Research Article **IJFNR (2019) 3:19**

International Journal of Food and Nutrition Research
(ISSN:2572-8784)

Ancient whole grain gluten-free quinoa, high protein, vegetable flatbreads

Talwinder S Kahlon, Roberto J Avena-Bustillos, Mei-Chen M Chiu and Ashwinder K Kahlon
Western Regional Research Center, USDA-ARS, 800 Buchanan St., Albany, CA 94710

ABSTRACT

The objective was to evaluate four kinds of ancient whole grain gluten-free Quinoa, high protein, vegetable, nutritious, tasty, health promoting flatbreads. The flatbreads were Quinoa Peanut Meal Kale (QPK), QPK-Onions, QPK-Garlic and QPK-Cilantro. Quinoa contains all the essential amino acids. Peanut Meal was utilized to formulate higher protein flatbreads and to add value to this low value farm byproduct. Fresh green leafy vegetable kale was used with health promoting potential as it binds bile acids. Onions, garlic and cilantro contain healthful phytonutrients. The level of fresh onions, garlic and cilantro were determined by consensus of the laboratory personnel. Flatbread dough was prepared using 50-67 ml water per 100g as is ingredients. The ingredients were Quinoa flour and Peanut Meal (39.4%) and fresh Kale (19.7%) as is basis. Onions, Garlic and Cilantro flatbreads contained 28%, 7% and 28% of the respective ingredients. 50g flatbread dough was pressed between parchment paper in tortilla flatbread press to about 17 cm circle. Flatbreads were cooked in flatbread cooker for 2-minutes at (165-195 °C). Seventy-one in-house volunteers evaluated Color/Appearance of the QPK, QPK-Onions and QPK-Garlic to be similar and significantly ($P \leq 0.05$) preferred than QPK-Cilantro flatbreads. Odor/Aroma of QPK-Onions and QPK-Garlic flatbreads was similar and significantly higher than QPK and QPK-Cilantro. Texture/Mouth Feel of the QPK-Garlic flatbreads was judged significantly higher than QPK and QPK-Cilantro. Taste/Flavor and Acceptance of QPK-Onions flatbreads was significantly better than QPK and QPK-Cilantro. The acceptance of the flatbreads tested was QPK-Onions 92%, QPK-Garlic 89%, QPK 77% and QPK-Cilantro 72%. These flat breads used only 3-4 ingredients and could be made in any house kitchen or commercial production. These whole gain, high protein, gluten-free, vegetable, flatbreads offer tasty, nutritious and healthy choice to all and those sensitive to gluten.

Keywords:
quinoa, peanut meal, kale, whole grain, gluten-free, flatbreads

Abbreviations: Quinoa Peanut Meal-Kale (QPK), bulk density (ρb), true density (ρt), water activity (Aw)

***Correspondence to Author:**
Talwinder S Kahlon
Western Regional Research Center, USDA-ARS, 800 Buchanan St., Albany, CA 94710

How to cite this article:
Talwinder S Kahlon, Roberto J Avena-Bustillos, Mei-Chen M Chiu and Ashwinder K Kahlon.Ancient whole grain gluten-free quinoa, high protein, vegetable flatbreads. International Journal of Food and Nutrition Research, 2019; 3:19.

eSciPub LLC, Houston, TX USA.
Website: http://escipub.com/

Introduction:

Flatbreads are the oldest of all bread products and are consumed in North Africa, Southern Europe, the Middle-East, Indian subcontinent, Turkey and Central America. Throughout history, many if not most cultures have had foods that can be classified as flatbreads.

Flatbreads are called by various names like “Bing”, “Chapati”, “Metzo”, “Nan”, “Pita”, “Roti”, and “Tortilla”. There are one hundred eleven different names for flatbreads in the world (https://en.wikipedia.org/wiki/Flatbread).

Flatbreads are becoming popular in the Western world for sandwiches, wraps and pizzas. Flatbreads are generally round and may be leavened or unleavened (without yeast or chemical leavening agents) and contain single or many layers. A review of flatbreads from around the world is provided by (Qarooni et al., 1992). Wheat is a common ingredient in many flatbreads. In Asia and Africa, wheat-based flatbreads are commonly baked on a griddle (roti or chapati) or in an oven (naan) or pan fried (paratha) or deep-fat fried (puri or bhatoora). Flatbreads can be used as dish or spoon to scoop up vegetables of meat portions of the meal. They can be served with soups, curries, vegetables, and meat dishes. A variety of other ingredients, such as meats, vegetables, condiments, and spices, may be incorporated into flatbread doughs. Consumption of flatbreads with breakfast, lunch, and dinner meals is common in cultures in which flatbreads are the staple. As world changing demographics and the expanded distribution of ethnic foods among new populations, flatbreads are increasing in popularity. Recognizing this trend, in USA some fast food chains have successfully introduced flatbread wraps and sandwiches. American Baking Society will be conducting scholarships awarding contest “The 2019 Product Development Theme is Flatbreads” https://www.asbe.org/pdc-overview. The U.S. Department of Agriculture (USDA) Dietary Guidelines for Americans 2015-2020 (https://health.gov/dietaryguidelines/2015/guidelines/) recommend: consuming grains at least one-half as whole grains like wheat (gluten containing) or quinoa (gluten free), dark leafy vegetables like kale, and variety of nuts like peanuts as protein and fat sources. Consumption of whole grain products would lower the risk of many preventable life style degenerative diseases (Whole Grain Council, 2009). It has been observed that whole grain rye and oats but not wheat lowered the heart disease risk (Halnaes et al., 2016). Wheat is the primary grain used in loaf and flat breads due to the special properties of gluten. Hypersensitivity to gluten has been increasing worldwide. Individuals with celiac disease, who are hypersensitive to gluten, must follow a gluten-free diet, which restricts their wheat containing options. Hypersensitivity to gluten results in eroding of the lining of small intestines (Lebwohl et al., 2015). This results in delayed growth and many serious health problems. Healthy intestinal lining is required to absorb the needed nutrients. Food and Drug Administration (2014) defines “gluten-free” with less than 20 parts per million of gluten http://www.fda.gov/downloads/ForConsumers/ConsumerUpdates/UCM363276.pdf. This is the level that can be validly tested and can be tolerated by most gluten sensitive individual. Some of the potential reasons for hypersensitivity to gluten could be the use of microbial transaminase enzyme as animal protein glue to produce low cost meat patties from meat scraps. Transamination of gluten in the gut could make it hypersensitive. Another reason could be that pollution and toxic environment has altered gut microbiome resulting in loss of gluten immunity. If one family member is gluten sensitive, the whole family needs to consume gluten-free foods. As gluten contamination in the kitchen would enlist allergic reaction in celiac patients (Hollon, et al., 2013). Flatbreads made of gluten-free whole grains would be desirable. Most individuals and especially children and seniors do not meet the recommended intake of whole grains, protein and vegetables (Mother-Jones, 2017). The

