food. Because of garlic's multiple facets, possibilities for renewed promotion among consumers and small-scale local gardeners warrants investigation.

The allium family includes garlic, onions, shallots, chives, and leeks. They all have health-promoting properties and can be included in a balanced diet to help prevent chronic disease. Native to Central Asia, garlic and onions have a more than 4,000-year use for culinary and health benefits. Historically, an ancient Egyptian text cites 22 applications for garlic. For example, Hippocrates suggested garlic as a laxative and diuretic, and Aristophenes and Galen promoted its use for treating uterine cancer.[1] Garlic grows wild in some areas of the world, including Central Asia, but garlic is now cultivated on more than 2.5 million acres (1 million hectares) for a worldwide market according to the U.S. Agricultural Research Service [2]

Garlic has been used in culinary and medicinal applications. Fresh, powdered, oil, aged garlic extract (AGE), black garlic and purple garlic are among the options. Compounds in these varieties have greater potency when cooked, for example, as opposed to some compounds that are emphasized when garlic is eaten raw.[3,4]

Common bioactive compounds of garlic that have been studied include polysaccharides, saponins, phenolic compounds, and S-allyl-cysteine.[3,4] The main bioactive components include polyphenols, flavonoids, flavanols, and tannins.[5] High levels of potassium, phosphorus, zinc, and sulfur are found in garlic, along with lesser amounts of selenium, calcium, magnesium, manganese, and iron. The sulfur-containing compounds in garlic are known as alliin, allicin and ajoene, among others.[5,6] Garlic also contains various enzymes, along with phellandrene, citral, linalool, and geraniol.[5] Overall, some compounds, such as the phenols, are higher in garlic than in many other common vegetables.[3]

Garlic has long been used in a variety of ways for potential health benefits, including cardiovascular, immunity, infection, and oxidative stress.[7] The purported actions of garlic are many: reduction in severity of colds and flu, protection against various alimentary canal cancers among others, protection of the liver, and high level of anti-microbial activity. For example, the Rosato and Caposele varieties from Italy are effective against *Penicillum expansum*, *Aspergillus versicolor* and *Penicillum citrinum*.[3]

Some gut-health-promoting prebiotics are found in garlic and in other foods. The properties of some polysaccharides are anti-inflammation, antioxidation, and immunomodulation. They relieve colitis by reducing levels of inflammatory factors and improving the microbiome. Garlic polysaccharides' other properties include antitumor, anticoagulation, liver protection, and microbiome balance.[8]

Many viruses have threatened human health recently, such as SARS in 2003, MARS in the Mid-East in 2012, Ebola in West Africa in 2014 and of course, COVID-19 worldwide in 2020. Prevention of viral disease stymies current treatment because it emerges and spreads rapidly and has drug-resistance, adapting quickly to treatments as strains mutate. Even though some success has emerged in medical prevention and treatment in lieu of a fast-changing environment; e.g., with herpes simplex, HIV and hepatitis B, some people look to applications of functional foods in order to bolster their immune systems.[9]

The many potential benefits of garlic are affected by the various pre- and post-harvest methods employed in the growing cycle. In pre-harvest activities, genotype is the first consideration. The selection of a particular cultivar may result in an increase in total phenolics. The differing colors of some cultivars also affect nutrition: vitamin C and total fractionated oil are higher in purple varieties, and total phenolic compounds and flavonoid content are higher in white garlic. Harvesting garlic later in the season allows for the compounds to travel from the leaves into the bulbs, where they are most frequently utilized for culinary or medicinal purposes. In post-harvest, it is important to consider processing in order to maintain quality.[6]

Garlic has been applied to maintain health and treat disease throughout history. In some published research, aged garlic extract (AGE) in dietary supplements is shown to improve immune system function, decrease severity of cold and flu symptoms, reduce obesity-induced inflammation, and increase healthy microbial activity in the gut.[5] Some of the ways garlic has been prepared for consumption in health maintenance are garlic powder, garlic oil, and commercial extracts. AGE is commonly found in dietary supplements throughout the retail environment. AGE is made by slicing garlic cloves and storing them in a water-ethanol solution until the volatile components are converted into stable compounds.[10]

