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Recommendations for a Water Conservationist Diet in California

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ABSTRACT

RECOMMENDATIONS FOR A WATER CONSERVATIONIST DIET IN CALIFORNIA

by Helen M. Lee

As the world's population continues to increase, a focus on nutrition security and water sustainability is needed to ensure enough resources for future generations and their wellbeing. The agricultural sector uses the most water worldwide, so identifying agricultural commodities that use less water and are more nutritious could help society reach these goals. California is the largest producer of agriculture in the United States. Therefore, an analysis of water use and nutritional value was conducted using water footprint (WF) and nutrient rich food scores (NRF) of California's agricultural products. The results of the WF and NRF analysis showed that the category of low water use and high nutritional value was made up of fruits and vegetables, including leafy green vegetables and all melons. On the other hand, most animal products, most field crops, and all nuts belonged in the high water use and low nutritional value category. In addition, this study gauged the importance and interest of agricultural water use to California consumers when making food choices through a multipart survey. The survey showed that among environmental factors, agricultural water use in food choice was one of the least important factors. However, when asked what water issues they would like to learn more about, consumers ranked agricultural water use for food production 3rd out of 16 options, showing an interest to learn more. This study provides a preliminary look at the consumer's thoughts on the issue of agricultural water use and a clear understanding of which agricultural products could be integrated in the consumer's diet with consideration to its impact on water sustainability and nutrition security.

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TABLE OF CONTENTS

List of Tables viii

List of Figures ix

List of Abbreviations x

CHAPTER 1: Literature Review 1
Introduction 1
Water Sustainability and Nutrition 3
A Global Concern 3
A Universal Measure of Water 3
Nutrition Security 4
Why Does Water in Agriculture Matter? 5
Agricultural Water Use at the Global Level 5
Factors Stressing Global Water Resources 6
California Agricultural Water 7
The Importance of CA's Agricultural Water Use 7
Current Agricultural Water Use and Practices in CA 7
Drought Implications in CA 8
The Redistribution of Crops 10
California's Water Footprint 11
Dietary Patterns and Water Conservation 12
Nutrient Profiling 13
Evaluating the Water Use and Nutritional Value of Individual Crops 14
The Consumer's Role 15
Conclusion 16

CHAPTER 2: Journal Article 18
Abstract 19
Introduction 20
Materials and Methods 23
Data Collection 23
Data Analysis 27
Results 29
Water Use and Nutritional Value for CA Agricultural Products 29
Food Choice and Water Survey 30
Discussion 40
California Water Footprint & NRF10.3 40
Food Choice and Water Survey 43

Limitations and Future Research 45
Conclusion 47
Acknowledgement 48
Declaration of Interest Statement........ 48
References........ 49

CHAPTER 3: Summary and Recommendations 54
Summary 54
Recommendations........ 56
References........ 58

Appendices........
A. IRB Approval Letter 63
B. Food Choice and Water Survey 65
C. Recruitment Materials – Sample Flyers 76

LIST OF TABLES

Table 1. California Water Footprint and Nutrient Rich Food Scores – All Commodities 31

Table 2. Demographics of Food Choice and Water Survey Respondents. 35

Table 3. Importance of Environmental Factors on Food Choice, Water Issues, and Learning More About Water 38

LIST OF FIGURES

Figure1. California Water Footprint and Nutrient Rich Food Scores – Animal Commodities 32

Figure 2. California Water Footprint and Nutrient Rich Food Scores – Fruit Commodities 32

Figure 3. California Water Footprint and Nutrient Rich Food Scores – Vegetable Commodities 33

Figure 4. California Water Footprint and Nutrient Rich Food Scores – Other Commodities 33

LIST OF ABBREVIATIONS

CA - California
CCAC - California County Agricultural Commissioners
CDFA - California Department of Food and Agriculture
CDWR - California Department of Water Resources
DRI - Dietary Reference Intakes
FAO - Food and Agriculture Organization of the United Nations
g - grams
HEI - Healthy Eating Index
ISO - International Organization for Standardization
IWMI - International Water Management Institute
kcal - kilocalories
LIM - nutrients to limit
NOAA - National Oceanic and Atmospheric Association
NRF – Nutrient Rich Food Scores
NRF9.3 - Nutrient Rich Foods Index 9.3
NRFn.3 - Nutrient Rich Foods Index
NRn - nutrients to encourage
PPIC - Public Policy Institute of California
RNI - recommended nutrient intake
SDGs - Sustainable Development Goals
UN - United Nations
US - United States
USDA - United States Department of Agriculture
USGS - United States Geological Survey
WF - water footprint
WHO - World Health Organization

CHAPTER 1

Literature Review

Introduction

As the population of the world increases, the importance of environmental sustainability is becoming more apparent to individuals and world leaders alike (Mancosu et al., 2015; Sokolow et al., 2019). Since 2012, agriculture has become a focus of sustainability research because it is a large consumer of natural resources, especially in land and water use. Even though many farms are watered by rain, agriculture is still responsible for the largest portion of water withdrawals on fresh water sources worldwide (Food and Agricultural Organization of the United Nations [FAO], 2011). As the world's population continues to increase, so will the need for food and the water to support its growth, which will stress an already limited resource. It is also imperative that the food that is grown provides enough nutrients to ensure the wellbeing of the population. Therefore, a closer examination of agriculture with regard to water sustainability and nutrition security is necessary and timely.

While a look at water resources worldwide gives a general sense of water use in agriculture, it is important to take a closer look at water use and commodity production in specific regions of interest which can vary widely due to differences in factors such as climate and soil type. In the United States (US), California (CA) is the leading producer of agricultural products with the highest percent of farm sales among all the states (Johnson & Cody, 2015). Depending on the source, CA agriculture uses between 40 and 80% of the state's water supply (Johnson & Cody, 2015). However, CA is prone to drought which is predicted to get worse because of climate change (Mount et al., 2015). Therefore, efforts in agricultural water conservation in CA are especially important because these water savings can be substantial in the drought-prone state.

Furthermore, food security has been the focus of global concerns in conjunction with sustainability efforts. However, a shift from food security to nutrition security is warranted. While food security focuses on the ability to access food, nutrition security goes a step further in making certain that this food also meets nutritional requirements (Mozaffarian et al., 2021). In order to facilitate the comparison between water use and nutritional value of agricultural commodities, researchers have evaluated different nutrient profiling tools. In the past decade, publications on nutrient profiling methods have greatly increased, and in a recent literature review, the Nutrient Rich Foods Index 9.3 (NRF9.3) was identified as the most comprehensive model in alignment with existing measures of diet quality to evaluate nutrients in foods (Fernández-Ríos et al., 2021).

The role of the consumer is also an important consideration that has the potential to contribute to an increase in water sustainability in the agricultural sector. Studies have shown that a rise in consumer demand for agricultural goods has led to an increase in their production (Fulton et al., 2019; Hanak, 2011). If consumers started choosing more water-efficient food options, it could have a positive effect in reducing agricultural water use. Moreover, studies have shown that consumers are willing to pay more for environmentally friendly products (Kiesel & Villas-Boas, 2007; Villas-Boas & Hallstein, 2013). This information could help agricultural producers in considering the return on investment when choosing which types of plant- or animal-based commodities to produce. However, there are no studies to date on the consumer's interest in agricultural water use and how it impacts their food choices. Therefore, this review will investigate agricultural water use, nutrient profiling methods, existing research on dietary patterns and their water use, and the consumer's influence on agriculture in order to evaluate the need for assessing nutrient status in individual drought-tolerant agricultural products and the consumer's opinion on agricultural water use for a more sustainable and healthier future.

Water Sustainability and Nutrition

A Global Concern

In the past decade, sustainability has become a high global priority. In 2015, the United Nations (UN) adopted 17 Sustainable Development Goals (SDGs) as a part of a global agenda in sustainable development, which includes the need for people worldwide to have access to safe and sustainable water and adequate nutrition (Sachs, 2012; UN, 2015). Furthermore, the Water-Energy-Food nexus was developed to recognize the interconnectedness of the three components, where energy is needed to move and produce food and water, and water is needed in order to produce food (Fernández-Ríos et al., 2021). The adoption and use of both of these frameworks show a shift in global consciousness to prioritize the sustainability of natural resources in order to protect the world's food supply.

A Universal Measure of Water

A water footprint (WF) is a way to look at how much water is used and polluted throughout the whole process of producing a good. The WF metric was created in 2002 by Arjen Hoekstra while working at the UNESCO-IHE Institute for Water Education and was used by many well-known companies such as Unilever, Coca-Cola, and Nestle to understand their dependence on water after being introduced into academic literature in 2007 (Water

Footprint Network, n.d.). In 2014, the International Organization for Standardization (ISO) issued ISO 14046:2014 that defined guidelines, requirements, and principles for WF (ISO, n.d.). In the simplest of terms, Mekonnen and Hoekstra (2011) defined the WF as the combination of three types of water: green, blue, and gray. Green water is the soil moisture that comes from rainfall, and blue water is water from rivers, wetlands, lakes, and groundwater used for irrigation (International Water Management Institute [IWMI], 2007). In addition to green and blue water, gray water was defined as the fresh water needed to bring any water contaminated by pollutants during the production of a good back-to-the initial water quality standards (Mekonnen & Hoekstra, 2011). In 2011 and 2012, researchers Mekonnen and Hoekstra published studies estimating the global consumption of green, blue, and gray water of plant-based crops and animal products. Traditionally, blue water was the only water considered in agricultural water usage, but with the development of the WF, a more complete picture of water use by agricultural products can be seen today.

Nutrition Security

In recent years, indicators and tools have been developed to assess different elements of the UN's SDGs and Water-Energy-Food nexus and tackle policy decisions according to their broader framework, including measures of malnourishment in populations and the availability of water resources (Fernández-Ríos et al., 2021). While both systems of thought take an extensive look at the intersection of many factors including water, food, and energy with society, the economy, and the environment, they have only examined food security and nutrition in the most general terms such as energy intake and protein. However, in the past year, there has been a call to switch focus from food security to nutrition security, defined by the United States Department of Agriculture (USDA) as all people having access to enough nutritious food to fulfill their dietary requirements to achieve an active and healthy lifestyle, which is often missing from many public health screening tools to the detriment of the general public (Mozaffarian et al., 2021; Ramaswamy, 2017). In order to support the shift, comprehensive tools are needed to accurately and efficiently assess the nutritional value of foods. These nutrient profiling tools have been developed and have been implemented with significant frequency in research in the past decade (Fernández-Ríos et al., 2021).

Why Does Water in Agriculture Matter?

Agricultural Water Use at the Global Level

Both rain and irrigated water are important resources that are widely used in farming around the world. Rain is primarily used to water global agricultural land and accounted for 80% of agricultural evapotranspiration, which is the combination of soil evaporation and transpiration from plants into the atmosphere, in 2007 (FAO, 2011; IWMI, 2007). Even with the wide use of rainwater, about 70% of global water withdrawals from aquifers, streams, and lakes were used for agriculture; in comparison, only 20% of blue water was used for industry and 10% for municipalities (IWMI, 2007). In addition to the large amounts of water already used in agriculture, the need for water will keep rising in the future with researchers estimating a more than 50% increase in need for irrigated water in developing areas and around a 16% increased need in developed areas from 2000 to 2080 (Fischer et al., 2007).

