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Quality Assessment and Consumer Preferences of Locally Produced Freekeh (Green Wheat)

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Quality Assessment and Consumer Preferences of Locally Produced Freekeh (Green Wheat)

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Dedication

In the name of the Almighty, I begin this dedication by expressing profound gratitude to God, the source of all blessings and guidance throughout my journey.

To my dearest parents, whose prayers always surrounded me until I became what I am now. Your encouragement and sacrifices have shaped my path.

To my beloved husband, whose support have been the cornerstone of my journey. Your patience, understanding, and belief in me have been my guiding light.

To my precious little Son, you inspire me with your innocence and curiosity; when I see your inspirational eyes, all the difficulties of my life become easy.

To my dear brother and sisters, your encouragement and shared wisdom have been invaluable. Your support has been a source of strength.

This thesis stands as a tribute to your love, encouragement, and unwavering support. Thank you for being my pillar of strength and belief throughout this journey.

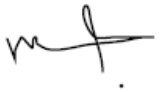
I wish to benefit my Palestinian nation.

Researcher:

Razan Taisir Hamdan

Declaration:

I certify that this thesis submitted for the degree of Master in Institute for Sustainable Development is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not be submitted for a higher degree to any other university or institution.

Signed …  …

Razan Taisir Lutfi Hamdan

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Researcher:

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Quality Assessment and Consumer Preferences of Locally Produced Freekeh (Green Wheat)

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Abstract

Freekeh is a traditional Middle Eastern grain that is particularly popular in Palestinian cuisine. It was a traditional Palestinian grain before rice was introduced in the Ottoman era. This makes it a special food, whether eaten in soup, in a salad, or cooked like rice. It is made from premature green wheat that goes through a roasting and threshing process. In Palestinian cuisine, freekeh is appreciated not only for its unique taste but also for its cultural and historical significance.

The objective of this study is to evaluate the chemical, physical, and microbiological properties of freekeh products available in the Palestinian market. In addition, to assess consumer preferences and purchasing behavior towards locally produced freekeh (demographic information, purchase behavior, and consumer awareness and behavior) in respect to product characteristics. Moreover, the effect of physical properties of the freekeh on consumer preferences and purchasing behavior has been evaluated.

About 9 kg of freekeh was collected from markets representing nine different Palestinian companies (the company names were coded as SkF, SkC, Mn, SnN, KS, LZ, Aq, Shq, and Nkh). About 700-800 g from each company has drawn from both fine and coarse products. Only two companies' produce locally fine freekeh, the seven other companies produce coarse freekeh. Additionally, labelling information of freekeh products was collected, such as weight, type and shelf life. Furthermore, nearly 200 g of crushed freekeh from each company was dedicated to proximate chemical analysis (moisture, fat, protein, fiber, and ash content). In addition, physical analysis has been carried out including color measurement based on CIE system (L*a*b*) and impurities content. Moreover, a microbiological analysis was used to assess the count of bacteria, mold, and yeast in the purchased product. Finally, the consumer preference and purchase behavior toward locally produced freekeh (in terms of physical and nutritional properties) has been carried out via an online survey on the Google Forms platform. More than 500 Palestinian consumers were participated in this survey representing the north of Palestine. The research tool utilized in the study was a structured questionnaire that underwent extensive evaluations to guarantee its reliability and content validity.

The results of the study showed that there were statistical significant differences in ash, crude fat, crude fiber, and protein content between the products, while there were no significant differences ($p>0.05$) in moisture content between different products from different companies. On the other hand, it was found that freekeh products in Palestinian market were significantly different in their color traits. In this context, there were significant differences in L* (degree of lightness) and a* (redness index) values between products while b*-value did not show any significant differences. Our survey showed that more than 50% of respondents consumed regularly freekeh products. Moreover, 3.3% of respondents declared that they do not usually consume freekeh at all. In respect to microbiological analysis, products from company NKH had the highest fungal count while products from company MN showed the lowest fungal count and the differences between these two companies were very high (1.39 to 4.29). Freekeh products from company SKC (one of the Palestinian companies whose product was tested) exhibited the highest bacterial count while products from company MN exhibited the lowest bacterial counts. In conclusion, our study revealed that locally produced freekeh products have different chemical and physical characteristics. Product characteristics such as color, particle size, and the presence of physical impurities had significant role in determination the consumer preferences toward freekeh products.