development of whole grain, gluten-free, high protein, vegetable, nutritious and tasty flatbreads would help to meet such a need. Consumers need to be educated to desire healthy home cooked or commercially produced health promoting flatbreads. Such flatbreads could include health promoting ingredients like onions, garlic and cilantro.

Quinoa

Quinoa (*Chenopodium quinoa*) is a pseudocereal, round disc shaped grain like sorghum. After harvesting, the quinoa seeds are processed to remove the saponin-containing outer coating. Quinoa cooks like rice and is gluten-free. It is considered perfect food as it contains all the nine essential amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine). Quinoa is a good source of dietary fiber, minerals and unsaturated fatty acids. The Food and Agricultural Organization of the United Nations (FAO, 2012) officially declared that the year 2013 be recognized as "The International Year of the Quinoa" http://www.un.org/News/ Press/docs/2012/note6367.doc.htm. FAO intended to focus world attention on the role that quinoa can play in providing food security and nutrition, and in the eradication of poverty. Top quinoa producing countries in 2015 were Peru 130, Bolivia 92 and Ecuador 16 thousand metric tons (The Top Quinoa Producing Countries in The World, 2015)

http://www.worldatlas.com/articles/the-top-quinoa-producing-countries-in-the-world.html.

Peanuts

Peanuts cultivation in South America dates back 7500 years. In the first century its production started in Mexico and spread to North America, China, India and Africa. Top peanuts producing countries in million metric tons are China, 13.4; India, 7.7; United States, 1.9; Nigeria, 1.5; Indonesia, 1.1; Myanmar, 0.7; Chad and Senegal, 0.5 each; Ghana and Argentina, 0.4 each (FAO, 2014). Peanuts produced in the U.S. are mostly used in food and confectionary products. More than 50 percent of the world production of peanuts is crushed for its oil. World production of peanuts is over 30 million metric tons per year. Nearly 16 million tons of peanuts are used to extract oil resulting in 8.0 million tons of peanut meal. Peanut meal contains 44% protein. However, it is a low value farm byproduct mainly used as animal feed. Peanut Meal when produced as food grade without the use of organic solvents could be used to make high protein nutritious food products. That would result in significant value addition to peanut growers.

Kale:

Kale is a popular cruciferous green leafy vegetable rich in lutein, sulforaphane, various flavonoids and polyphenols (Angeloni et al., 2009). Steam cooked kale retains more of its nutrients and binds significantly more bile acids than raw (Kahlon et al., 2008). Binding bile acids results in reduced fat absorption with potential to lower cholesterol. Sulphoraphane has been associated with reducing the risk of cancer (Amjad et al., 2015). A single cup of kale (67g) provides RDA of vitamin C 134%, vitamin A 206% and vitamin K 684%.

Garlic:

Garlic (*Allium sativum*) is a widely used spice. In 2014 world production of garlic was 25 million tons. Top garlic producers in million tons are: China, 20.0; India, 1.25; South Korea, 0.35; Egypt and Russia 0.26 each (FAO, 2014). Sharp flavor and taste of garlic is due to allicin, a sulfur containing compound. Garlic contains several phytonutrients with potential health benefits (Rahman, 2007; Guercio et al., 2016).

Onions

Onions (*Allium cepa*), is a vegetable and is most widely cultivated spice. World production of onion in 2014 was 88.5 million tons. Top producers in million tons are: China 22.5; India, 19.4; USA, 3.2; Egypt 2.5; Iran, 2.1 and Russia 2.0 (FAO, 2014). Phytonutrients and polyphenols of onions have health promoting potential (Slimestad et al., 2007).

Cilantro (Coriander)

Cilantro (*Coriandrum sativum)* is also called coriander, dhania or Chinese parsley. It is an annual herb of the family *Apiaceae*. All parts of the plant are edible, but the fresh leaves and the dried seeds are the parts most traditionally used in cooking. Fresh cilantro leaves contain 92% water, 4% carbohydrates, 3% protein, and less than 1% fat (Table 1). Cilantro is rich in vitamin C, folate, vitamin A, vitamin B12, and polyphenols, it is a promising functional food for promoting the well-being in the era of aging and lifestyle-related diseases (Prachayasittikul et al, 2018).