Factors Stressing Global Water Resources

An increasing global population; increased competition for water between agriculture, households, and industry; and climate change all play a role in placing strain on existing water resources. According to the UN (n.d.), the world's population is currently 7.7 billion people with projections showing a population of 9.7 billion by 2050 and a possibility of reaching 11 billion by 2100. In 2010, researchers stated that about 80% of the global population was already vulnerable to high levels of water insecurity (Vörösmarty et al., 2010). If trends continue, two thirds of people around the world may have to deal with water scarcity by 2050 (Wallace, 2000). In addition, an increase in population will escalate the demand for food and the water needed to grow it. The World Bank, a cooperative made up of 189 member countries with the goals of reducing poverty and building shared prosperity in developing countries through sustainable solutions, estimated that food production will need to increase by 50% by 2030 to keep up with global population demands (World Economic Forum, 2015). This will further strain already limited water resources. However, the growing population is not the only concern. The agricultural sector will have more competition for water resources in the future, in part due to an increasing demand for biofuels, which also requires crop land and water (Nhantumbo & Salomao, 2010). Furthermore, climate change forecasts an increase in temperatures worldwide and changes in precipitation patterns which may also increase irrigation water demands (Cisneros et al., 2014). With all of these factors pointing to further stress on water resources, it is imperative that large agricultural areas of the world take a more serious look at what can be done to minimize water use.

California Agricultural Water

The Importance of CA's Agricultural Water Use

California is the most important agricultural region for food production by state in the US. In 2020, farm sales in CA made up almost 12% of total US farm sales, the highest of any state; the monetary value of those sales was $54 billion (USDA, 2021). California also produces over a third of the country's vegetables and over two thirds of the country's fruits and nuts (California Department of Food and Agriculture, n.d.). In addition, the top seven agricultural producing US counties were in CA with the top county, Fresno, producing more sales than 25 states (USDA, 2019). From a production standpoint, the contribution from these counties is significant; however, the location of these counties could be problematic for CA water conservation. According to Hanak et al. (2011), 75% of CA's rainfall occurs in Northern CA away from cities and farms, but 75% of water demand lies in Southern CA, including most of the seven leading agricultural counties mentioned above. There is an imbalance in CA's water supply and demand that implies the necessity of water-saving strategies in the state. Therefore, CA's current water practices should be explored to see where improvements can be made.

Current Agricultural Water Use and Practices in CA

Understanding how CA currently uses its water resources is an important step in identifying how to best preserve them. California agriculture currently uses 40–80% of the state's total water supply according to various sources (Johnson & Cody, 2015). According to Johnson and Cody (2015), two government sources of agricultural water data are the US Geological Survey (USGS) and the California Department of Water Resources (CDWR). The USGS estimated water use for agricultural irrigation in CA at 61% of total withdrawals whereas the CDWR estimated it to be 41% (Johnson & Cody, 2015). The Pacific Institute, a water research institution, reported agriculture to account for 80% of CA's developed water supply (Cooley, 2015; Johnson & Cody, 2015). The difference in reporting is due to the various survey methods and assumptions made by the agencies which includes the key divergence on what is considered to be available water supply; the large range in the reported numbers also indicates the difficulty in tracking agricultural water use due to the lack of local reporting (Hanak et al., 2011; Johnson & Cody, 2015). While the exact percentage of water use by CA's agricultural sector is up for debate, there is no doubt that CA's agricultural sector uses a large portion of the state's water. Moreover, compared to the rest of the US, CA used around 25% more irrigated water in 2013, and CA's total water use was twice the national average at 3.1 acre-feet per acre versus 1.6 acre-feet per acre (Johnson & Cody, 2015). Since much of CA's rainfall occurs away from agricultural land and CA lacks rain during summer months, the state relies more heavily on irrigated water than rainfall for agricultural production, which is contrary to what is seen in the rest of the world (Fulton et al., 2014; Hanak et al., 2011; Marrin, 2016). Since CA is the largest agricultural producer in the US, reducing the amount of irrigated water use in CA could make a big impact in improving water sustainability in addition to addressing other important reasons for needing to curb water use in the state.

Drought Implications in CA

Another reason for why water conservation should be at the top of CA's priority list is the fact that CA experiences droughts, which can have devastating effects on the state's agricultural sector. Drought is defined as the lack of precipitation over an extended time that results in an inadequacy of water and is further classified into five categories by the US Drought Monitor (D0 = Abnormally Dry, D1 = Moderate Drought, D2 = Severe Drought, D3 = Extreme Drought, D4 = Exceptional Drought) (National Oceanic and Atmospheric

Association [NOAA], n.d.-a). Long-term drought occurs when precipitation deficits last for more than six months and can cause serious damage to agriculture including crop failures and livestock sell-offs (NOAA, n.d.-b). The longest drought in CA with conditions between D1 - D4 occurred between 2011 and 2019, with the worst week resulting in 58% of CA at a rating of D4 (NOAA, 2021). The ramifications of the D4 category in terms of agriculture are the fallowing of fields, removal of orchards, and low vegetable yield which occurs in addition to D3 conditions where livestock requires pricey additional feed, cattle and horses are sold off, minimal pasture is available, fruit trees bud early, and irrigation starts in winter (NOAA, 2021). As of September 2021, 87.9% of CA was in Extreme Drought and 45.7% was in Exceptional Drought, including some of CA's largest agricultural producing counties (NOAA, 2021). Additionally, in some climate change models, CA was projected to have an increase in drought years which could lead to more extreme weather and increase levels of water scarcity (Byrd et al., 2015; Hanak et al., 2011). Because CA's agricultural sector uses a large portion of locally produced blue water resources, the effects of climate change on CA's drought patterns could lead to adverse outcomes in agricultural production if precautionary measures are not taken now (Marrin, 2016).

To make matters more complicated, CA farmers have switched to higher-value perennial crops, such as almonds, which are alive year-round and can be harvested multiple times before they die. Almond orchards in CA have increased by 81% from 2005 to 2015, due to an increase in global demand, and contributed $5.1 billion in exports in 2015 (Fulton et al., 2019). According to Hanak et al. (2011), the problem with the switch to perennial crops lies in the fact that the land cannot be fallowed during drought years like annual crops that grow and are harvested typically in as short as one season such as beans, cauliflower, and lettuce. In times of water shortages, irrigation deliveries are usually lowered by 5–25%, and higher-value crops suffer more (Hanak et al., 2011). Because almonds are such high-value crops, the possible loss of the harvest due to drought could be a larger economic blow to CA almond farmers than to those who plant annual crops. Therefore, it is important to examine water-saving strategies even in non-drought years to safeguard against the detrimental effects that climate change and water shortages can have on the economy of the state's agricultural sector.

The Redistribution of Crops

One way to improve CA's agricultural water use comes from a nationwide study that showed that by changing the types of crops grown to maximize climate conditions, more crops could be produced without using more water resources (Davis et al., 2017). The researchers studied 11 crop types which made up 86% of crops grown in the US, including groundnuts, maize, potato, rapeseed, rice, sorghum, soybean, sugar beets, sugar cane, sunflower, and wheat. In CA, the researchers found that the optimal redistribution of crops would lead to a 56% water savings and a 32% increase in economic value mainly by replacing wheat and sugar beets with some of the other crops such as potatoes and soybeans. The study also found that the redistribution was especially beneficial in areas that used a higher amount of irrigated water, like CA, and along with the water savings, the nutrients produced by the redistribution of crops increased in terms of the number of kilocalories (kcal) and protein by 29 and 54%, respectively. This study highlighted that choosing the right crops can be beneficial for producers, consumers, and the environment.

California's Water Footprint

Water conservation in CA agriculture can be achieved by growing crops that need less water or by reducing the amount of irrigated land that is used in production (Hanak et al., 2011; Mancosu et al., 2015). This also applies to the water use of animal commodities since 98% of their water use is attributed to the crops grown for animal feed (Mekonnen & Hoekstra, 2012). In order to know which crops to grow, careful attention should be paid to how much water is needed to grow each crop. However, the research on the agricultural water use of CA crops is limited. The CDWR estimates water use by crop into 20 general categories, which makes it hard to distinguish these groups of crops from one another (Cooley, 2015). For example, water use is measured for the CDWR Crop Category cucurbit which includes melons, squash, and cucumbers, but a further breakdown of how much water the individual crops use is not provided. It is also important to note that the numbers from the CDWR are based on models, not actual measurements; however, it is still the most useful water use information currently available (Cooley, 2015). Thus, subsequent research in CA's agricultural water use has been based on the CDWR water estimates like in Fulton et al.'s 2012 report that used data from the CDWR and other sources to calculate the water use of a handful of CA's agricultural products. In a more recent article, CA's WF data was calculated again in order to rank the WF of over 40 CA crops; however, animal commodities were not included in the publication (Fulton et al., 2019). To date, a comprehensive list of the WF of CA agricultural products is not available.

Dietary Patterns and Water Conservation

Water sustainability and food production are interconnected; without water, food cannot be grown. Although there has been much discussion on implementing measures of food security in the larger framework of sustainability, nutrition security has not been addressed to the same degree (Mozaffarian et al., 2021). When considering water sustainable diets, nutrient value of foods must play a role because the food that is grown or produced will not be a good option if it cannot provide adequate nourishment for the human population. Currently, the majority of the studies that address nutrition in the context of water savings have focused on how savings can be achieved by switching to a different diet. Researchers found the primary reason for saving water through dietary changes was a switch from diets that included animal products to diets that minimized animal products and increased the consumption of plant products (Blas et al., 2016; Marlow et al., 2015; Marrin, 2016). In the first study, researchers found a 29% decrease in water use when people consumed a Mediterranean diet, with its emphasis on the high consumption of plant products and the low consumption of animal products, when compared to the Dietary Guidelines for Americans that had a higher recommendation for animal products (Blas et al., 2016). The second study found water savings in real-world data taken from the Adventist Health Study in CA where participants who ate a diet higher in animal products used 10,252 liters more water than those who ate a diet lower in animal products; the difference mostly came from eating beef (Marlow et al., 2015). The last study found that switching to a vegan meal for one day a week saved more water than a 25% reduction in direct consumer water use, and switching to vegan meals once a day conserved more water than a 40% reduction in direct consumer water use (Marrin, 2016). These studies clearly showed how changing the diet to include more plant-based options can increase water conservation efforts. However, consumers may not be ready to completely change to a Mediterranean or vegan diet, so it would be helpful to investigate the water use and the nutritional value of individual food items to inform consumers on how to make smaller changes in their diets that would be beneficial for both their health and the environment in terms of water conservation.

Nutrient Profiling

There are many different types of nutrient profiling models. In a 2021 review article, researchers explained that nutrient profiles were made up of either foods to encourage, nutrients to encourage or a combination of foods to encourage, nutrients to encourage, or nutrients to limit (Fernández-Ríos et al., 2021). The 31 models examined in the study varied in either being 'across-the-board', which compared foods between groups (e.g., fruits vs. grains), or 'specific category', which compared foods within groups such as apples vs. bananas. The reference amounts used in each nutrient profile were normalized to 100, 1,000, or 2,000 kcal - which favored more nutrient rich, less energy-dense foods; 100 grams - which favored high-energy foods and was similar to European Union food labeling standards; or serving size - which was most beneficial for consumers (Bianchi et al., 2020; Fernández-Ríos et al., 2021). Out of all the nutrient profiles included in the review, the NRF9.3 model was rated the best option for use in the wider framework of the Water-Energy-Food nexus index due to its high validation against the Healthy Eating Index (HEI) and its ability to provide a nutrient specific versus food specific profile (Fernández-Ríos et al., 2021). The NRF9.3 is made up of nine nutrients to encourage and three to limit and is usually normalized to 100 kcal of the food item (Drewnowski, 2009). While researchers can add more nutrients to encourage, doing so arbitrarily does not increase the adherence of the food to dietary guidelines (Bianchi et al., 2020). Researchers showed that in addition to having the highest coherence with the HEI, the NRF9.3 was one of the most widely used nutrient profiling methods in research (Fernández-Ríos et al., 2021). The use of the NRF9.3 model is an important tool that can help policy-makers judge far-reaching decisions and consumers identify what foods are most in line with dietary recommendations.