تقييم الجودة وتفضيلات المستهلك للفريكة المنتجة محلياً (القمح الأخضر)

إعداد: رزان تيسير لطفي حمدان

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الملخص

الفريكة هي حبوب شرق أوسطية تقليدية تحظى بشعبية خاصة في المطبخ الفلسطيني. لقد كانت الفريكة من الحبوب الفلسطينية التقليدية قبل إدخال الأرز في العصر العثماني. مما يجعله طعامًا مميزًا، سواء تم تناوله في الحساء، أو في السلطة، أو مطبوخًا مثل الأرز. إنه مصنوع من القمح قبل تمام نضجه (القمح الأخضر) الذي يمر بعملية التحميص والدرس. في المطبخ الفلسطيني، تحظى الفريكة بالتقدير ليس فقط لمذاقها الفريد ولكن أيضًا لأهميتها الثقافية والتاريخية.

تهدف هذه الدراسة إلى تقييم الخصائص الكيميائية والفيزيائية والميكروبيولوجية لمنتجات الفريكة المتوفرة في السوق الفلسطيني. بالإضافة إلى ذلك، تقييم تفضيلات المستهلك وسلوك الشراء تجاه الفريكة المنتجة محليًا (المعلومات الديموغرافية، وسلوك الشراء، ووعي المستهلك وسلوكه) فيما يتعلق بخصائص المنتج. علاوة على ذلك، تم تقييم تأثير الخصائص الفيزيائية للفريكة على تفضيلات المستهلك وسلوكه الشرائي.

تم جمع حوالي 9 كغم من الفريكة من أسواق تمثل تسع شركات فلسطينية مختلفة (تم ترميز أسماء الشركات بـ SkF، SkC، Mn، SnN، KS، LZ، Aq، Shq، وNkh). يتم سحب حوالي 700–800 جرام من كل شركة من المنتجات الناعمة والخشنة. شركتان فقط تقدمان الفريكة الناعمة (منزوعة القشرة)، بينما الشركات السبع الأخرى تقدم الفريكة الخشنة (الكاملة، مع القشرة). بالإضافة إلى ذلك، تم جمع المعلومات الملصقة على منتجات الفريكة، مثل الوزن والنوع ومدة الصلاحية. علاوة على ذلك، تم تخصيص ما يقرب من 200 جرام من الفريكة المطحونة من كل شركة للتحليل الكيميائي التقريبي (محتوى الرطوبة والدهون والبروتين والألياف والرماد). بالإضافة إلى ذلك، تم إجراء التحليل الفيزيائي بما في ذلك قياس الألوان استنادًا إلى نظام CIE (L*a*b*) ومحتوى الشوائب. علاوة على ذلك، تم استخدام التحليل الميكروبيولوجي لتقييم عدد البكتيريا والعفن والخميرة في المنتج النهائي. أخيرًا، تم إجراء تفضيلات المستهلك وسلوك الشراء تجاه الفريكة المنتجة محليًا من خلال استطلاع عبر الإنترنت على منصة Google Forms. وشارك في هذا الاستطلاع أكثر من 500 مستهلك فلسطيني يمثلون شمال فلسطين. كانت أداة البحث المستخدمة في الدراسة عبارة عن استبيان منظم