The objective this study was to evaluate four kinds of ancient whole grain, gluten-free, Quinoa, high protein, vegetable, nutritious and tasty flatbreads. The aim was that these flatbreads should have >70% acceptability. The flatbreads were Quinoa Peanut Meal Kale (QPK), QPK-Onions, QPK-Garlic and QPK-Cilantro.

Methods and Materials:

Ancient whole grain gluten-free quinoa; peanuts, kale, red onions, garlic bulbs and fresh cilantro were purchased from local foods markets. Quinoa flour was prepared by using Blendtec Kitchen Mill Model 91 at medium setting (Blendtec Inc., Orem, UT, 84058 USA). Peanut meal was produced by extracting oil using Vevor Oil Press (Joyfay International, Cleveland, OH, 44103 USA). Kale was chopped using Mini-Prep Processor (Cuisinart, East Windsor, NJ, 08520 USA). Prepared flatbreads and the ingredients (Quinoa flour, Peanut Meal, Kale, Red Onions, Garlic and Cilantro) were analyzed for nitrogen, using (AOAC method 990.03, 2000) by Leco FP628 analyzer (Leco Corporation, St Joseph, MI, 49085 USA); crude fat by Soxhlet extraction with petroleum ether using method 963.15, ash using method 923.03 and moisture using method 925.10 (AOAC, 1990).

Composition of Quinoa flour, Peanut Meal, Kale, Red Onions, Garlic and Cilantro is given in Table 1. Various levels of quinoa, peanut meal, kale, onions, garlic and cilantro were evaluated. The final composition of acceptable, tasty flatbreads was decided by the consensus of laboratory personnel. Dough Composition of the flatbreads tested on as is basis was Quinoa and Peanut Meal (28-39%), Kale (14-20%), Onion and Cilantro (28%) and, Garlic (7%) is given in Table 2. Flatbreads dough was prepared by adding 50-67 ml water to 100g of as is ingredients. Dough was covered with polyvinyl film (Polyvinyl Films, Sutton MA, USA 01590) and set at room temperature for 30 min.

Preparation of Flatbreads:

Small portions (50 g) of dough was put on a non-stick, up to 215^{o}C safe parchment paper (Reynolds Consumer Products, Lake Forest, IL, 60045 USA) and pressed to about 17 cm circle in a 20 cm Tortilla Flatbread Press (Webstaurant Store, Inc., Lancaster, PA, USA 17602). Dough could be prepared by hand mixing and flatbreads could be made into circles by pressing the dough with moist hands or using a rolling pin. Flatbreads may be prepared and stored in the freezer. These flatbreads could be cooked as needed for sensory evaluation or consumption. Flatbreads were cooked the morning of the sensory evaluation day for 2 minutes (1 min each side) in parchment paper on a 1000 Watts CucinaPro Flatbread Maker (SCS Direct, Inc. Trumbull, CT, USA 06611). The cooking temperature ranged from 165-195 ^{o}C as measured by Fluke 61 Infrared Thermometer (Fluke Australia Pty Ltd, Baulkham Hills, NSW 2153). For crispier or chewy flatbreads cooking time can be adjusted up or down as desired according to the personal preference. Cooked ancient grain gluten-free flatbreads are shown in Figure 1, (A) QPK-Onions; (B) QPK-Garlic; (C) QPK; and (D) QPK-Cilantro. Cooked flatbreads were stored in an insulated lunch box. Flatbreads were cut into 8 sectors with a pizza cutter and all four kinds of flat bread samples were presented to the volunteer tastes, appropriately labelled as shown in Figure 2 (A) QPK-Onions; (B) QPK-Garlic; (C) QPK; and (D) QPK-Cilantro. The instructions were to evaluate

sensory parameters for each flatbread sample individually and not on a relative scale. The volunteer tasters n=71, with ethnic origin and gender (males/females) were Caucasian 19/16; Asian 9/11; Hispanic 3/3; Black 1/2 and undeclared 5. The tasters evaluated the whole grain gluten-free flatbreads for Color/Appearance, Odor/Aroma, Taste/Flavor, Texture/Mouth-feel on a scale of 1 - 5 (like very much = 5, like slightly = 4, neutral = 3, dislike slightly = 2, dislike very much = 1). The overall acceptable preference was on a scale of 1 - 2 (acceptable = 2, not acceptable = 1).

Water Activity:

Water activity of the Quinoa-Peanut Meal-Kale (QPK) flatbreads was measured at 25.01 ± 0.02 °C in triplicate using an AquaLab 4TE dew point water activity meter (Decagon Devices, Inc., Pullman, WA).

True Density:

True density (ρt) of the QPK flatbreads was determined using gas displacement pycnometer AccuPyc II 1340 (Micromeritics Instrument Co., Norcross, GA, 30093 USA) at 21.4 ± 0.4 °C. Sample of flatbreads were dried in triplicate at room temperature for 15h at 0% relative humidity in a vacuum desiccator with anhydrous calcium sulfate (W. A. Hammond Drierite, Xenia, OH, 45385 USA). After drying, small pieces of sample were compressed into a density measuring cylinder of the pycnometer and five true density measurements were recorded.

Bulk Density:

The bulk density (ρb) of QPK flatbreads was measured using Syntron Vibra-Flow, Model

F-T01 (Syntron Company Homer City, PA, 15748 USA). In a 202 ml volume jar, displacement by 10g flatbread sample in Ottawa Sand was measured. The first reading was taken after shaking for 15 min., subsequent two readings were taken after additional shaking for 5 min each time.