Some of the marketing claims for AGE and other garlic-infused dietary supplements include fighting free radicals, reduction of cold and flu symptoms, reduction of upper respiratory tract infections, supporting immunity, inhibition of blood platelet formation, lowering of blood pressure, and lowering of blood lipids. There is some evidence in the research for garlic's efficacy; however, a variety of preparations have been used across a variety of methods in studies, and some preparations have varying levels of quality, therefore, not one single brand of AGE can be conclusively recommended.[7]

Home-based food production and preparation became very popular during the global pandemic, and research has shown significant public health benefits and practices of gardening that can be applied during times of crisis.[11] Further, consumer interest in garlic has grown.[2] In addition, enhancing flavor in foods with the addition of

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salt-free herbs and spices (such as garlic powder or fresh garlic) can decrease salt content in recipes and potentially reduce the risk for chronic disease.[12]

Garlic in moderation is considered safe, especially when consumed in foods. Further, garlic consumption has shown potential health benefits linked to its lipid-lowering, antioxidant and anti-inflammatory effects in several randomized controlled trials.[5] Too much garlic, however, especially when eaten raw, can promote upset stomach or heartburn.[13] Food consumption has a major impact on health at all stages of life, from birth through advanced age, and a dietary pattern based on science-based research can reduce the risk for chronic disease, according to the U.S. Dietary Guidelines for Americans.[14] Although dietary supplements of various types are popular among consumers, they cannot replace a healthful diet; the Food and Drug Administration uses different criteria for overseeing supplements compared with foods and drugs.[15]

Study Purpose and Design

The purpose of this survey was to assess the level of consumer interest, knowledge, and experience with using (i.e. cooking, eating) and growing fresh garlic. We wanted to determine general knowledge, including historic/folkloric as well as scientific research results, to get a sense of background reference points from which consumers orient themselves. Through efforts of the Cooperative Extension program, the results will be used to create local and national educational programming and online materials for consumers and growers in their homes and within their local communities.

Mixed methods were used to collect data from consumers, relying on the survey tool administered through Qualtrics (Provo, UT). The study was approved by North Dakota State University Internal Review Board protocol #IRB0005164 on April 24, 2024. Twenty questions were asked; of those, four were solely quantitative where participants selected responses from a provided list, ten were quantitative combined with a qualitative optional write-in answer, five were demographic, and the final question pertained to the anonymous prize drawing. All questions were designated as being optional for the participant to answer, allowing for skipping questions. As a survey, the basis for data collection relied on quantifiable questions and answers in order to observe larger trends. However, a number of the questions (10/14) had options for qualitative answers; that is, open-ended responses, which resulted in broader, richer data.

Questions were developed into three areas of inquiry: consuming garlic, health benefits of garlic, and growing garlic. Consuming garlic questions were based on prior experience of Cooperative Extension community-based educational programming in food and nutrition. Health benefits of garlic questions were based on the literature, and growing garlic questions were asked as initial inquiry into what might be consumers' current experience (or inexperience) they had in personal-scale garlic cultivation.

The survey was distributed via email listservs and e-newsletter subscriptions of various Extension food and nutrition networks across the country known to one of the co-authors, and through social media (Facebook) to reach a diverse audience. A total of 558 respondents completed the survey, which opened on May 1, 2024 and closed on June 6, 2024. The authors' goal was to reach 500 respondents, which is common in this type of research, so the response rate for this type of survey was considered a success.

Data Analysis and Results

DEMOGRAPHICS

The survey participants (558) were from half the states (25) in the United States, with 86% of survey respondents from the Midwestern states of North Dakota, Minnesota, Iowa, Nebraska, Ohio and South Dakota. Most reported being female (85%), preferred materials in English (99%), and they ranged in age from 18 to 80 and older, with most participants in the 40 to 69 age range. Tables 1 to 6 summarize the results of the survey questions.

Table 1. Garlic use.

Q1: Do you or anyone in household eat garlic?		
Select ONE Answer	**Percentage**	**Count**
You	15	76
You and other householder(s)	85	446
Other householder(s) only	0	1
No one in household, but interested in trying	0	1
Q2: If you eat garlic, in what form?		
Mark All That Apply	**Percentage**	**Count**
Fresh, raw garlic	83	437
Preserved, raw garlic in jar	63	332
Dried garlic powder	86	450
Dried garlic salt	50	264
Dried garlic granules or flakes	34	178
Other	7	35
Number of Responses	**Forms**	
5	pickled	
5	roasted	
5	oil infused	

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4	all forms
4	paste
3	frozen raw
2	scapes
1	dehydrated pods
1	'everything' bagel seasoning
1	in honey
1	confit
	How used
2	in canning
2	in cooking
1	stir fried
	Other
1	dietary supplement
1	raw when sick

Q3: If you use fresh, raw garlic, how often?