Evaluating the Water Use and Nutritional Value of Individual Crops

While there have been multiple studies on water conservation and dietary changes, only a handful have looked at water and nutrient content of individual foods and even fewer have analyzed WFs of agricultural products in CA. In 2012, researchers Fulton et al. assessed the WFs of agricultural products in CA using CA water data, which was the first analysis of its kind, but the study did not include a comparison to the nutrient quality of these foods. In 2019, the same researcher compared WFs of CA's plant commodities and their nutritional value and ranked each component for comparison (Fulton et al., 2019). However, the context of the study focused primarily on almonds and did not include any data on animal commodities. A third study compared global WF and nutritional value of individual plant-based crops (Sokolow et al., 2019). However, when examining water use and potential savings, it is imperative to use data from the region of interest since water use in agriculture can vary greatly based on factors such as climate, crop characteristics, and soil conditions (Mekonnen & Hoekstra, 2011). Furthermore, this study was also limited to plant commodities, leaving out a key component of the average diet in the US where meat consumption is three times the global average and contributes to 15% of daily energy intake (Daniel et al., 2011). The information provided by Sokolow et al. is a more detailed look at WFs and nutrient content that could be beneficial for commercial use, policy decisions, and for the general public in promoting water sustainability and eating nutritiously. However, these studies leave a gap in the literature because none of them give a detailed evaluation of the CAs WF and nutrient value for both plant and animal products.

The Consumer's Role

The consumer plays an important role in agricultural water savings because they have the power to influence what is grown through their food purchases, and researchers have favorably argued for their ability to have a real impact on the market (Hanak, 2011; McMullen & Halteman, 2019). Therefore, it is important to understand the consumer's interest in agricultural water use and how it impacts their food choices. However, no studies to date have been conducted on the consumer's opinion on agricultural water use when it comes to their food choice. For example, the Food Choice Questionnaire is a widely used survey to ascertain the importance of various factors in people's food decisions (Steptoe et al., 1995). The survey can also include an environmental component that was developed and added to the original survey in 2016; however, this section, developed to specifically address the importance of sustainability, does not include agricultural water use (Verain et al., 2016). In addition, the nationally distributed Water Survey Needs Assessment was created to evaluate the public's water priorities and realign educational goals if necessary, yet this comprehensive survey does not include agricultural water use in any way (Mahler et al., 2013). At present, there is a lack of studies on the opinions of consumers on agricultural water use.

Conclusion

In conclusion, the topics of water conservation in agriculture and nutrition security are timely and relevant to the concerns of the day. A large amount of available water worldwide is used by the agricultural sector and there are valid reasons to worry about its future availability due to an increase in the global population, competition between agriculture and other sectors, and the effects of climate change. In the US, CA is an integral part of agricultural production with the largest percent of farm sales nationwide. However, CA is prone to drought conditions that can worsen in the future due to climate change. A look into agricultural use of water in the state revealed that the agricultural sector uses a large portion of the state's water supply, but in contrast to world trends, CA uses a lot more irrigated water than rain to produce their agricultural commodities, highlighting the importance of evaluating water at the state level.

A few solutions to address CA's potential water shortage were proposed including a redistribution of crops to maximize climate conditions throughout the state and a possible shift to more drought crops that could benefit CA consumers and producers alike. In light of these ideas, a review of studies examining the water use of different dietary patterns revealed that more plant forward diets used less water overall. However, these studies limited the understanding of which particular foods could provide both a larger water savings and more nutrient density. To date, only a few studies have been published comparing WFs and the nutritional value of agricultural products. However, these studies lack recommendations based on CA WFs and are missing a major component of the American diet: animal products. In addition, consumers have an undeniable influence in what is grown by agricultural producers, yet there are no studies to date evaluating the public's opinions on agricultural water use when it comes to choosing food. These findings show a clear gap in literature for future research on the evaluation of all agricultural commodities, including plant and animal products, and CA specific WFs with regards to nutrition in addition to an evaluation of the consumer's opinion on agricultural water use. Exploring these voids in the literature could assist farmers, policy-makers, and the general public by providing a clear comparison of the water sustainability and nutrition that foods in CA can supply and a better understanding of the consumer's thoughts on agricultural water use.

CHAPTER 2

Journal Article

RECOMMENDATIONS FOR A WATER CONSERVATIONIST DIET IN CALIFORNIA

Abstract

To create a more sustainable food system, this study analyzed the water use and nutritional data for California (CA) commodities and conducted a Food Choice and Water Survey to gauge consumer opinions on agricultural water use. This non-experimental, descriptive, research study showed that consumers are not thinking about agricultural water use when choosing foods. However, agriculture is the number one user of water resources in the world, so there is an opportunity here to effect great change. Increased awareness and education are needed, and the CA water use and nutritional data analysis could aid in educating the public on this important issue.
Keywords: California agriculture, nutrition, sustainability, water footprint

Introduction

With a steady increase in global population, people are simultaneously taking up more space and requiring more food. According to the United Nations (UN), there are currently 7.7 billion people living in the world with projections showing a population of 9.7 billion by 2050.[1] In addition, the World Bank, a worldwide cooperative of over 189 countries dedicated to reducing poverty through sustainable solutions, estimated that food production will need to increase by 50% by 2030 to keep up with global population demands.[2] In the UN's Sustainable Development Goals set in 2015, researchers recognized the dilemma of providing enough food and nutrition to sustain a growing population while using fewer natural resources.[3] While there have been many studies on environmental sustainability in agriculture or on gaining adequate nutrition through the diet, studies combining the two are relatively new and imperative. Without sustainability in agriculture, food and nutrition security will be at risk.

The agricultural sector is the largest water user worldwide, so to increase sustainability in that sector, its water use should be examined. Rainwater is primarily used in global agriculture and accounted for 78% of the water used for crop production from 1996 to 2005.[4–6] Even with the wide use of rainwater, about 70% of global water withdrawals from aquifers, streams, and lakes were used for agriculture; in comparison, only 20% of water withdrawals were used for industry and 10% for municipalities.[5] Furthermore, researchers have estimated a more than 50% increase in need for irrigated water in developing areas and around a 16% increased need in developed areas by 2080.[7] Increasing practices of sustainable water use throughout the agricultural sector now, may ease the stress on this finite resource in the future.

California (CA) is the most important agricultural region for food production in the United States (US) with the highest percent of farm sales totaling over $54 billion in 2020.[8] California also produces more than a third of the nation's vegetables and two thirds of the nation's fruits and nuts.[9] Like the rest of the world, agricultural production accounts for a large portion of water used in CA, between 40 and 80% of its supply according to various sources.[10,11] However, CA relies more heavily on irrigated water for agricultural production than the rest of the world due to its climate.[12–14] The state is also susceptible to drought. Past research stated that severe droughts in CA occur every 15–40 years; however, current drought trends show that they are happening more frequently than projected, which could lead to adverse outcomes for CA's agricultural sector if changes in water use are not made now.[13,15–17] It is also important to note that water use can vary widely in different regions of the world due to factors such as climate, crop characteristics, and soil conditions.[6] Therefore, determining water consumption utilizing CA water data was necessary to get a picture of how much water is actually needed to grow agricultural commodities in CA.

When considering water sustainability in agriculture, the nutrient value of foods must also be considered because the food that is produced will not be a good option if it cannot provide adequate nourishment for the human population. Although there has been much discussion on implementing measures of food security in the larger framework of sustainability, nutrition security has not been addressed to the same degree.[18] Nutrition security, defined by the United States Department of Agriculture (USDA), is the idea that all people have access to enough nutritious food to fulfill their dietary requirements to achieve an active and healthy lifestyle.[19] However, measures of nutrition security are often missing from many public health screening tools to the detriment of the general public.[18]

In the current literature, the majority of studies that address nutrition and water savings have focused on the comparison of water use in different diets with the data showing that plant-based diets conserve more water than animal-based diets.[13,20,21] The few studies that compare water use and nutrition of individual foods have excluded animal products in their analysis. However, meat is a key component of the American diet where consumption is three times that of the global average and about 15% of daily energy intake.[22] Furthermore, even within plant-based diets, there is a large range of agricultural water use in growing different crops.[6] Therefore, research in water use efficiency and nutritional value of individual food items would be useful in educating consumers on how to make smaller changes in their diet that could benefit their health and the environment.

The consumer is an important consideration in agricultural water savings because they have the power to influence what is grown through their food purchases.[14,23] For example, almond orchards in CA have increased by 81% from 2005 to 2015, due to increased global demand.[24] Therefore, it is important to understand the consumer's interest in agricultural water use and how it currently impacts their food choices if at all. Moreover, studies have shown that consumers are willing to pay more for environmentally friendly products.[25,26] This information could assist agricultural producers in considering the return on investment when choosing which types of plant- or animal-based commodities to produce and could encourage farmers to choose more water sustainable and nutrient rich crops. Therefore, this study assessed nutrient status and water use of individual agricultural products grown in CA and investigated people's thoughts on agricultural water use when purchasing food to better inform the consumer, agricultural sector and public policy-makers in CA of ways to maximize water sustainability and nutrition security for a healthier and more sustainable future.

Materials and Methods

Data Collection

California Water Footprints

In order to assess the water use of different commodities, the water footprint (WF) concept, which was developed using a grid-based dynamic water balance model was employed.[6,27–29] Data to calculate WFs were collected from various sources. First, rates for effective precipitation and evapotranspiration of applied water for 20 CA crop categories were gathered from the CA Department of Water Resources (CDWR) California Land and Water Use data from 2011 to 2015, the latest available. Harvested acreage and production data for each commodity, including animal feed, were pulled from the California County Agricultural Commissioners' (CCAC) Reports, Crop Year 2014–2015. Crops that made up the category animal feed were defined in appendix 2 of Fulton et al.'s 2012 report, *California's Water Footprint*. For animal commodities, the pounds of production were collected from the CA Department of Food and Agriculture's annual California Agricultural Statistics Review 2014–2015. Also, a conversion factor of kilograms of animal feed per kilogram of product was found in UNESCO's report for calculating the WF for animal products.[28]

Nutritional Value of CA Agricultural Products

The 57 agricultural products chosen for analysis were plant and animal commodities listed in the California Department of Food and Agriculture report: the California Agricultural Statistics Review 2019–2020. The nutrient data for each food item was collected from the USDA's Food Central Database, mostly from the SR Legacy, the primary food composition database in the US for many years. If the food was not listed in the SR Legacy, the Food and Nutrient Database for Dietary Studies 2017–2018, used in the National Health and Nutrition Examination Survey, was utilized.