خضع لتقييمات واسعة النطاق لضمان موثوقيته وصحة المحتوى. وفيما يتعلق بالصدق، فقد تم فحص الاستبانة من قبل ثلاثة متخصصين قاموا بالتحقق من عناصرها وتقييم مدى ملاءمتها لقياس الفكرة التي تهدف الدراسة إلى اختبارها. تم القيام بذلك لضمان صحة المحتوى بالإضافة إلى الصلاحية الظاهرية. تم تقييم موثوقية الاستبيان باستخدام ألفا كرونباخ، حيث اعتبرت قيم الموثوقية 0.70 أو أعلى مرضية. تم جمع 25 استبانة كاختبار تجريبي لقياس الثبات، وأشارت النتائج إلى أن نتيجة كرونباخ ألفا كانت أعلى من 0.9. تم استخدام برنامج SPSS (الحزمة الإحصائية للعلوم الاجتماعية) الإصدار 21.0 لتحليل البيانات. تم إجراء التحليلات اللاحقة بما في ذلك التحليل: تم الحصول على ارتباطات بيرسون والإحصائيات الوصفية (مثل الوسائل والتكرارات والانحرافات المعيارية) عند الحاجة. تحليل التباين (ANOVA) لتقييم تأثير الظروف الجغرافية على تفضيل المستهلك وسلوك الشراء.

أظهرت نتائج الدراسة وجود فروق ذات دلالة إحصائية في محتوى الرماد والدهون الخام والألياف الخام والبروتين بين المنتجات، في حين لم تكن هناك فروق ذات دلالة إحصائي ($P>0.05$) في محتوى الرطوبة بين المنتجات المختلفة من شركات مختلفة. ومن ناحية أخرى، تبين أن منتجات الفريكة في السوق الفلسطينية تختلف بشكل كبير في سمات اللون. في هذا السياق، كانت هناك اختلافات كبيرة في قيم *L (درجة الخفة) وقيم *a (مؤشر الاحمرار) بين المنتجات بينما لم تظهر قيمة *b أي اختلافات كبيرة. أظهر استطلاعنا أن أكثر من 50% من المشاركين يستهلكون منتجات الفريكة بانتظام. علاوة على ذلك، أفاد 3.3% من المشاركين أنهم لا يتناولون الفريكة عادة على الإطلاق. فيما يتعلق بالتحليل الميكروبيولوجي، أظهرت منتجات شركة NKHأعلى عدد من الفطريات بينما أظهرت منتجات شركة MN أقل عدد من الفطريات وكانت الفروق بين هاتين الشركتين عالية جدًا (1.39 إلى 4.29). أظهرت منتجات الفريكة من شركة SKC أعلى عدد من البكتيريا بينما أظهرت منتجات شركة MN أقل عدد من البكتيريا. في الختام، كشفت دراستنا أن منتجات الفريكة المنتجة محليا لها خصائص كيميائية وفيزيائية مختلفة. كان لخصائص المنتج مثل اللون وحجم الحبيبات ووجود شوائب فيزيائية دور كبير في تحديد تفضيلات المستهلك تجاه منتجات الفريكة.

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List of abbreviations

Abbreviation	Description
SkF, SkC, Mn, SnN, KS, LZ, Aq, Shq, Nkh	Abbreviations for Palestinian freekeh products
AOAC	Association of Official Agricultural Chemists
HACCP	Hazard analysis and critical control points
NV	Nutritional value
PSI	Palestine Standards Institution
PCA	Plate Count Agar
PDA	Potato Dextrose Agar
RAPD	Random Amplified Polymorphic DNA
RAPD	Relative Afferent Pupillary Defect
SD	Standard deviation
CIE	The International Commission on Illumination
TQM	Total quality management

Chapter One: General Framework

1.1 Introduction

Agriculture is essential to Palestinian economic, cultural, and national life. Palestinians are pioneers in spreading and popularizing agricultural techniques in several countries inside and outside the region. Moreover, agriculture is essential to Palestinians because it demonstrates perseverance, confrontation, and attachment to their land in the face of the danger of confiscation and destruction by settlement activities. It also provides shelter, income, and food in times of crisis (MoA, 2009).