Select ONE Answer	**Percentage**	**Count**
Every day	14	73
Every week	53	274
Every month	15	77
A few times a year	12	60
Never	6	33

Q4: Why do you use fresh, raw garlic in meals?

Mark All That Apply	**Percentage**	**Count**
I like the taste	90	448
For the health benefits	41	203
Other householders like it	27	132
I don't, but am interested in learning more	5	26
Other	6	31

Number of Responses	**Responses**
9	recipe calls for it
6	grown at home
3	taste, flavor, aroma
1	healthy
1	prefer it
1	have it on hand
	Negative responses
4	don't use much/use other forms instead

Q5: Why *don't* you use fresh, raw garlic in meals?

Mark All That Apply	**Percentage**	**Count**
Don't like the taste/too strong	4	5
Difficult to digest	2	3
Don't want to smell like garlic	20	26
Too difficult to prepare	58	76
Other	27	36

Number of Responses	**Responses**
12	inconvenient (sticky, smelly, jar/bottle easier, powdered works better)
7	lack of time
5	no availability (small town/food desert)
3	use both fresh and jar
3	spoils, don't use it enough
2	no knowledge
2	don't keep it on hand
1	more expensive
1	need to disguise it for family
1	never had it

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Table 2. Garlic health benefits.

Q6: Based on what you've read, what are potential health benefits of garlic?		
Mark All That Apply	**Percentage**	**Count**
Cardiovascular	64	301
Anti-bacterial	45	212
[Blood detox]	17	79
Anti-fungal	24	110
Anti-viral	26	123
[Mosquito repellant]	25	116
Anti-cancer	26	123
Brain/memory support	19	90
Anti-diabetic	8	39
[Natural COVID-19 prevention]	3	13
Anti-obesity	6	27
Blood pressure support	37	173
Other	10	48
Number of Responses	**Responses**	
17	no knowledge (unsure/don't know/haven't heard/etc.)	
9	indifferent (eat for flavor/part of culture/don't care/etc.)	
6	anti-inflammatory	
3	need to do own research	
2	bones	
2	pre-biotic fiber	
1	heart	
1	metabolic stimulant	
1	cholesterol reduction	
1	anti-oxidant when ferment in honey	
1	could be all of the above	
1	have studied and found minimal benefit	
1	none of the above	
Q7: Which are examples of traditional or folk remedies of garlic?		
Mark All That Apply	**Percentage**	**Count**
Garlic oil for ear infections	20	103
[De-worming animals]	11	54
[Rubbing raw garlic on acne]	6	33
Stamina	4	20
Placing inside shoe for athlete's foot	13	67
[Blending with coconut oil for cold sores]	4	23
Eating raw garlic to prevent colds	41	212
Never heard of any of these	47	243
Other	5	24
Number of Responses	**Responses**	
11	ward off vampires/Dracula/witchcraft	
2	many/some listed may actually work	
1	bee stings	
1	cough – eat steamed garlic	
1	wart removal – press garlic on it	
1	intestinal worms	
1	garlic compress on chest as child/home remedies staple in Native culture	
1	weight loss	
1	blood pressure	
1	preventing colds	
1	haven't heard any listed	

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Table 3. Garlic supplements.

Q8: If you have every taken a garlic supplement, why?		
Select ONE Answer	**Percentage (%) of respondents**	**Count**
Currently taking	3	16
Number of Responses	**Reasons**	
6	cardiovascular/heart health	
2	mosquito/insect repellent	
2	easy	
2	gut health	
2	immunity/anti-viral	
1	general health	
1	like the flavor	
Keep them on hand	1	4
1	blood pressure	
1	cooking	
Haven taken in the past	4	19
2	bug repellent	
2	cardiovascular/heart health	
2	immune health	
2	blood pressure	
2	cholesterol	
2	good for everything	
1	weight loss	
1	candidiasis/fungal infection	
1	anti-biotic	
1	free sample	
Have considered taking	2	8
2	multiple health reasons listed above	
2	blood pressure	
1	if I knew benefits I would take	
Never taken	90	443
64	eat it/fresh is better	
55	no reason/why/not necessary/don't want to/no need/never occurred	
25	no knowledge/not researched/not enough evidence/no benefits	
17	did not know there was such a thing	
14	don't use/avoid supplements	
13	odor/taste	
7	supplements not tested/don't trust/uncomfortable using	
5	doctor did not recommend	
1	too expensive	
Q9: How often do you take garlic supplements?		
Select ONE Answer	**Percentage (%) of respondents**	**Count**
Every day	21	9
Almost every day	16	7
Sometimes	21	9
When I remember	21	9
Tried it once or twice	21	9