After careful review, the Nutrient Rich Foods Index (NRFn.3) was chosen to analyze the nutrient profile of different CA agricultural commodities because of its frequent use in research and validation and high correlation with the Healthy Eating Index (HEI), an accepted measure of diet quality.[30,31] Nutrients for analysis were selected to reflect the most recent Dietary Guidelines for Americans 2020–2025. The data collected for the ten nutrients to encourage (NRn) were protein and fiber; vitamins A, C, E, and D; and calcium, iron, magnesium, and potassium. In addition, the data for the three nutrients to limit (LIM) included saturated fat, added sugar, and sodium.[30,32] A validation study of NRF scores showed that the addition of more vitamins and minerals to encourage led to a decline in index performance when compared with the HEI, so only ten NRns were utilized.[30] In addition, LIMs were kept to three due to the fact that total and saturated fat were highly correlated, which was also true for total and added sugar.[30]

Food Choice and Water Survey

As a part of this mixed-methods descriptive study, a self-administered online survey questionnaire entitled the Food Choice and Water Survey was made available through Qualtrics, a web-based survey tool, from March 1, 2021, to July 31, 2021. The purpose of the Food Choice and Water Survey was to assess the role of nutrition and water sustainability in current food choice decisions and to gauge the general public's interest in learning more about agricultural water sustainability in relation to their food purchases. The study protocol (21051) was approved by San Jose State University's Human Subjects Institutional Review Board.

Participants were recruited through social media posts, via email and through advertisements on social media platforms Facebook and Instagram. The participation population included any member of the general public who was proficient in English, 18 years and older, and currently living in CA with access to the internet. A non-probability, convenience sampling method was used in the online survey where people self-identified as living in CA. At the end of the survey, respondents were given the option to enter a raffle prize drawing for a $50 Amazon gift card. Survey responses were excluded if the participants were under 18 years of age or did not live in California. Incomplete surveys were also kept out of the final analysis. The sample size needed for survey results with a confidence level of 95% and a 4% margin of error was calculated as 601 participants using an online sample size calculator from calculator.net.

The Food Choice and Water Survey was composed of three sections. The first page of the online survey displayed an introduction to the study which included a consent notice. The first section (questions 1–7) collected demographic information including gender, age range, race and ethnicity, county of residence in California, highest level of education, household income range, and diet information.

The second section of the Food Choice and Water Survey (questions 8–9) was created based on a validated single item Food Choice Questionnaire that included an environmental survey component (Cronbach $\alpha = 0.76$).[33,34] Both questions eight and nine started with the statement, "It is important to me that the food I eat on a typical day …," and ended with different options. Question 8 included general food choice options such as " … is healthy, … is convenient, … is affordable, etc.," while question 9 included more environmentally specific choices such as " … has environmentally friendly packaging, … is organic, … is produced within the season, etc." The option " … is produced with minimum agricultural water use," was added to Question 9 for the purpose of this survey. Participants rated each statement based on a continuous scale from zero to one hundred, with 0 = *Not at all important*; 50 = *Moderately important*; and 100 = *Extremely important*. There was also the option of checking a box marked "No opinion/Don't know" for each statement.

The third and final section (questions 10–13) included items from the National Water Survey Needs Assessment, which was originally developed to assess the public's thoughts and opinions regarding water resource issues.[35] Questions 10 and 11 asked, "*10. How important are each of the following water issues to you?*" and, "*11. How important are the following actions in protecting our water resources?*", which participants could answer on the same continuous scale used for questions eight and nine. Question 10 was modified from the original question with the addition of " … drought" as a line item. Question 11 was also modified with the inclusion of, " … eating food that uses a minimal amount of agricultural water to produce". Questions 12 and 13 allowed participants to check all that applied and asked, "*12. Have you or someone in your household done any of the following as part of an individual or community effort to conserve water or preserve water quality?*" and, "*13. Would you like to learn more about any of the following water quality issue areas?*". Question 12's answer choices were changed to be more in line with consumer water use and were taken from a list of suggestions from the California Department of Water Resources on how to reduce water consumption. Finally, the line item, "Agricultural water use for food production," was added to question 13.

Data Analysis

Water Footprint and Nutrient Rich Food Scores

For plant commodities in CA, effective precipitation—defined as the amount of rainfall effectively used by a crop—was used to calculate green WFs; similarly, evapotranspiration of applied water—defined as the net amount of irrigation water needed to produce a crop—was used to calculate blue water WFs. The effective precipitation and evapotranspiration of applied water were matched to individual crops in the CCAC's Reports, Crop Year 2014–2015 using the CDWR's crop grouping chart[11] and multiplied by the harvested acreage to get the total green and blue WFs for various individual crops produced in the state. Both the effective precipitation and evapotranspiration of applied water were reported as acre-ft/acre of water used, so the total green and blue WFs were converted from acre-ft to cubic meters and divided by production per ton so that they could be easily compared to the global water footprint estimates which were reported in units of cubic meters per ton. As a final step, the blue and green WFs were added to get the total WF of each agricultural product.

The calculations for the WF of animal commodities in CA were more complex than those for plant commodities, but a part of the same method was utilized. Since 98% of animal water use comes from the crops grown for their feed, the WF for animal products in this report was solely made up of the WF of animal feed. The blue and green WFs of these crops were calculated using the same methods defined in the previous section to get the total WF for animal feed. Then, the pounds of the animal commodities produced were converted into kilograms and multiplied by the conversion factor of kilograms of animal feed per kilogram of product. Finally, the feed for each animal commodity was converted from kilograms into tons, multiplied by the total WF of animal feed, and divided by the ton of animals produced to get the total WF of the animal in cubic meters per ton.

The algorithm used to calculate NRF10.3 was a summation of the NRn minus the summation of the LIM for the reference value of 100 kilocalories (kcal) of food as found in Drewnowski, 2009.[32] The chosen reference amount was shown to favor low energy dense foods in line with dietary recommendations opposed to 100 grams (g), which favored energy-dense foods, or portion size which varies around the world.[36] Each of the 10 nutrients found in 100 g of the agricultural commodity in question was divided by the corresponding Dietary Reference Intakes (DRI), found in the DGA 2020–2025,[37] for women between 19 and 30 years old as a representative sample. That number was then divided by the number of kcal per 100 g of food divided by 100 g to get the number of kcal per g and multiplied by 100 kcal to get the amount of the nutrient for the reference value of 100 kcal. Any nutrient over the

DRI was capped at 100 so that the total maximum score for the nutrients to encourage was 1,000. The 10 nutrients to encourage were added together to create a NRn subscore. Then, a LIM subscore was calculated using a similar method as the NRn subscore except the DRIs were replaced with a maximum reference value. Finally, the LIM subscore was subtracted from the NRn subscore to get the NRF10.3 score for each food.

Finally, Microsoft Excel was used to compile nutrient and WF data for 57 of CA's plant and animal commodities. The scores were initially compared side-by-side to the median of all commodity scores in order to evaluate the tradeoffs between an individual good's WF and NRF10.3 score. The commodities were then divided into one of four groups—animal commodities, fruits, vegetables, and other—for a comparison within specific categories.

Food Choice and Water Survey

Descriptive statistics for the survey were generated using SPSS Version 28.0.0.0 (190) for Mac (IBM Corp., Armonk, NY, USA). Averages and standard deviations were calculated for questions in which participants gave an importance rating (questions 8–11). SPSS was also used to run a Chi-Square Test of Independence to see if there was any significance between selecting interest in wanting to learn more about agricultural water use for food production and various demographics.

Results

Water Use and Nutritional Value for CA Agricultural Products

The primary aim of this study was to compare the nutritional value and WF of CA agricultural products in order to determine which foods were both higher in nutrients and lower in agricultural water use relative to each other. The calculated CA WFs and NRF10.3

scores for all commodities were graphed on a scatter plot. Since there is no universal standard for rating WFs or NRF10.3 scores, the agricultural commodities were separated into four categories for comparison by the median WF and NRF10.3 scores as can be seen in Table 1. The foods that had the bottom half WFs and top half NRF10.3 scores would be the most beneficial for improving water sustainability efforts in CA agriculture while providing consumers with high levels of nutrient density. With the exception of milk and cream and wheat, all animal, nut, and field crop commodities were in the top half of WFs and bottom half of NRF10.3 scores when compared with all other commodities. Milk and cream and wheat were in the bottom half of WFs and NRF10.3 scores. Both columns with the top half NRF10.3 scores only contained fruits and vegetables whereas all animal products, nuts, and field crops were in the columns with the bottom half NRF10.3 scores.

While across-the-board comparisons can be helpful in seeing which food group tends to be more water sustainable and highly nutritious, a comparison within specific categories is more useful when encouraging the consumption of foods from the same group. For a closer comparison, CA WFs and NRF10.3 scores of CA agriculture products were split into four categories—animal products, fruits, vegetables, and other: field crops, nuts, and seeds—as can be seen in Figures 1–4. Each figure was divided by WF and NRF10.3 score median lines.

Food Choice and Water Survey

Participant Demographics

There were 888 responses to the Food Choice and Water Survey by the end of the survey period, and the responses were filtered to meet the inclusion criteria of the study. Survey responses from anyone under 18 years of age (n=34) were omitted, and if anyone chose

Table 1. California water footprint and nutrient rich food scores[a]—all commodities.			
High WF & Low NRF10.3[b]	**Low WF & Low NRF10.3[b]**	**High WF & High NRF10.3[b]**	**Low WF & High NRF10.3[b]**
Nectarines	Wheat	Asparagus	Spinach
Garlic	Raisins	Broccoli	Lettuce
Dry Beans	Potatoes	Green Beans	Pumpkins
Plums	Pears	Artichokes	Tomatoes
Almonds	Milk and Cream	Kiwifruit	Peppers
Blueberries	Grapes	Oranges	Cabbage
Cherries	Corn	Grapefruit	Cantaloupe
Eggs		Apricots	Cauliflower
Avocados		Tangerines	Squash
Apples			Carrots
Oats			Celery
Barley			Lemons
Prunes			Strawberries
Cattle and Calves			Raspberries
Pistachios			Onions
Dates			Sweet Potatoes
Walnuts			Cucumbers
Rice			Honeydew
Hogs and Pigs			Sugar Beets
Olives			Watermelon
			Peaches

Abbreviation: WF, water footprint. NRF10.3, Nutrient Rich Food Score 10.3.
[a]Commodities listed in order of highest to lowest NRF10.3
[b]Data is divided by median where high equals the top half and low equals the bottom half.

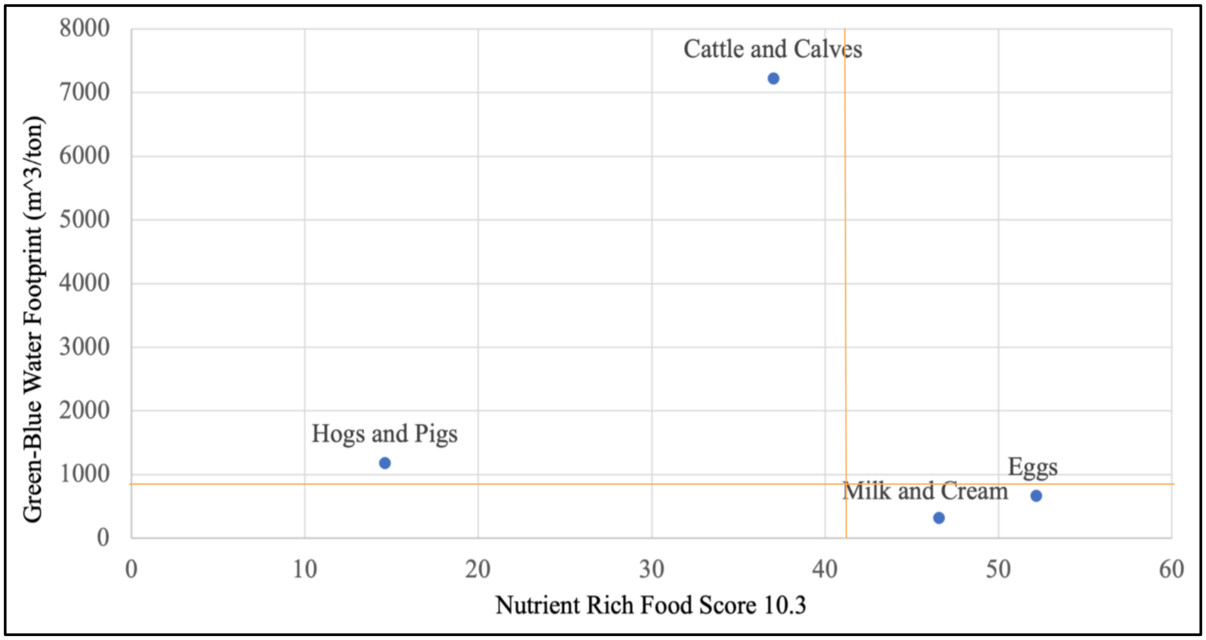

Figure 1. California water footprint and nutrient rich food scores—animal commodities.