Statistical Analysis:

Statistical analysis of QPK flatbreads sensory evaluation data scale (1-5) and acceptability data scale (1-2) for all 71 individual tasters were analyzed with Minitab software version 14.12.0 (Minitab Inc., State College, PA, 16801 USA) using basic statistics for mean ± SEM and one-way analysis of variance and Tuckey's multiple comparison tests with ($p \leq 0.05$) was considered the criterion of significance.

Results and Discussion

Color/Appearance of Quinoa-Peanut Meal-Kale (QPK), QPK-Onions, QPK-Garlic were judged by 71 volunteer tasters to be similar and significantly ($p \leq 0.05$) higher than QPK-Cilantro flatbreads (Table 3). Odor/Aroma of QPK-Onions and QPK-Garlic flatbreads was similar and significantly ($p \leq 0.05$) better than QPK and QPK-Cilantro. Taste/Flavor of the QPK-Onions was significantly higher than QPK and QPK-Cilantro flatbreads. Values for QPK-Garlic were also significantly better than QPK. Texture/Mouth feel of the QPB-Garlic flatbreads was significantly higher than QPK and QPK-Cilantro flatbreads. Acceptability of QPK-Onions flatbreads was significantly higher than QPK and QPK-Cilantro. Acceptability of QPK-Garlic flatbreads was also significantly higher than QPK-Cilantro. All the sensory parameters for the QPK-Onions flatbreads were most preferred by the tasters.

The desirability index for sensory parameters was calculated as percent of tasters judged [like very much + like slightly + ½ (neutral)] Kahlon et al. (2013a); Kahlon et al. (2013b). Desirability index for QPK, QPK-Onions, QPK-Garlic and QPK-Cilantro flatbreads was for color/appearance 82, 82, 83 and 68%; for odor/aroma 81, 87, 87 and 80%; for taste flavor 71, 89, 82 and 75%; for texture/mouth feel 70, 82, 85 and 72% respectively. The aim was to achieve the desirability index of >70%. This object was attained for QPK, QPK-Onions and QPK-Garlic flatbreads, exception for QPK-Cilantro where color/appearance desirability index was only 68%. Data suggest that partial green color imparted by Kale in the flatbreads QPK, QPK-Onions and QPK-garlic was preferred, however, additional intense green

Table 1. Composition of Quinoa Flour, Peanut meal, Kale, Red Onions, Garlic and Cilantro, As Is basis% **%**

Ingredients	Protein	Fat	Minerals	Carbohydrate	DM	Water
Quinoa	**13.17±0.05**	**6.25±0.19**	**3.38±0.01**	**67.37±0.07**	**90.17±0.01**	**9.83±0.07**
Peanut meal	**43.64±0.13**	**16.34±0.04**	**3.94±0.05**	**29.41±0.07**	**93.33±0.04**	**6.67±0.07**
Kale	**3.06±0.01**	**0.75±0.01**	**1.88±0.02**	**7.41±0.03**	**13.10±0.07**	**86.90±0.03**
Red Onions	**0.63±0.01**	**0.13±0.01**	**0.38±0.01**	**8.38±0.03**	**9.52±0.09**	**90.48±0.07**
Garlic	**5.98±0.02**	**0.64±0.01**	**1.67±0.01**	**31.19±0.04**	**39.48±0.10**	**50.52±0.04**
Cilantro	**2.79±0.01**	**0.40±0.01**	**1.32±0.01**	**3.75±0.03**	**8.26±0.09**	**91.74±0.03**

Values are mean ± SEM; Nitrogen to protein factors used was 6.25; Dry matter, DM. Carbohydrate = [100 − (Protein + Fat + Ash)]. Samples were analyzed in triplicates.

Table 2. Dough Composition of Ancient Whole Grain Gluten-free Quinoa (Q), Peanut Meal (P), Kale (K), Onions, Garlic and Cilantro Flatbreads, as is basis, % **%**

Flatbreads	Quinoa	Peanut Meal	Kale	Salt	Onion	Garlic	Cilantro	Water
QPK	**39.37**	**39.37**	**19.69**	**1.57**	**---**	**---**	**---**	**67 ml**
QPK-Onions	**28.25**	**28.25**	**14.12**	**1.13**	**28.25**	**---**	**---**	**50 ml**
QPK-Garlic	**36.50**	**36.50**	**18.25**	**1.45**	**---**	**7.30**	**---**	**62 ml**
QPK-Cilantro	**28.25**	**28.25**	**14.12**	**1.13**	**---**	**---**	**28.25**	**50 ml**

Level of Onions, Garlic and Cilantro was decided by consensus of laboratory personnel.

Dough was set at room temperature for 30 min.

Table 3. Sensory Evaluation of Quinoa-Peanut Meal-Kale (QPK) Whole Grain, Gluten-Free, High-Protein, Vegetable Flatbreads[ab] **%**

Snack	Color/ Appearance	Odor/ Aroma	Taste/ Flavor	Texture/ Mouth feel	Acceptance
QPK	**3.99±0.19a**	**3.70±0.07b**	**3.61±0.13c**	**3.58±0.12b**	**1.77±0.05bc**
QPK-Onions	**3.97±0.11a**	**4.21±0.11a**	**4.27±0.11a**	**3.85±0.10ab**	**1.92±0.03a**
QPK-Garlic	**3.97±0.10a**	**4.18±0.11a**	**4.11±0.13ab**	**3.92±0.10a**	**1.89±0.04ab**
QPK-Cilantro	**3.56±0.12b**	**3.77±0.09b**	**3.82±0.14bc**	**3.58±0.11b**	**1.72±0.05c**

[a]Values (mean ± SEM) within columns with different letters differ significantly ($p \leq 0.05$), n=71.