Table 4. Growing garlic.

Q10: Have you ever grown garlic?		
Select ONE Answer	**Percentage (%) of respondents**	**Count**
Yes, every year or almost every year	22	16
Yes, in the past but not recently	13	67
Yes, tried it once or twice but didn't work	10	51
Don't have room to grow it	10	51
Don't have knowledge to grow it	28	148
Other	17	87

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Number of Responses	Responses
26	just haven't/don't use enough/never tried/no desire/never occurred/lazy
13	trying it this year
11	grew up around it but no knowledge/like to try
6	easier to buy (fresh or jar)
5	not enough time
4	live around it/neighbor has it/live in garlic-saturated community
2	no garden space/do not garden
1	grow garlic-flavored chives
1	not enough sun
1	eat too much to grow
1	unable/bed-ridden
1	can't eat all the garden would produce
1	not enough space
1	don't know how, maybe not a good fit for my garden
1	planted last year, but not sure if it is coming up
1	was given a bulb and plan to plant it

Q11: If you have grown garlic, on what scale?		
Select ONE Answer	**Percentage (%) of respondents**	**Count**
Very small amounts in pots at home	13	33
In home or community garden	81	203
Small commercial operation, selling locally	5	12
Other	1	3

Number of Responses	Responses
1	scattered in flower beds
1	a couple bulbs in the garden
1	planning to plant a bulb

Q12: Rate your knowledge of growing garlic		
Select ONE Answer	**Percentage (%) of respondents**	**Count**
None	35	184
Little	36	186
Some	15	77
Fairly confident	13	70
Expert	1	5

Table 5. Garlic educational resources.

Q13: No matter your knowledge, what resources would you find helpful?		
Mark All That Apply	**Percentage (%) of respondents**	**Count**
Video tutorial	66	337
Online growing guides, downloadable	71	365
Print	44	227
Online recipes	45	230
Live webinars	28	145
Live, in-person hands-on classes indoors	23	118
Live, in-person hands-on classes garden site	27	140
Other	4	23

Number of Responses	Responses
	TOPICS
32	GROWING – PLANTING - HARVESTING
	geographic growing zones
	years it takes to get full bulb heads
	increasing yields without chemicals/organic growing
	growing other edible alliums
	plot preparation

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	soil alkalinity issues
	finding an area to grow garlic, i.e. pot, ground, etc. options
	ordering bulbs for planting
	saving bulbs from previous harvests for planting
	handling pests, e.g. animals that dig up bulbs yet don't eat them
	why some bulbs produce a couple of huge cloves and not multiple smaller
5	FOOD PREPARATION, incl. safe handling, garlic-infused oil
4	SAFE STORAGE, e.g. spoil quickly, one clove bad can still keep the others
4	COOKING, incl. scapes
3	EATING, incl. digestive issues
1	PRESERVATION
	MODES
3	hybrid live and on-demand
3	print material with high-quality, detailed images
2	hands-on classes
2	webinars
1	snail-mailed
1	emailed
1	"learn as we grow": in-person fall planting session, spring webinar on scape harvest, etc.
	OTHER RESOURCES/GENERAL COMMENTS
4	already using local Extension resources
4	always looking for more resources
2	using local garlic festivals and community garden programming
1	more information from NDSU Extension
1	advertise in local paper when new resources become available
1	languages other than English

Table 6. Final comments from participants on garlic.