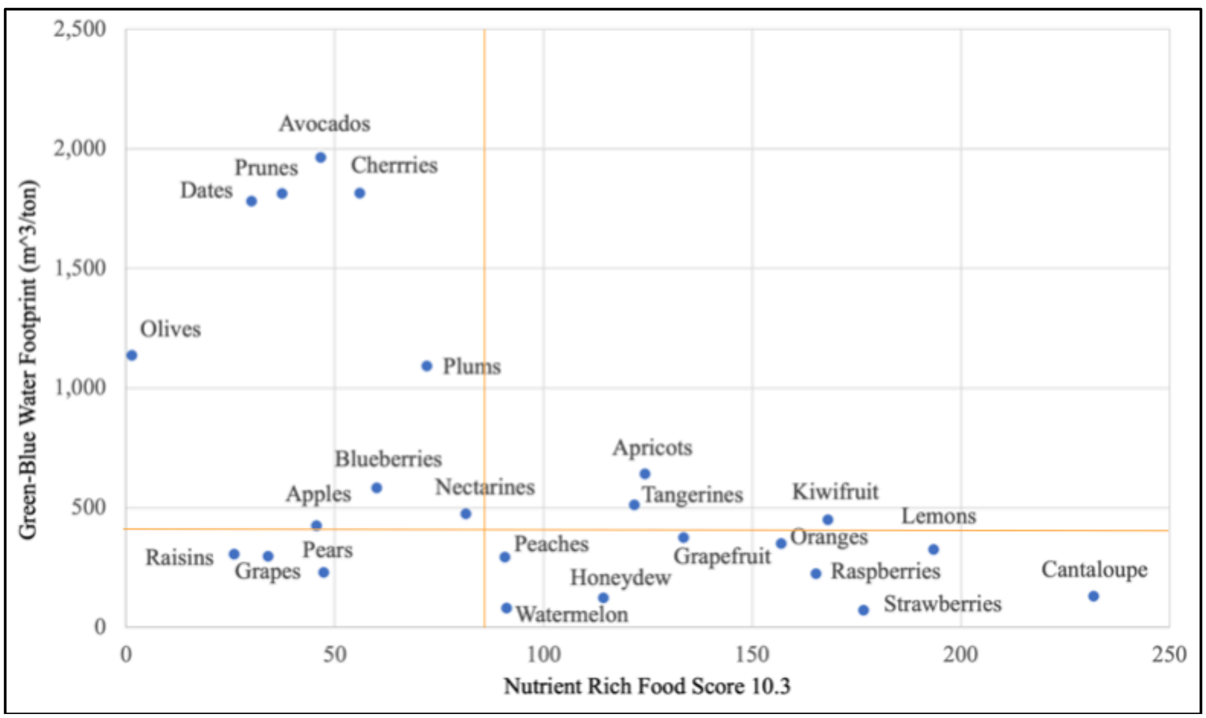

Figure 2. California water footprint and nutrient rich food scores—fruit commodities.

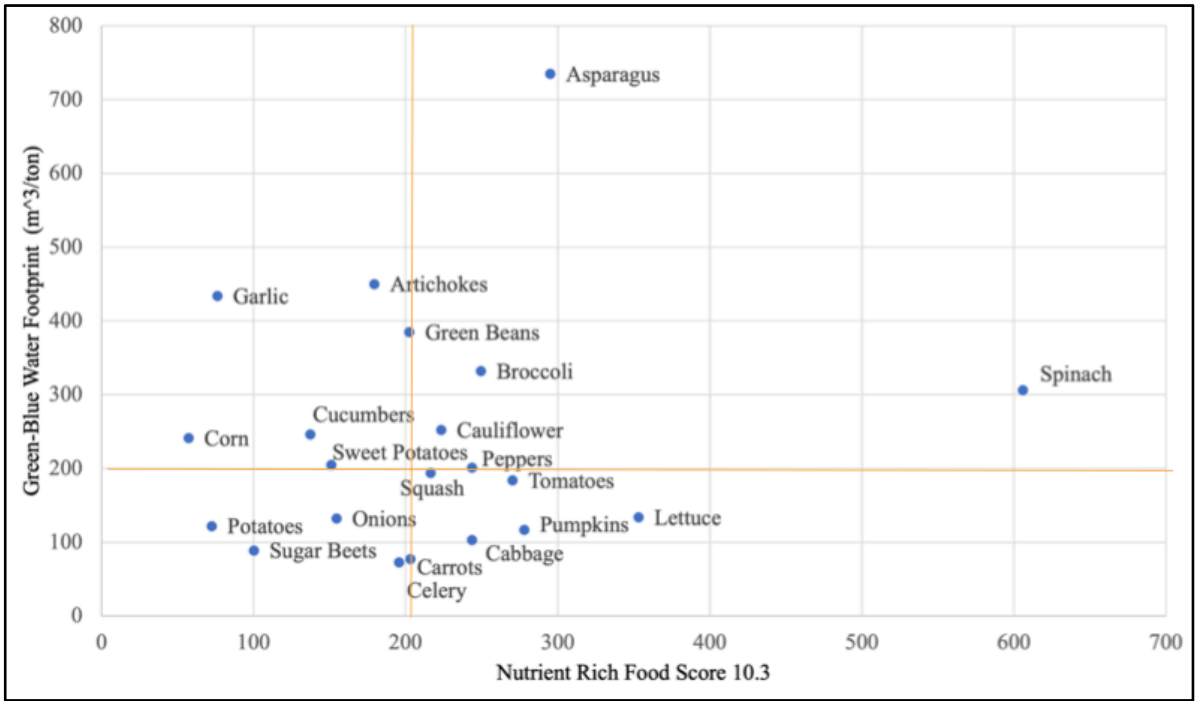

Figure 3. California water footprint and nutrient rich food scores—vegetable commodities.

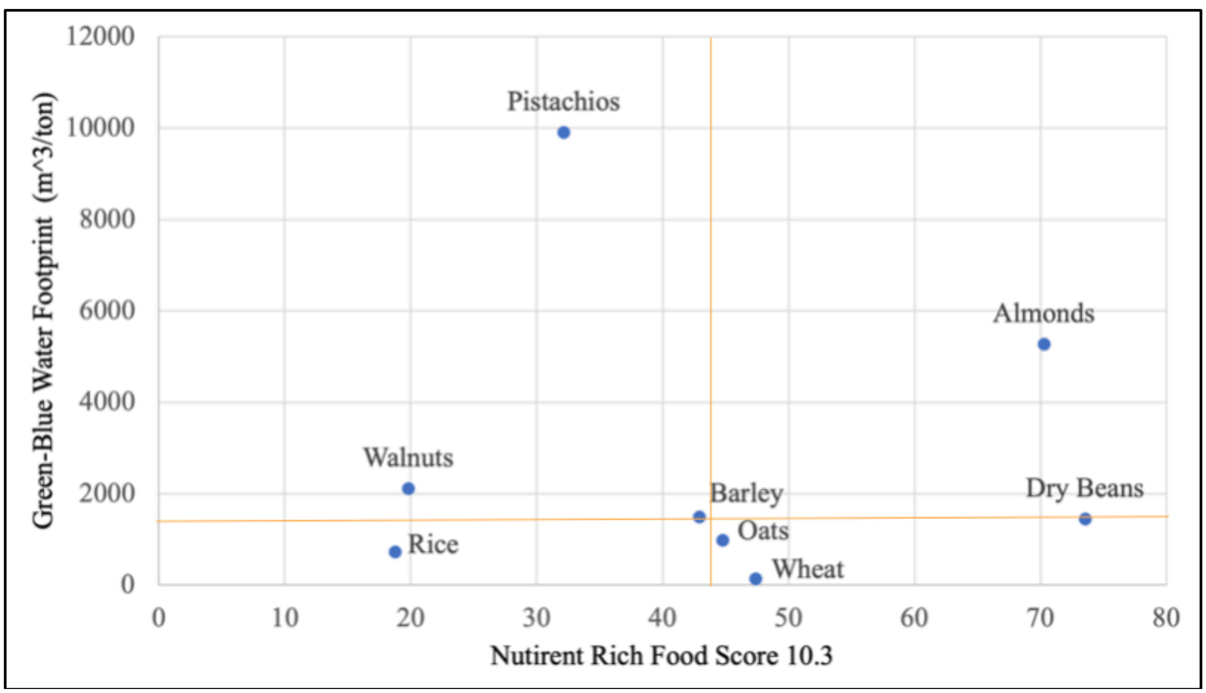

Figure 4. California water footprint and nutrient rich food scores—other commodities.

"Other" or "Prefer Not to State" for the question, "What California county do you live in?", their surveys were also omitted (n=147). Incomplete surveys were also excluded from the final analysis (n=77) which resulted in a final sample of 630 participants. The participant's demographics are presented in Table 2. Of the 630 participants, the majority were female (70.0%), and the plurality of respondents (42.7%) were 18–24 years old. As the age groups increased, the number of respondents decreased. In addition, the respondents' counties of residence were grouped into the nine distinct CA Agricultural Statistics Districts, with the largest number of responses coming from the Central Coast (234; 37.1%), which included Alameda, Contra Costa, Lake, Marin, Monterey, Napa, San Benito, San Francisco, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, and Sonoma counties. This region was followed closely by Southern California (217; 34.4%), which included Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, and Ventura counties. In terms of race and ethnicity, the largest portion of respondents were white (n=245; 38.9%); followed by Asian (n=157; 24.9%); and Hispanic, Latino or Spanish (n=92;14.6%). Education and income were more evenly distributed across the groups. Finally, when asked if they followed a specific diet, 144 (22.9%) responded yes, and the most frequent specified answer given was that they followed a vegetarian or vegan diet (n=51; 35%).

Factors Influencing Food Choice, Water Issues, and Use

The survey also assessed whether or not agricultural water use was a factor in Californians' food choices or water-saving activities. In the question regarding the importance of general food choice (data not shown) the highest-rated option was that the food, "provides me with pleasurable sensations (e.g., texture, appearance, smell and taste),"

Table 2. Demographics of food choice and water survey respondents.