[b]Sensory evaluation parameters were on a scale of 1-5 (Like very much = 5, like slightly = 4, neutral = 3, dislike slightly = 2 and dislike very much = 1); Acceptance was on scale of 1-2 (Acceptable = 2 and Unacceptable = 1).

Table 4. Water Activity (Aw), True Density (ρt), Bulk Density (ρb), Porosity and Expansion of Quinoa-Peanut Meal-Kale (QPK) Whole Grain, Gluten-Free, High Protein Flatbreads s

Snack	Aw	ρ*t*	ρb	Porosity	Expansion
QPK	**0.93±0.01b**	**1.29±0.01a**	**1.13±0.02a**	**0.13±0.02c**	**1.15±0.03c**
QPK-Onions	**0.94±0.01a**	**1.29±0.01a**	**0.97±0.02d**	**0.25±0.02a**	**1.33±0.03a**
QPK-Garlic	**0.92±0.01c**	**1.28±0.01b**	**1.02±0.01c**	**0.21±0.03b**	**1.26±0.02b**
QPK-Cilantro	**0.94±0.01a**	**1.28±0.01b**	**1.09±0.03b**	**0.15±0.03c**	**1.18±0.04c**

Values (mean±SEM) within columns with different letters differ significantly ($p \leq 0.05$), n=71. Water activity (Aw) was measured (N=3) at 25.01 ± 0.02 °C by AquaLab dew point water activity meter 4TE (Decagon Devices, Inc., Pullman, WA). True density (**ρ***t*) was determined (N=5) by AccPyc II 1340 gas pycnometer (Micromeritics Instrument Co., Norcross, GA) at 21.4 ± 0.4°C. The bulk density (**ρ***b*) of each sample was measured (N=3) by Ottawa Sand volume displacement by about 10g of sample in triplicate after 15-5-5 minutes shaking in a jar of 202 cc volume. Porosity was calculated using the equation [Porosity = 1 – (ρb / ρt)]. Expansion was calculated using the equation [Expansion = (ρt/ ρb)].

Table 5. Composition of Quinoa-Peanut Meal-Kale (QPK) Whole Grain, Gluten-Free, High Protein, Vegetable Flatbreads, dry matter basis % %

Breads	Protein	Fat	Ash	Carbohydrate
QPK	**23.05±0.02**	**15.40±0.04**	**4.41±0.02**	**57.14±0.04**
QPK-Onions	**22.60±0.06**	**16.27±0.05**	**4.43±0.02**	**56.70±0.06**
QPB-Garlic	**22.95±0.06**	**16.79±0.09**	**4.38±0.03**	**55.88±0.10**
QPK-Celantro	**23.32±0.12**	**15.68±0.04**	**4.88±0.02**	**56.14±0.09**

Nitrogen to protein factors used was 6.25. Dry matter, DM. Carbohydrate = [Dry Matter − (Protein + Fat + Ash)]. Samples were analyzed in triplicates. Values are mean±SEM, (n=3).

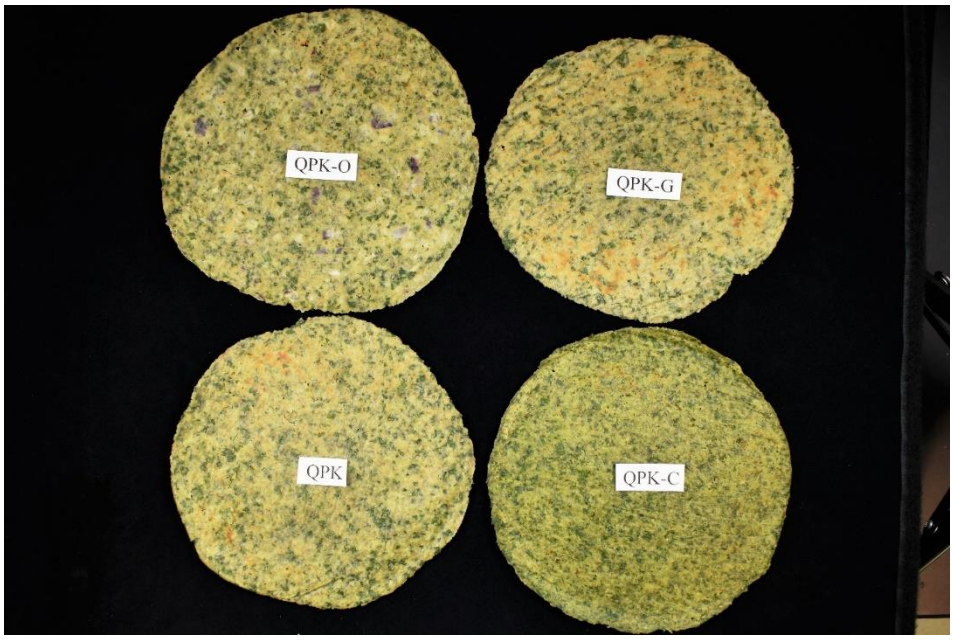

Figure 1. Cooked Flatbreads; top left, Qinoa-Peanut Meal-Kale-Onions (QPK-O); top right, QPK-Garlic; bottom left, QPK and bottom right, QPK-Cilantro.