Q19: Final Comments	
Number of Responses	**Responses**
	ENTHUSIASM
16	love garlic
7	love growing garlic
2	love garlic classes and other information
	RECIPES
1	garlic scape pesto
1	Hawaiian: white rice, shrimp, garlic, pineapple, Spam
1	fresh garlic marinade for grass-fed meats
1	pasta sauce
1	garlic toast
1	smoothies
1	German fry sausage
1	homemade dill pickles with garlic
1	slice raw garlic in any meat dish
1	good with homegrown tomatoes
	HEALTH BENEFITS
1	natural remedy
1	reduced my A1c
1	good for me

Discussion

GARLIC USE

As shown in Table 1, most survey respondents (85%) reported that they and/or at least one other householder ate garlic. Because our pool of survey participants was drawn from already established email listservs, social media (Facebook), a column reaching numerous newspapers, and digital newsletter subscribers of food and nutrition information, we expected a fair amount of interest in garlic as we would other food and nutrition topics. However, our survey solicited information that would help us further understand the degree to which enthusiasm or interest in the specific topic of garlic would extend. The results within the garlic use or consumption category of questions supported that assumption, either by personal response or household interest, as almost all of the participants or their household members reported eating garlic.

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Frequency of garlic consumption was fairly regular, on a weekly basis, and the main reason for consumption was for the taste, followed by health benefits. One respondent reported in the 'other' answer line that "aroma is better when using fresh raw garlic," and another stated "I think it's the healthiest option." We also wanted to find out why respondents did not use fresh raw garlic in their meals, with the majority selecting the answer response that indicated it was too difficult to prepare. Even though there are new and old tools available to help home cooks prepare garlic from the fresh state, one respondent summed up the disadvantage well with "the time it takes to clean the garlic press."

In terms of garlic form used, the top two responses were 'dried garlic powder' and 'fresh, raw garlic,' at 86% and 83% respectively. Close behind were 'preserved, raw garlic in jar' (63%) and 'dried garlic salt' (50%). Most people reported using garlic every week at a rate of 53%, followed by every day and every month at 14% and 15% respectively. Twelve percent of respondents said they used fresh, raw garlic only a few times a year, with 6% reporting they never use it. About 41% noted that the health benefits of garlic was a reason for using it, followed by 27% saying they use it because of others in the household, with 5% reporting no use at all, but interested in learning more. Those respondents that *don't* use fresh, raw garlic in their meals selected the reason as too difficult to prepare, at 58%, whereas not liking the taste came in almost in last place at 4% of the responses, marking all that apply.

When respondents could choose more than one answer, we saw percentages jump, as many forms of garlic were consumed, especially garlic powder along with fresh raw garlic. Enthusiasm showed itself in almost every question asked, and in question 2, one respondent, replying to what form garlic was eaten, commented, "any form we can find it." Respondents reported using garlic in canning (food preservation), cooking and stir fry applications. A wide variety of other forms were reported, from pickled to confit.

More qualitative responses were reported for *not* using fresh, raw garlic, with the most saying it is too inconvenient because of its sticky and smelly qualities, along with saying that there were other forms of garlic more convenient to use (12 count). Next in line of descending responses were lack of time (7 count), no availability because of rural area or food desert (5 count), use both fresh and jar (3 count), and spoils quickly (3 count).

One of the themes we noted from the survey that was first revealed in the garlic use category of questions was the lack of availability of fresh, raw garlic, noting that rural area grocery stores do not stock it or have trouble keeping the fresh article in stock: "Fresh garlic of good quality is not readily available in small town grocery stores; what they have is often dried out." Another repeated the sentiment: "not available in my small town grocery," and later in the survey "I want to plant garlic for my own use because I think it would taste better than what I purchase in a grocery store." Thus, we found that some stores do not keep good stock of fresh garlic on hand, which could be true for other types of fresh produce as well.

GARLIC HEALTH BENEFITS

As shown in Table 2, the top reason for using garlic, at 64% of responses, was 'cardiovascular' benefits, followed by 'anti-bacterial' at 45% and 'blood pressure support' at 37%. The next block of responses around the 25% mark were 'anti-cancer,' 'anti-viral,' 'anti-fungal,' and 'mosquito repellant,' the last of which was one of the 'distractor' answer responses.

The health benefits of garlic question category may be divided into two areas of inquiry: scientific and traditional health benefits of garlic (Q6 and Q7), and the use of garlic dietary supplements for enhanced health benefits (Q8 and Q9). Those 'distractor' or 'fake' answer choices are bracketed. Otherwise, answer responses offered in both of these questions were based on current research. Both questions 6 and 7 provided respondents with the 'other' category in order that they may list (or repeat or emphasize, in some cases) benefits and uses of garlic with which they were more familiar.