Demographic variables	**n**	**(%)**
Gender		
Male	155	24.6
Female	441	70.0
Non-binary/third gender	28	4.4
Prefer not to answer	6	1.0
Age		
18–24	269	42.7
25–34	149	23.7
35–44	105	16.7
45–54	41	6.5
55–64	32	5.1
Over 65	29	4.6
Prefer not to answer	5	0.8
Race/Ethnicity		
White	245	38.9
Asian	157	24.9
Hispanic, Latino, or Spanish	92	14.6
More Than One Race	74	11.7
Black or African American	25	4.0
Middle Eastern or North African	5	0.8
Some Other Race or Ethnicity	4	0.6
American Indian or Alaska Native	3	0.5
Native Hawaiian or Other Pacific Islander	2	0.3
Prefer not to answer	23	3.7

Table 2 (cont). Demographics of food choice and water survey respondents.

Demographic variables	**n**	**(%)**
Education		
Some high school or less	8	1.3
High school diploma or GED	107	17.0
Some college but no degree	140	22.2
Associates or technical degree	63	10.0
Bachelor’s degree	182	28.9
Graduate or professional degree	120	19.0
Other	4	0.6
Prefer not to answer	6	1.0
Income		
Less than $25,000	124	19.7
$25,000-$49,999	115	18.3
$50,000-$74,499	97	15.4
$75,000-$99,999	81	12.9
$100,000-$149,999	68	10.8
$150,000-$199,999	35	5.6
More than $200,000	39	6.2
Prefer not to answer	71	11.3
Follows a Specific Diet		
Yes	144	22.9
No	474	75.2
Prefer not to answer	12	1.9

with an average rating of 75.7, in between a rating of moderately important (50) and extremely important (100). This was closely followed by affordability, with an average rating of 74.1, and health at 71.9. The rating for food's environmentally friendliness fell in 6th place out of 11 options with an average rating of 59.6.

Participants were asked to rate how important seven different environmental factors were based on the food they ate in a typical day (Table 3). All of the factors were rated moderately important with average ratings ranging from 50.2 - 60.0. The most important factor was that the food was produced in an environmentally friendly manner with an average rating of 60 out of 100. The rating for food produced with minimum agricultural water use was ranked second to last with an average rating of 50.5. Regarding the importance of water issues (Table 3), the ratings ranged from 58.6, close to moderately important, to 90.3, closer to extremely important. Clean drinking water was rated as the most important issue out of 11 options, and water for agriculture was ranked 6th with an average rating of 76.

For the importance of water actions (data not shown), respondents rated "making water quality and quantity available to the public" first out of 12 options with an average of 79.2, and "eating food that uses a minimal amount of agricultural water to produce" was ranked last with an average of 66.5.

The last two questions in the survey asked people which water conservation actions they had taken and what water issues they would like to learn more about, with the option to check all that applied for both inquiries. The water saving action taken by most people (data not shown) was "turned off water when brushing teeth or shaving" (n = 491, followed by

Table 3. Importance of environmental factors on food choice, water issues, and learning more about water.

Question	Average rating (±SD)*
9. It is important to me that the food I eat on a typical day…	
… is produced in an environmentally friendly manner	60.0 (±27.1)
… is produced without pesticides	59.7 (±30.5)
… has an environmentally friendly packaging	57.0 (±28.1)
… is produced within the season	54.7 (±29.0)
… is produced without a minimum of carbon dioxide (CO2) emissions	54.6 (±28.9)
… is produced with minimum agricultural water use	50.5 (±28.7)
… is organic	50.2 (±30.1)
10. How important are each of the following water issues to you?	
Clean drinking water	90.3 (±16.8)
Clean groundwater	80.8 (±21.8)
Clean rivers	80.0 (±22.0)
Drought	77.9 (±23.6)
Prevention of fish extinction	77.4 (±24.7)
Water for agriculture	76.0 (±23.8)
Loss of wetlands	74.1 (±25.2)
Watershed restoration	73.2 (±24.6)
Having enough water for economic development	71.3 (±27.1)
Water for power generation	69.6 (±25.6)
Water for recreation (fishing, boating, rafting)	58.6 (±28.3)

Table 3 (cont). Importance of environmental factors on food choice, water issues, and learning more about water.

Question	Count (%)
13. Would you like to learn more about any of the following water quality issue areas? (Check **all** that interest you)**	
Protecting public drinking water supplies	221 (35.1)
Forest management and water issues	193 (30.6)
Agricultural water use for food production	192 (30.5)
Fish and wildlife water needs	188 (29.8)
Home and garden landscaping	187 (29.7)
Nutrient and pesticide management	179 (28.4)
Community actions concerning water issues	163 (25.9)
Restoring fish and aquatic habitat	158 (25.1)
Water policy and economics	157 (24.9)
Watershed restoration	141 (22.4)

* Rating Scale: 0 =Not Important; 50=Moderately Important; 100=Extremely Important
**Includes top 10 out of 16 choices

"used dishwashers and washing machines with full loads only" (n = 383) and "fixed leaks, including leaky toilets" (n = 376).

Question 13 asked what people wanted to know more about (Table 3), and "protecting public drinking water supplies" came in first (n = 221), "forest management and water issues" came in second (n = 193), and "agricultural water use for food production" came in third (n = 192).

A Pearson Chi-Square Test of Independence was conducted to see if there was any association between various demographic variables and selecting the option of wanting to know more about "agricultural water use for food production". The analysis showed no association between wanting to know more about "agricultural water use for food production" and gender.

Discussion

California Water Footprint & NRF10.3

The first part of this study provides an assessment of CA agricultural products to see which are both nutritious and low agricultural water users for the benefit of the public. A look at the integration of WF and NRF10.3 scores yielded some intriguing results. First, three of the four animal products that were analyzed (cattle and calves, hogs and pigs, eggs) and all three of the nut commodities (almonds, pistachios, walnuts) were in the top 50% for water use and bottom 50% for nutrient value when comparing all agricultural products. The high WF for animal products can be attributed to the vast amount of feed that is needed to sustain the life of the animal in order to produce these animal products.[28] While nut and fruit trees use relatively the same amount of water,[38] it takes more trees and thus more water to grow the same amount of nuts versus fruits by weight. Also, animal and nut commodities were ranked in the lower half of their NRF10.3 scores when compared to all other commodities. While animal and nut commodities tend to be higher in energy and protein, they can be relatively low providers of other nutrients that make up a healthy diet resulting in overall lower NRF10.3 scores. The NRF10.3 scores in this study were normalized to 100 kcal of each product which tends to favor nutrient dense foods versus using 100 g which, in contrast, values energy density,[36] which could be another reason for the lower scores. However, since the agricultural products were categorized into quadrants relative to each other, the research still showed that most animal and all nut products were still higher water users and lower in nutrient value to other commodities grown in CA.

Surprisingly, pistachios had a higher WF than almonds since almonds are more well known for being high water users. This result was similar to a global WF analysis,[39] but contrary to what was seen in a different study calculating CA WFs which ranked almonds as the highest water user of all evaluated commodities.[24] One of the reasons that could have contributed to this result is the fact that WFs in this study were calculated by tons produced in one year. Harvests can vary from year to year, especially since trees take years to mature and reach the height of their production, so WFs based on tons produced will vary from year to year.

On the opposite end, leafy green vegetables, melons and most berries were classified as lower water users with high nutritional value which was also seen in similar research.[39] More specifically when comparing foods within the same group, strawberries, raspberries, all melons (cantaloupe, honeydew, watermelon), and cabbage and lettuce were found to be in the most beneficial category of the bottom half of water use and the top half of nutritional value as the study comparing nutrient value to global WFs. However, blueberries and spinach were categorized as higher water users in the evaluation of CA WF which is the opposite of what is seen in the global WF analysis, highlighting the relative nature of these categories depending on which commodities are included in the analysis and the differences in water use that can occur with the same products when grown in a different region of the world.

There are some factors that are important to consider while interpreting the WF assessment. First, WF assessments are based on estimates. As with the method for global

WFs, the WFs in this study uses data derived from water estimates and assumes 100% irrigation efficiency.[6,40] It is challenging to accurately estimate how much water is used in agriculture, so while the WFs are not 100% accurate, they are the closest to accurate that they can possibly be with the existing data. Next, global WF data is comprised of three types of water: green, blue, and gray. However, similar to other studies of this kind,[29,39] gray water was not used to calculate WFs in this study because it is a measure of water quality and not a measure of water that is actually consumed by the agricultural products. Finally, the unit of measurement for WF in this study was calculated for cubic meters per ton of product in order to easily compare CA WFs to global numbers. By calculating the WF per ton of product, the WFs are normalized to the same weight which makes it a good tool for long-term planning purposes. However, for short-term planning, it may be more useful to assess the total amount of water being used by a product to target the largest water users in the state.

The work done in this study can be influential at three levels of society: the consumer level, the agricultural sector, and in public policy. The benefit for the consumer lies in the fact that this is the most recent tabulation of water footprint data for CA, the largest provider of agricultural commodities in the US. When combined with nutrient value, this gives the consumer the power to choose foods that are healthy and beneficial to the environment. Another consideration for consumers is that the quadrants in which the agricultural commodities were divided were based on the mean scores of each grouping (all, animal, fruit, vegetable, other). Therefore, adding or subtracting commodities could easily affect the placement of these products within the different quadrants. When interpreting these results, it is important to remember that the division of these foods into quadrants is all relative.

Therefore, consumers should be encouraged not eliminate entire quadrants of food, but perhaps take a more balanced approach of eating high water use and less nutrient dense foods less often.

Food Choice and Water Survey

The Food Choice and Water Survey was an exploratory survey to get a sense of how important agricultural water use in food production was to California consumers. The survey included questions based on the single-item food choice questionnaire which has been shown to help understand the reasons for food consumption.[33] Relevant agricultural water options such as "produced with minimum agricultural water use" and "drought" were included to see if they were important factors in choosing food for CA consumers. Regarding general factors that influence food choice, participants ranked all 11 factors between 54.8-75.7, signifying each factor was at least moderately important. Pleasure and affordability were ranked 1st and 2nd respectively, which was similar to other studies where taste and price were rated as important factors in food choice.[41,42] In a 2017 qualitative study, researchers found that people were not familiar with the idea of healthy and environmentally friendly food as a joint concept.[41] Similarly, the results from this Food Choice and Water Survey showed that health and environmental friendliness were rated differently in terms of importance with ratings of 71.9 for health and 59.6 for environmental friendliness, similar to a 2017 French study.[43] When participants were asked specifically about various environmental factors, agricultural water use was found to be one of the least important factors, coming in second to last with a rating of 50.5. Many studies conducted on health and environmental sustainability have no mention of agricultural water use as a factor for consideration, so the low rating of importance compared to other environmental factors is not surprising.[41,42,44,45]

In terms of the importance of water issues, results showed that clean water for drinking, clean groundwater and clean rivers were the top three issues with average scores of 90.3, 80.8, and 80 respectively, which were similar to several Water Surveys administered throughout the US.[46,47] Interestingly enough, drought was considered to be the most important factor after clean water factors with a more than moderately important rating of 77.9 by California consumers. Since California frequently experiences drought conditions, participants of the survey may have been more familiar with drought than with agricultural water use as an issue of concern. In addition, California was entering a new period of drought at the beginning of this survey, so participants may have felt more urgency of action regarding drought as opposed to other water issues presented in the survey.