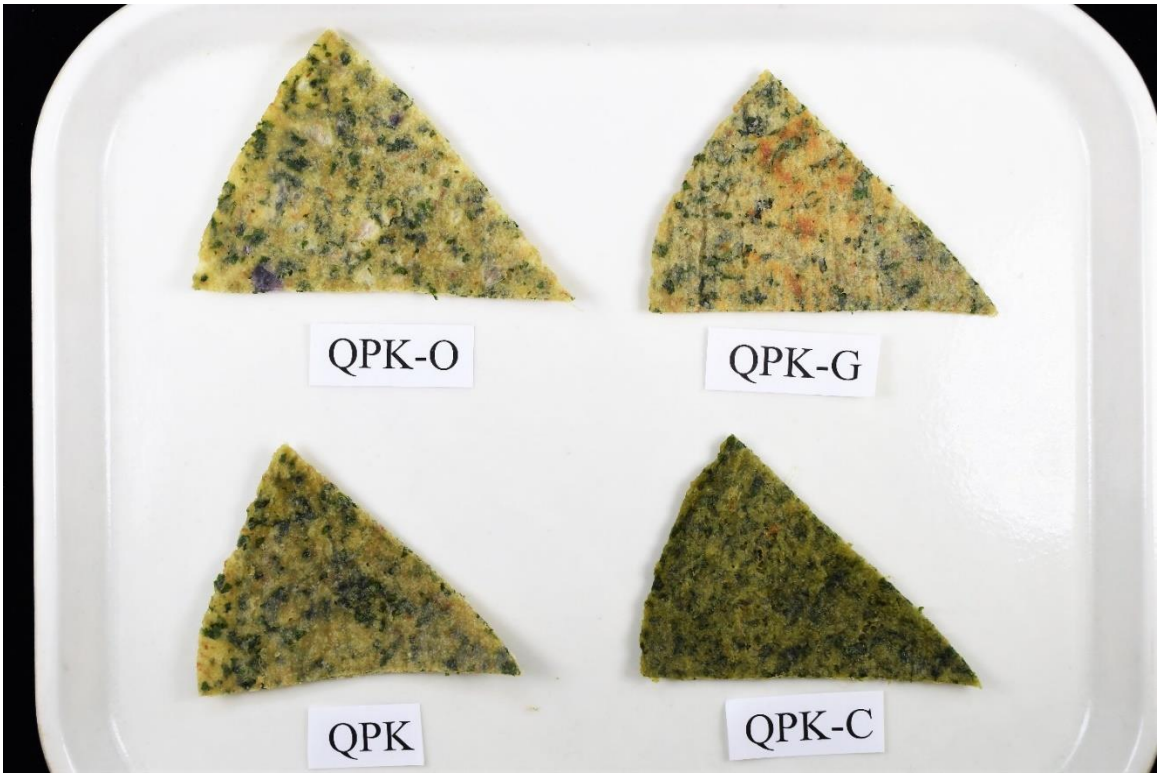

Figure 2. Flatbread samples as presented for sensory evaluation: top left, Qinoa-Peanut Meal-Kale-Onions (QPK-O); top right, QPK-Garlic; bottom left, QPK and bottom right, QPK-Cilantro.