The 'other' option amusingly listed various versions of warding of vampires, witches, or Dracula at 11 count. The survey participants may not have taken those options seriously, either, because some chose those options made popular in American vampire movies. A variety of single responses listed remedies for various maladies such as bee stings, cough, warts, worms, and some actually are reported as valid in the literature: weight loss, blood pressure, and preventing colds. Two respondents reported that some of the listed answers may actually work, and one stated that home remedies were part of their Native American culture.

When asked to fill in the 'other' answer line, the majority of those answers indicated that respondents had not heard of health benefits, or needed to do their own research. We found this interesting, as garlic has been researched for a number of years, especially in the supplemental form of aged garlic extract. Some respondents avoided the topic altogether by stating that "I eat for the flavor and not health benefits," with one answer contradicting the research: "I have studied this a fair bit and I feel that there are minimal health benefits."

GARLIC SUPPLEMENTS

The second area of inquiry in the health benefits category was the use of dietary supplements among respondents (Table 3). The vast majority (90%) of respondents had 'never taken' garlic supplements, stating that fresh was better than supplements, or that the idea of taking a supplement never occurred to them. Some stated there wasn't enough evidence to support taking garlic supplements, and others eschewed all supplements no matter the source or function: "supplements have no testing requirements," "my doctor hasn't recommended taking supplements," and "are there any FDA approved garlic supplements?". Some quotes infer that they are aware that the FDA does not approve, condone, or support any type of dietary supplement but uses different regulations than those used for food or drugs.[15]

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Only 3% of respondents reported they were currently taking garlic supplements, with the most reasons given for cardiovascular or heart health. One reason was for blood pressure, and the other responded "for cooking." The third response offered was if respondents took supplements in the past, which was the second highest answer response with 4. The fourth response choice asked if respondents had ever considered taking a supplement, and only 2% indicated in the positive. Those reasons again were for multiple health reasons previously listed along with one respondent saying they would take a supplement if they knew the health benefits. The fifth category of answers was the most selected, with 90% of respondents (443) saying they have never taken supplements. Of those respondents who said they never took a garlic supplement, 64 responded they would rather consume fresh garlic than by taking it in a supplement.

GROWING GARLIC

Growing garlic (Table 4) was part of our survey because we are interested in developing educational programming focused on growing garlic, because it is not a straight forward process. Instead of planting in the spring, like many vegetables, garlic is planted in the fall, similar to floral bulbs, which will then sprout in the spring and grow in the summer. There is a spring harvest of garlic scapes, which are the chive-like shoots, and bulb harvest in the late summer. We were interested in how many of our 558 respondents ever tried growing garlic, or perhaps had a small holding and sold commercially. Most respondents did not have any knowledge about growing garlic (28% from question 10) and when asked to rate their knowledge, 71% (combined) had no or little knowledge (question 12). Of those who had grown garlic, most reported in home or community gardening (question 11).

Some of the respondents in the 'other' answer lines stated that "it was planted in my garden when I bought the house but I don't harvest it the correct way so I replant it every year" and "my mother gave me a bulb from garlic she has in her yard and I plan to plant it," which were illustrative of the lack of knowledge to grow it. These statements at least show an interest as well as attempts at growing their own garlic, which is promising for program planning. Of the 17% of respondents who answered the 'other' option, 26 count said they either don't use enough garlic to grow it on their own, had no desire, or it just never occurred to them (Table 4, Q10).

Of the 17% of respondents who selected to offer their own response, 26 said some version of just never trying it, or not having the desire to do so. This was followed by 13 respondents saying they were trying it 'this year', which correlates with the quantitative responses where participants answered similarly in numbers for these answer sets. Eleven respondents said they grew up around garlic growing activities and were interested in trying, followed by six who said garlic was simply easier to buy and use than going to the trouble of growing it. Further, five respondents said they didn't have the time to grow, four said there were others around them growing garlic from which they could draw, such as community gardens or neighbors, and two did not have the space to grow. In single numbers, there were a variety of reasons to not grow garlic, such as not enough sun or space, eat too much garlic to grow enough, tried planting but not sure if it is working, and growing other herbs instead.