Also of interest was the desire to learn more about agricultural water use for food production. Even though participants rated the importance of eating food produced with minimum agricultural water use rather low in a previous question, learning more about agricultural water use for food production was the third-highest topic of interest to learn more about out of 16 possible factors. When the Chi-Square Test of Independence was run, there was no significance between demographic factors and the selection of learning more about agricultural water use. Therefore, a wider audience should be targeted for any informational campaigns to educate the public about agricultural water use in food production as a way to promote water sustainability. Consumer demand has the power to influence which agricultural products are grown in CA. By giving consumers information on which agricultural goods use less water in production, a bottom-up approach can be taken to influence farmers to grow crops that use less water, translating into much-needed water savings for CA.

The information from this study could also be helpful to the agricultural sector. California ranks number one in farm sales for many of the crops that they produce, including milk and dairy, and provides a third of the nation's vegetables and two thirds of the nation's fruits and nuts.[9,48] While CA is certainly a major ag producer, the state also suffers from droughts that could adversely affect the farming community and agricultural economy of the state. Therefore, the analysis on WFs using CA water data could assist farmers in deciding which commodities to grow in order to produce more goods with less water during times of drought. Furthermore, as this data is specific to CA, it can be used to inform water policies throughout the state. Although the data analysis compiled data for the whole state, future studies could match different agriculture and water regions in CA to produce an even closer look at agricultural water use in a search for solutions to water savings. Finally, the study can be used beyond CA. If researchers can identify similar climate and soil conditions throughout the world, this data could be helpful in informing water and agricultural decisions in other regions as well.

Limitations and Future Research

While this study brings new information to the current body of work on sustainability and nutrition security, it also has its limitations. First, the Food Choice and Water Study used convenience sampling, so it cannot be generalized to the opinions of all consumers in CA. In addition, the survey was based on previously developed and validated survey tools. However, a reliability test could have been performed on the added choices in this survey such as "agricultural water use" and "drought", and a pilot test could have been conducted prior to the distribution of the survey to ensure the clarity of the additional factors. Furthermore, the ratings used in the survey were based on a scale from 0 to 100 with limited descriptions of 0=not important, 50=moderately important, and 100=extremely important. If the scale had been better defined, possibly in increments of 10, the research could have revealed a more nuanced understanding of consumers' opinions. Also, if the 50=moderately important guidance had been left out, people may have chosen a broader range of results. Finally, although using a continuous scale had the benefit of deriving average ratings, previous versions of the surveys used a Likert scale, which limited the ability to compare survey results from this study to previous studies.

With regards to the CA WF analysis, available agricultural information limited the ability to analyze all agricultural commodities produced in CA. Specifically in animal commodities, CA WFs for farm chickens, turkeys, sheep and lamb, and honey could not be calculated due to missing production data or the lack of conversion factors for kg of feed per kg of animal product. For farm chickens, the footnote in the California Agricultural Statistics Review states that the reason for the lack of this data is because of the confidentiality procedures of the USDA Economic Research Service. This lack of information is unfortunate, especially because chicken is such a large part of the American diet, with chicken consumption outpacing beef in the US starting in the 1990s and continuing today.[49,50] Another limiting factor was the lack of data on animal feed. While many animals are fed on pastures, the production data needed to calculate the WF per ton of pasture was not included in the county agricultural reports. Therefore, the CA WF for animal commodities does not include the water needed for pasture. Finally, the WF in this report is based on water data from one water year. While this study provides a good initial look at CA WFs, a multi-year analysis would be beneficial in accounting for any anomalies that may appear in just one year. In addition, future studies investigating CA WFs could include an analysis of WF data at the county level to inform water policy by water region since climate can vary greatly throughout CA. In addition, calculating the total WF for agricultural commodities in a given year, instead of normalizing the water use to per ton of production, would be beneficial in examining overall water use by product and could help to create relevant and realistic short term water goals at the policy level.

Finally, while the NRF profiling method is a robust tool that has been validated multiple times, it is still limited by the nutrients chosen for analysis and the basis of analysis of 100 kcal of food. For a more consumer-friendly look at nutrient value of CA agricultural goods, serving size could be used as the basis of analysis in future studies. Also, while current guidelines recommend limiting added sugar, agricultural products are not processed and do not contain any added sugar. Therefore, future researchers could use total sugar as a limiting factor in their analysis instead of added sugar, which could drastically alter NRF scores and lead to some interesting results.

Conclusion

In conclusion, this study provides the first consumer survey on the importance of agricultural water use in food production on consumer choice. Results showed that the agricultural use of water is not a priority in making sustainable food choices although survey participants were interested in learning more about agricultural water use in food production. The survey can be helpful in creating information campaigns stressing the importance of the consumer's role in influencing agricultural water use through the foods they eat. It is also the first study to take a detailed look at CA WFs of CA agricultural products and their nutritional value, by way of their NRF10.3 scores. While a previous study compared global WFs to nutritional data, this is the first study to use CA water data and provide specific information on commodities including animal products. Because WFs can vary by climate and production, consumers of CA agriculture now have a clearer picture of how much water is actually being used to make the food they buy. With this knowledge, consumers can make better informed food choices that can potentially increase water sustainability and the nutritional content of their diets. The agriculture sector is the largest water user in CA and the world, so changes in this industry at consumer, business, and policy levels can lead to big impacts in reaching global goals of a more sustainable and nutrient rich food system.

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Declaration of Interest

There are no known or anticipated conflicts of interest.

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CHAPTER 3

Summary and Recommendations

Summary

Sustainability and meeting nutritional needs have become a top global priority in the past decade. Starting with the adoption of the UN's SDGs in 2015, the recognition of the intersection between sustainability and food security has led to research on how to produce more food for a growing world population in a sustainable way. One of the biggest ways to increase sustainability in food production is to conserve water resources, which are becoming scarcer every year. In order to meet these goals, new measures of water sustainability and nutrient profiling methods have been developed, such as the WF and the NRF9.3. In past studies, researchers have combined global WFs and nutrient profiles in the hopes of aiding policy-makers to track the advancement of the SDGs related to sustainability and nutrition. One of the limitations from that study was the lack of region-specific WF analysis which can vary widely due to differing climates, soil conditions, and plant variety among other factors (Mekonnen & Hoekstra, 2011). The region of interest in this study was CA, the largest agricultural producing state in the US (USDA, 2021). Few studies have been conducted on CA WFs and nutritional profiles of CA's agricultural commodities, and none included animal products. Furthermore, previous studies showed that consumers can have a large impact on what is commercially grown in CA, but no studies had been done on whether or not consumers considered agricultural water use in choosing foods. Therefore, the purpose of this study was to conduct an exploratory survey on CA consumers' opinions about the importance of agricultural water use in their food choice. Another objective of this study was to identify agricultural products in CA that used the least amount of water while providing the highest amount of nutritional value by determining the regional WFs and nutritional value of food grown in the state.

This study measured the importance that Californians attributed to agricultural water use in their food choices and as a topic for water conservation. While similar surveys have been conducted on sustainability in food choice and the importance of water issues, none have included agricultural water use in their measures. This survey showed that people are unfamiliar with agricultural water use in food production and do not find it very important in making their day-to-day food decisions. However, the survey also showed that people are interested in learning more about this topic, and that a broad audience should be targeted in the development of educational materials. This information has implications for farmers, policy-makers and future researchers. If consumers begin to base their food purchasing decisions on agricultural water use and nutritional value, it would create a demand for more low-water/high-nutrient agricultural products. This would be a boon for farmers as well since they could spend less of their resources on purchasing water, especially during times of drought which has been a more common occurrence in recent years. This shift in consumer (and constituent) priorities could also aid state legislators in gaining more support for and ultimately passing water legislation that would make this natural resource more sustainable for future generations.

This was also the first study to take a detailed look at WFs of agricultural products using CA water data and to combine that information with the nutrient profiles of food grown in CA. While this type of analysis had been done using global WFs, an analysis using CA water data was needed in order to evaluate water use in this robust agricultural region with its specific climate patterns and soil conditions. This study was also the first of its kind to include animal products in its analysis which is an integral part of the American diet. The results showed that all nuts and animal products, with the exception of milk and cream, were categorized in the group of agricultural commodities that needed more water to grow and were in the bottom 50% of nutrient scores when compared to all of the other agricultural products that were analyzed. Interestingly, this category also included blueberries and avocados, which are considered to be superfoods by many people, and also low-cost energy sources such as grains and dry beans with the exception of wheat. On the opposite end, all of the agricultural products in the bottom 50% water use and top 50% nutritional value category were all fruits and vegetables. Moreover, out of all of the food groups (animal products, fruits, vegetables, and field crops and nuts), the lowest water using foods were vegetables which also tend to provide essential nutrients. The results show that agricultural goods that are highly nutritious, do not always take a lot of water to grow. This data adds to the growing body of literature on sustainability in regards to food production and can help inform consumer food choice to reduce agricultural water while still eating foods that provide good nutritional value.

Recommendations

The survey results from this study support the recommendation to educate the public on agricultural water use in food production. The consumer has the ability to influence what is grown by the agricultural sector in CA, and the agricultural sector is the largest water user of the state. By using the WF and nutrient data in this study to create educational tools for the general public, consumers can tap into the potential for great gains in water sustainability while still consuming a nutritionally appropriate diet. Future research implications include conducting another survey with more detailed questions regarding agricultural water use, nutrition, and food choice; analyzing WFs for multiple years, by county, or looking at total water use for short-term implications; and possibly assessing NRF scores based on serving size to be more useful for consumers.

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Appendix A

SJSU SAN JOSÉ STATE UNIVERSITY

Office of Research
Division of
Research and Innovation

San José State University
One Washington Square
San José, CA 95192-0022

TEL: 408-924-2272
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SAN JOSE STATE UNIVERSITY
HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD

IRB Notice of Approval

Date of Approval: 2/25/2021

Study Title: Food Choice Survey

Principal Investigator: Dr. John Gieng

Student(s): Helen Lee

Other SJSU Team Members:

Funding Source: 21051

IRB Protocol Tracking Number: 21051

Type of Review

☒ Exempt Registration: Category of approval §46.104(d)(2ii)
☐ Expedited Review: Category of approval §46.110(a)()
☐ Full Review
☐ Modifications
☐ Continuing Review

Special Conditions
☒ Waiver of signed consent approved
☐ Waiver of some or all elements of informed consent approved
☐ Risk determination for device:
☐ Other:

Continuing Review
☒ Is not required. Principal Investigator must file a status report with the Office of Research one year from the approval date on this notice to communicate whether the research activity is ongoing. Failure to file a status report will result in closure of the protocol and destruction of the protocol file after three years.

☐ Is required. An annual continuing review renewal application must be submitted to the Office of Research one year from the approval date on this notice. No human subjects research can occur after this date without continuing review and approval.

IRB Contact Information:
Alena Filip
Human Protections Analyst
Office of Research
Alena.Filip@sjsu.edu
408-924-2479

Dr. Priya Raman
Institutional Review Board Chair

Dr. Mohamed Abousalem
Vice President for Research & Innovation
Institutional Official

Primary Investigator Responsibilities

- Any significant changes to the research must be submitted for review and approval prior to the implementation of the changes.
- Reports of unanticipated problems, injuries, or adverse events involving risks to participants must be submitted to the IRB within seven calendar days of the primary investigator's knowledge of the event.
- If the continuing review section of this notice indicates that continuing review is required, a request for continuing review must be submitted prior to the date the provided.