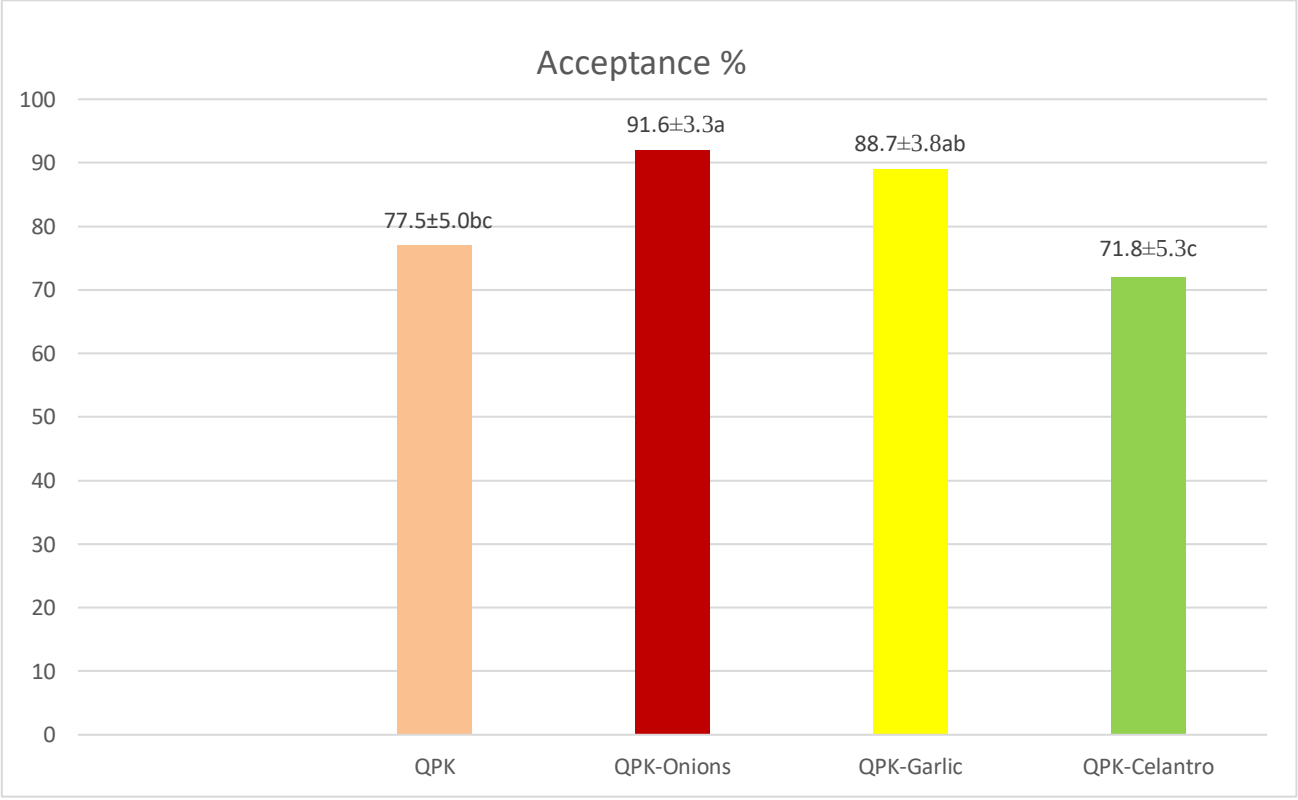

Figure 3: Acceptance percent (mean ± SEM) of Quinoa Peanut Meal Kale (QPK), QPK-Onions, QPK-Garlic and QPK-Cilantro Flatbreads (n=71). Values with different letters differ significantly (p ≤0.05).

color from cilantro was not liked by the tasters (Figure 1).

Percent acceptance of the ancient whole grain, gluten-free, Quinoa-Peanut Meal-Kale flatbreads is given in Figure 3. Acceptance of flatbreads tested was QPK-Onions (92%), QPK-Garlic (89%), QPK (77%) and QPK-Cilantro (72%). Acceptance values for QPK-Onions were significantly higher than QPK and QPK-Cilantro flatbreads. Value for QPK-Garlic was also significantly higher than QPK-Cilantro flatbreads. The objective of attaining acceptability of >70% was achieved as all these values acceded by 2-22%. The QPK-Onions flatbreads were most preferred by all the tasters.

Water activity (Aw) of QPK-Garlic flatbreads was significantly lower than QPK, QPK-Onions and QPK-Cilantro (Table 4). Aw of the QPK was also lower than QPK-Onions and QPK-Cilantro flatbreads. Aw of the flatbreads tested ranged from 0.92-0.94. Most spoilage molds, yeasts and bacteria could grow on foods with Aw of 0.80, 0.88 and 0.90, respectively, (Water Activity, Safe foods 360, http://safefood360.com/resources/Water-Activity.pdf). The flatbreads tested had similar Aw as observed in caviar, red bean paste, and cheese spread with Aw of 0.92, 0.93 and 0.95, respectively; US Food & Drug Administration (FDA) Inspection Guides, 2018. (https://www.fda.gov/iceci/inspections/inspectionguides/default.htm). Aw test data suggests that these flatbreads were chewy and should be preferably served freshly cooked. They could be stored in refrigerator up to three days. These uncooked flatbreads were vacuum sealed after flushing with nitrogen and stored in the freezer using zip lock bags. After six months these flatbreads were thawed to room temperature and cooked as described earlier. No adverse effects in sensory parameters was observed by the laboratory personnel.

True density (ρt) of the QPK-Garlic and QPK-Cilantro was similar and significantly lower than QPK and QPK-Onions flatbreads (Table 4). The ρt values for the flatbreads tested were in a very close range 1.28-1.29. Bulk density (ρb) values of the four kinds of flatbreads tested were significantly different from each other QPK, 1.13 > QPK-Cilantro, 1.09 > QPK-Garlic, 1.02 > QPK-Onions, 0.97. Porosity as well as expansion values for the flatbreads QPK-Onions were significantly higher than QPK-Garlic, QPK-Cilantro and QPK. Values for QPK-Garlic were also significantly higher than QPK-Cilantro and QPK. Porosity and expansion values for the flatbreads tested ranged from 0.13-0.25 and 1.15-1.33, respectively. Data suggest that these flatbreads were not very fluffy and would require small storage or freezer space.

Composition of cooked ancient whole grain, gluten-free, high protein, vegetable flatbreads is given in (Table 5). On dry matter basis flat bread values were protein (23%), crude fat (15-17%), ash (4-5%) and carbohydrate (56-57%). The objective to attaining final product with high protein was attained at 23%. The mineral content of the flatbreads tested was very desirable (4-5%), suggesting that these whole grain gluten-free flatbreads were good source of essential minerals as only less than 1.6% salt was added (Table 2).

The acceptability of whole grain, gluten-free, high protein, vegetable, flatbreads tested is given in Figure 3. QPK-Onions flatbreads were judged to be significantly higher in acceptability than QPK and QPK-Cilantro. Value for QPK-Garlic were also significantly higher than QPK-Cilantro flatbreads. The objective of the study was to achieve >70% acceptability for the whole grain, gluten-free, high protein, vegetable, nutritious, tasty, flatbreads containing health promoting phytonutrients. This objective was clearly acceded by 2-22% with QPK-Onions flatbreads as highly acceptable.

Conclusions

The flatbreads containing ancient whole grain gluten-free Quinoa, Peanut Meal Kale (QPK), QPK-Onions, QPK-Garlic and QPK-Cilantro were evaluated. The objective was to make whole grain, gluten-free, high protein flatbreads with all essential amino acids, add value to

peanut meal as well increase vegetable consumption with health promoting phytonutrients. The acceptance of the flatbreads tested was QPK-Onion 92%, QPK-Garlic 89%, QPK 77% and QPK-Cilantro 72%. The objective of acceptability ≥ 70% was clearly met (acceded by 2-22%) and protein level attained as 23%. These flat breads used only 3-4 ingredients and could be made in any house kitchen or by commercial production. It will add value to low value farm byproduct peanut meal as well as increase vegetable consumption. These high ideal protein, gluten-free, whole grain, vegetable flatbreads offer nutritious, tasty and healthy choice to all and those sensitive to gluten.