GARLIC EDUCATIONAL RESOURCES

The survey explored the type of programming and educational materials in which respondents would be interested or most likely to engage (Table 5). The single most selected answer was 'online growing guides that are downloadable' at 71% of respondents who answered the question, followed relatively closely by 66% who selected 'video tutorial' as a helpful resource. About 45% and 44% respondents chose 'online recipes' and 'print' resources, respectively, as helpful in their engagement with garlic, while 28% chose 'live webinars' as something they would prefer. Finally, respondents were asked if they thought either 'live, in-person hands-on classes indoors' or 'live, in-person hands-on classes at a garden site' would be helpful for them, and 23% selected the first of those two choices while 27% selected the second of those two. The educational resources most requested by respondents for information on cooking, eating, or growing garlic were online growing guides that were downloadable.

To determine varying levels of ability in order to attend or participate in educational resources, 87% indicated that written materials were preferable, 55% selected 'audio' from the answer list, and mobility alternatives for in-person classes were required by 8% of respondents. Necessary to some of the educational programming was determining geographical growing regions, or growing zones in which respondents were located, so they were asked to name their state of residence.

When asked to offer their own ideas for resources, respondents reported either topics or mode of delivery, with the majority of responses including some version of the growing, planting, and harvesting cycle. Seventeen respondents suggested information on a range of garlic preparation, cooking, and preserving activities. Modes of delivery basically reiterated the modes offered in the answer set listed in question 13.

PARTICIPANT COMMENTS

As shown in Table 6, open-ended answers from respondents giving their final comments were organized into four main topic areas: enthusiasm, recipes, health benefits, and appreciation. The majority of those responding to this open forum, 16 count, reiterated how much they love garlic, with 7 count expressing love for growing garlic, and 2 count saying they love garlic classes and other information about garlic.

Final comments on the survey were somewhat expected, showing enthusiasm about the survey and the topic of garlic in general. We could surmise that most people taking a survey about garlic are already interested in the topic, so this correlated with the energetic responses, such as "if a recipe calls for a couple cloves, we add a couple heads," "my family recipes do not even have amounts—we measure with our heart (and nose)," and "there is no downside to garlic—if the recipe calls for two cloves, you use six!"

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Besides the enthusiasm, a number of respondents shared with us the various recipes in which they use garlic; one surprising response stated that they put garlic in smoothies, a type of creamy energy drink usually made to be on the sweet or fruity side. Another shared an application of garlic that dovetailed with their home enterprise of raising grass-fed beef: "I am a great meat cook especially as we raise grass fed/finished beef and lamb and fresh garlic in marinades is THE BEST!!! It pushes it over the top!" A few health benefits were also reported as final comments, with one respondent stating that "consuming raw garlic helped me decrease my A1c (blood glucose control measure) from 5.7 to 5.1"

Conclusion

Using garlic in culinary applications and growing garlic are two educational programming opportunities ripe for promotion, especially in lieu of post-pandemic efforts of consumers to become more self-sustaining in ensuring their own food supply lines locally and independently. These efforts are backed by the many studies showing the potential benefits of garlic for human health [1, 3, 4, 9, 10], which should be included in educational programming due to the lack of knowledge of health benefits shown in our garlic survey results. Programming for growing garlic will most likely be pursued separately from consuming garlic. The survey did not specifically ask if respondents would like to grow garlic if given the opportunity, but the optional qualitative responses showed about 26/76 of respondents would be open to programming about growing garlic.

Education about garlic consumption, including preparation, cooking, storing, and preserving garlic, is ongoing, and the survey results showed that more programming is needed to emphasize the health benefits of the natural phytochemicals (plant chemicals) contained in garlic. General education on garlic supplements, including the research, could be provided to supply background for our constituents, allowing them to make savvy decisions between choosing freshly prepared nutritious food or dietary supplements that have scientific backing.

Future research could expand to an international audience and include separate and more detailed questions about consuming, growing garlic and using garlic in worldwide cuisine. We were limited by the geographic aspects of growing garlic; different growing zones in the U.S. and throughout the world require different information about growing conditions. The survey did not inquire about food deserts or fresh food availability, which came up in some of the responses for consuming garlic. However, programming for growing and using garlic would be advantageous for a global audience.

More information about garlic is available in the applicable garlic section within the resources: www.ag.ndsu.edu/fieldtofork

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