Appendix B

SJSU SAN JOSÉ STATE UNIVERSITY

Exit Survey

Consent Notification

Welcome to the **Food Choice Survey!**

RESEARCHERS
This study is being conducted by John Gieng PhD, Assistant Professor, Department of Nutrition, Food Science & Packaging, San José State University and Helen M. Lee, Graduate Student, Department of Nutrition, Food Science, & Packaging, San José State University.

PURPOSE
The purpose of this study is to assess the reasons behind food choices in the general population.

PROCEDURES
The participants will first read this consent notice and then complete the following survey. This should take less than 10 minutes.

COMPENSATION
The participants of the survey may enter a raffle drawing to win a $50 Amazon gift card. The odds of winning are 1 in 50. The participant is not required to complete the survey in order to enter into the raffle drawing. If you would like to enter into the raffle drawing without completing the survey, click on the exit button at the top of any page at any time, and you will be directed to a form where you can enter into the raffle drawing.

CONFIDENTIALITY
No identifying information will be collected as a part of this survey. However, if you wish to enter

into the raffle drawing, you will need to provide your email address after exiting the survey. Your email address will only be used for this raffle drawing and will not be used or shared for any other purposes.

Data and findings will be presented to the Nutrition, Food Science and Packaging Department and potentially among larger conferences and publications; however, all data presented will be non-identifiable. The results of this study may be used for teaching purposes, presented at a professional meeting, or published in a peer-reviewed journal. Additionally, your data without any identifying information may be used for other related research questions.

YOUR RIGHTS
Your participation in this study is completely voluntary. You can refuse to participate in the entire study or any part of the study without any negative effect on your relations with San José State University. You also have the right to skip any question you do not wish to answer.

CONTACT INFORMATION
If you have any questions regarding the study, contact Helen M. Lee at helen.lee@sjsu.edu or John Gieng PhD at john.gieng@sjsu.edu.

AGREEMENT TO PARTICIPATE
Your completion of the study indicates your willingness to participate. Please keep this document for your records.

Demographics

1. How would you describe your gender?

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer not to answer

2. How old are you?

- Under 18
- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- Over 65
- Prefer not to answer

3. What is your race or ethnicity?
Check all that apply

- White - please specify:
- Hispanic, Latino, or Spanish - please specify:
- Black or African American - please specify:
- Asian - please specify:
- American Indian or Alaska Native - please specify:
- Middle Eastern or North African - please specify:
- Native Hawaiian or Other Pacific Islander - please specify:
- Some Other Race or Ethnicity - please specify:
- Prefer not to answer

4. What California county do you live in?

5. What is the highest level of education you have achieved?

- ◯ Some high school or less
- ◯ High school diploma or GED
- ◯ Some college but no degree
- ◯ Associates or technical degree
- ◯ Bachelor Degree
- ◯ Graduate or professional degree
- ◯ Other: ______
- ◯ Prefer not to answer

6. What was your household income before taxes in the past 12 months?

- ◯ Less than $25,000
- ◯ $25,000 - $49,999
- ◯ $50,000 - $74,499
- ◯ $75,000 - $99,999
- ◯ $100,000 - $149,999
- ◯ $150,000 - $199,999
- ◯ More than $200,000
- ◯ Prefer not to answer

7. Do you follow a specific diet?

- ◯ Yes - If yes, please specify: ______
- ◯ No
- ◯ Prefer not to answer

8. It is important to me that the food I eat on a typical day...

(0 = Not at all important; 50 = Moderately important; 100 = Extremely important)

	0	10	20	30	40	50	60	70	80	90	100	No Opinion/Don't Know
...is healthy												☐
...is a way of monitoring my mood (e.g.. A good feeling or coping with stress)												☐
...is convenient (in buying and preparing)												☐
...provides me with pleasurable sensations (e.g.. texture. appearance. smell and taste)												☐
...is natural												☐
...is affordable												☐
...helps me control my weight												☐
...is familiar												☐
...is environmentally friendly												☐
...is animal friendly												☐

9. It is important to me that the food I eat on a typical day...

(0 = Not at all important; 50 = Moderately important; 100 = Extremely important)

	0	10	20	30	40	50	60	70	80	90	100	No Opinion/Don't Know
...has an environmentally friendly packaging.												☐
...is produced in an environmentally friendly manner												☐
...is produced without a minimum of carbon dioxide (CO2) emissions.												☐
...is organic												☐
...is produced with minimum agricultural water use.												☐
...is produced without pesticides.												☐
...is produced within the season.												☐

Water Survey Assessment

10. How important are each of the following water issues to you?

(0 = Not at all important; 50 = Moderately important; 100 = Extremely important)

	0 10 20 30 40 50 60 70 80 90 100	No Opinion/Don't Know
Clean rivers		☐
Clean groundwater		☐
Clean drinking water		☐
Drought		☐
Having enough water for economic development		☐
Prevention of fish extinction		☐
Water for recreation (fishing, boating, rafting)		☐
Loss of wetlands		☐
Watershed restoration		☐
Water for power generation		☐
Water for agriculture		☐

11. How important are the following actions in protecting our water resources?

(0 = Not at all important; 50 = Moderately important; 100 = Extremely important)

	0 10 20 30 40 50 60 70 80 90 100	No Opinion/Don't Know

0 10 20 30 40 50 60 70 80 90 100

Treating storm runoff	☐
Improving waste water treatment	☐
Residential water conservation	☐
Building new water storage structures (dams, reservoirs)	☐
Improving home and garden practices	☐
Eating food that uses a minimal amount of agricultural water to produce	☐
Preserving & restoring buffer zones & wetlands	☐
Improving agricultural practices	☐
Preserving agricultural land & open space	☐
Better management of shoreline access to prevent erosion	☐
Improving water quality monitoring to detect pollution	☐
Making water quality and quantity data available to the public	☐

Educating municipal officials ☐

12. Have you or someone in your household done any of the following as part of an individual or community effort to conserve water or preserve water quality?

*(Check **all** that apply)*

- ☐ Fixed leaks, including leaky toilets
- ☐ Installed high-efficiency toilets, aerators on bathroom faucets, and water-efficient shower heads
- ☐ Took shorter (5 minute) showers
- ☐ Tracked your water bill and meter to curtail water use
- ☐ Turned off water when brushing teeth or shaving
- ☐ Used dishwashers and washing machines with full loads only
- ☐ Planted drought-tolerant/resistant plants and trees
- ☐ Recycled indoor water to use on plants
- ☐ Refrained from watering your home landscape when it rains
- ☐ Replaced your grass/turf with water-wise plants
- ☐ Used a broom to clean driveways, patios, and sidewalks instead of water from a hose
- ☐ Watered your outdoor landscape earlier in the day when temperatures are cooler
- ☐ Other: ____________
- ☐ Prefer not to answer

13. Would you like to learn more about any of the following water quality issue areas?

*(Check **all** that interest you)*

- ☐ Watershed management
- ☐ Watershed restoration
- ☐

- Forest management and water issues
- Irrigation management
- Agricultural water use for food production
- Nutrient and pesticide management
- Private well protection
- Septic system management
- Protecting public drinking water supplies
- Water policy and economics
- Community actions concerning water issues
- Fish and wildlife water needs
- Home and garden landscaping
- Restoring fish and aquatic habitat
- Landscape buffers
- Shoreline clean-up
- Animal waste management
- Other: ________
- Prefer not to answer

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SJSU SAN JOSÉ STATE UNIVERSITY

Exit Survey

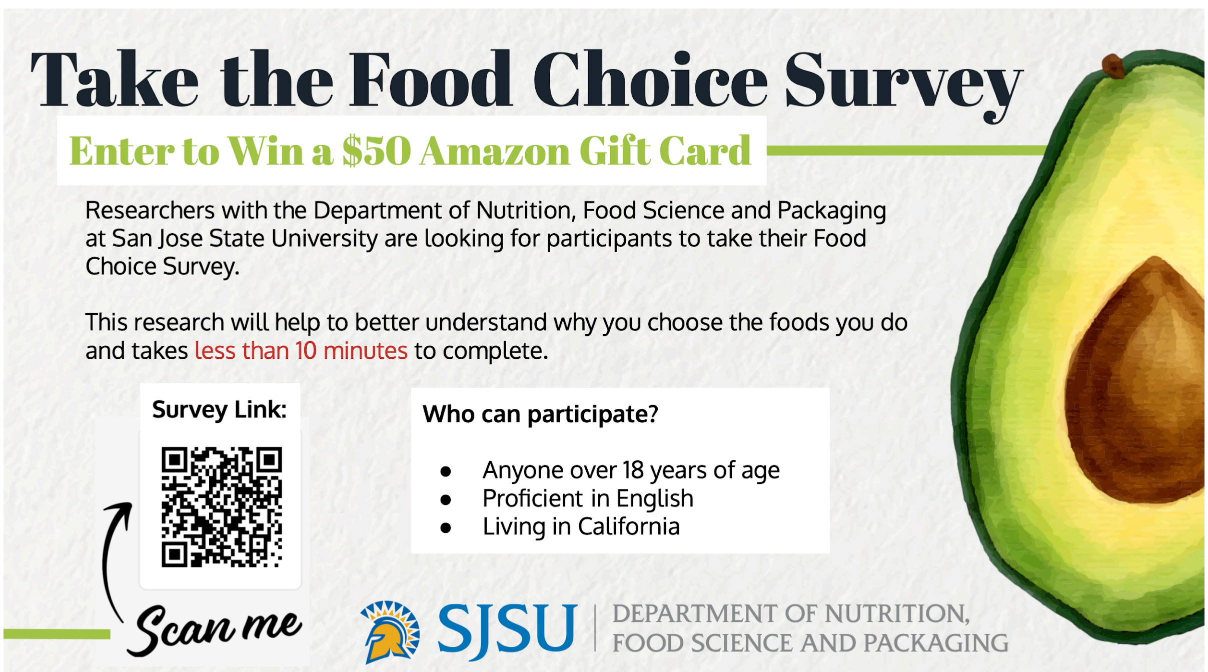
SJSU | DEPARTMENT OF NUTRITION, FOOD SCIENCE AND PACKAGING

Thank you for completing the Food Choice Survey! We appreciate your time. If you would like to enter the $50 Amazon Gift Card Raffle, please click here.

If you have any questions regarding the survey, please contact researchers Helen M. Lee at helen.lee@sjsu.edu or John Gieng PhD at john.gieng@sjsu.edu.

Appendix C


Enter to Win a $50 Amazon Gift Card!
Take the Food Choice Survey
Scan me
Be done in less than 10 mins!
Brought to you by researchers at:
SJSU
DEPARTMENT OF NUTRITION, FOOD SCIENCE AND PACKAGING


Take the Food Choice Survey
Enter to Win a $50 Amazon Gift Card
Researchers with the Department of Nutrition, Food Science and Packaging at San Jose State University are looking for participants to take their Food Choice Survey.
This research will help to better understand why you choose the foods you do and takes less than 10 minutes to complete.
Survey Link:
Scan me
Who can participate?
Anyone over 18 years of age
Proficient in English
Living in California
SJSU
DEPARTMENT OF NUTRITION, FOOD SCIENCE AND PACKAGING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DEPARTMENT OF NUTRITION,
FOOD SCIENCE AND PACKAGING
Enter to Win a $50 Amazon Gift Card
Take the
Food Choice
Survey
Researchers with the Department of Nutrition, Food Science and Packaging at San Jose State University are looking for participants to take their Food Choice Survey.
This research will help to better understand why you choose the foods you do and takes less than 10 minutes to complete. Who can participate?
• Anyone over 18 years of age
• Proficient in English
• Living in California
Survey Link:
Scan me