Acknowledgements: The authors sincerely thank all the tasters of the sensory evaluation of the gluten-free whole grain high protein vegetable flatbreads.

Conflict of Interest: The authors declare no conflict of interest with any of the products or statements in this manuscript.

References

1. Qaroni, J. P. Ponte, J. G., Posner, E. S., 1992. Flat bread of the world. Cereal Food World 37, 863-865.
2. Product Development Contest 2019, American Society for Baking: Flatbreads (2018) https://www.asbe.org/pdc-overview
3. USDA. 2015, Nutrition Policy and Promotion; Dietary Guidelines for Americans. http://health.gov/dietaryguidelines/2015/guidelines/.
4. Whole Grain Council, 2009. http://www.wholegrainscouncil.org/.
5. Halnaes, A., Kyro, C., Anderson, I., Lacoppidan, S., Overvad, K., Christensen, J., Tjonneland, A., Olsen, A., 2016. Intake of whole grains is associated with lower risk of myocardial infarction: the Danish Diet, Cancer and Health Cohort. Am. J. Clin. Nutr. 103, 999–1007. doi: 10.3945/ajcn.115.124271.
6. Lebwohl, B., Ludvigsson, J.F., Green, P.H. 2015. Celiac disease and non-celiac gluten sensitivity B M J (Review). 351, h4347. doi: 10.1136/bmj.h4347.
7. Food and Drug Administration defines gluten-free (FAO), 2014. http://www.fda.gov/downloads/ForConsumers/ConsumerUpdates/UCM363276.pdf.
8. Hollon, J.R., Cureton, P.A/, Martin, M.L., Puppa, E.L., Fasano, A., 2013. Trace gluten contamination may play a role in mucosal and clinical recovery in a subgroup of diet-adherent non-responsive celiac disease patients BMC Gastroenterol. 13, 40-49. doi: 10.1186/1471-230X-13-40.
9. Mother-Jones. 2017. No, Feeding Hungry Kids and Seniors Isn't a Waste of Money. www.motherjones.com/politics/2017/03/trump-budget-school-meals-on-wheels/.
10. Food and Agricultural Organization of the United Nations (FAO), 2012. http://www.un.org/News/Press/docs/2012/note6367.doc.htm.
11. The Top Quinoa Producing Countries in The World, 2015. http://www.worldatlas.com/articles/the-top-quinoa-producing-countries-in-the-world.html
12. UN Food & Agriculture (FAO, 2014), Production of Crops by Countries. www.fao.org/traditional-crops/.
13. Angeloni, C., Leoncini, E., Malaguti, M., Angelini, S., Hrelia, P., Hrelia, S., 2009. Modulation of phase II enzymes by sulforaphane: implications for its cardioprotective potential. J Agric Food Chem. 57, 615-622. doi: 10.1021/jf900549c.
14. Kahlon, T.S., Chiu, M.M., Chapman, M.H., 2008. Steam cooking significantly improves in vitro bile acid binding of collard greens, kale, mustard greens, broccoli, green bell pepper, and cabbage. Nutr. Res. 28, 351–357. doi: 10.1016/j.nutres.2008.03.007.
15. Amjad, A.I., Parikh, R.A., Appleman, L.J., Hahm, E.R., Singh, K., Singh, S.V. 2015. Broccoli-derived sulforaphane and chemoprevention of prostate cancer: from bench to bedside. Curr Pharmacol Rep. 1, 382–390.
16. Rahman K., 2007. Effects of garlic on platelet biochemistry and physiology. Mol Nutr Food Res. 51, 1335–1344. doi: 10.1002/msnf.200700058.
17. Guercio, V., Turati, F., La Vecchia, C., Galeone, C., Tavani, A., 2016. Allium vegetables and upper aerodigestive tract cancers: a meta-analysis of observational studies. Molecular Nutrition & Food Res. 60: 212–222. doi: 10.1002/mnfr.201500587.
18. Slimestad, R., Fossen, T., Vågen, I.M. 2007. Onions: A source of unique dietary flavonoids. J Agr. & Food Chem. 55, 10067–10080. doi: 10.1021/jf0712503.
19. Prachayasittikul, V., Prachayasittikul, S., Ruchirawat, S., Prachayasittikul, V., 2018. Coriander (Coriandrum sativum): A promising functional food toward the well-being.

Food Res Int. 105, 305-323. doi: 10.1016/j.foodres.2017.11.019.

20. AOAC, 2000. Official Methods of Analysis of the Association of Official Analytical Chemists, 17th edition. The Association: Arlington, VA., methods 985.29 and 990.03.
21. AOAC, 1990. Official Methods of Analysis of the Association of Official Analytical Chemists, 15th edition. The Association: Arlington, VA., methods 963.15, 925.10 and 942.05.
22. Kahlon, T.S., Milczarek, R.R., Chiu, M.M., 2013a. Whole Grain Gluten-free Egg-free Pasta. Cereal Foods World. 58**,** 4-7.
23. Kahlon, T.S., Milczarek, R.R., Chiu, M.M., 2013b. Whole Grain Gluten-free Egg-free High Protein Pasta. Vegetos. 26, 65-71.
24. Water Activity in Foods - Safefood 360°. https://safefood360.com/free-resources/whitepapers/preview/water-activity-in-foods/
25. US Food & Drug Administration (FDA) Inspection Guides, 2018. (https://www.fda.gov/iceci/inspections/inspectionguides/default.htm)