Cereals have been cultivated since 8000 B.C. Historically, wheat has been considered the first essential and strategic crop for most of the world's population. Moreover, it is the most cultivated plant. It is well known that this culture was cultivated in the earliest places of civilization and has played an important role wherever society has developed. Almost one-third of the world's population depends on this crop daily (Atawnah, 2013).

All wheats belong to the genus Triticum, which is divided into three groups according to the number of chromosome sets in their genome. These groups are diploid, tetraploid, and hexaploid. The primary classes are hexaploid and tetraploid.

Common wheat (Triticum aestivum) is the general name of the hexaploid wheat, while durum wheat (Triticum durum) is the most commercially important species of tetraploid wheat (Dimitrios, 2023).

One of the oldest and most well-known dishes made from whole wheat, freekeh (also known as firik), has a distinctive smoked flavor. This young wheat product is becoming increasingly popular worldwide and already consumed in many Middle Eastern and North African nations (Al-Mahasneh & Rababah, 2007). Freekeh is typically made from immature wheat, where wheat is harvested when the grains are still tender and green, at a stage ranging from 75 to 89 on the Zadok's scale (Zadoks, 1974), by boiling it at atmospheric pressure or roasting (scorching) the young spikes on a grill to burn off the awns and leafy debris. The kernels and hulls will then separate from the cooked spikes, which dried in the sun and threshed. The parching or charring imparts a distinctive flavor to freekeh (Dick, 1988).

An ancient grain with roots in Middle Eastern and Mediterranean cultures has been gaining attention in culinary circles worldwide. It is a testament to the harmonious fusion of tradition and modern nutritional awareness. Freekeh is the food process's name rather than a specific grain type (Ajmera, 2022). However, it is made from wheat and, most commonly, durum wheat.

It is a whole grain with high nutritional value, is easy to digest, has a low-fat content, and contains a good percentage of fiber. It is almost free from pesticide residue. Freekeh considered one of the healthy alternative foods on the list of diet foods. Moreover, it is one of the desired meals for vegetarians. Because they rarely find smoked flavors of vegetable origin (Bird, 2003).

Freekeh has low cholesterol and is rich in iron, fiber, and lutein (Carsanba, 2017). It is also a good source of fructo-oligosaccharides and other functional compounds. Freekeh is considered a functional food with many positive effects on consumers' health. The accumulation of functional compounds in the grain begins from the formation until the end of the milky stage. Harvesting at the dough stage of seed development provides a large amount of the fructan group, which increases the efficiency of calcium and iron utilization (Huynh, 2008). The antioxidant, physicochemical, and nutritional values of freekeh obtained from immature seeds vary depending on variety and maturity stage (Sramkova, 2009). Besides antioxidant activity, the content of total phenolic compounds decreased during ripening (Özkaya, 2018).

Freekeh stands out as a unique and culturally significant grain with potential health benefits and distinctive flavors in a world increasingly characterized by health consciousness and a desire for culinary exploration. As traditional and novel foods gain prominence, researchers and industry experts are increasingly interested in investigating how consumers respond to these offerings (Ajmera, 2022). Exploring consumer preferences is a pivotal aspect of understanding any food product's reception and potential success in the market. Moreover, understanding consumer preferences toward freekeh is valuable for producers and marketers looking to tailor their strategies and individuals interested in promoting healthier and culturally diverse dietary choices.

Over recent decades, there has been a consistent rise in the demand for high-quality food products. This surge can be attributed to various factors, including increased consumer awareness and knowledge, as well as heightened market pressures.

Additionally, concerns regarding health and the environment have further fueled this trend. The modern-day consumer is notably discerning, placing significant emphasis on both the quality and health benefits of the products they purchase. Consequently, food quality has emerged as a pivotal issue within the realm of food economics. The evolving preferences of consumers, driven by a desire for healthier lifestyles and environmental stewardship, have profoundly influenced purchasing behaviors and perceptions of food quality.(Petrescu, 2020)

1.2 Problem Statement

Over the years, there has been a noticeable decline in the consumption of Freekeh products in Palestine. In 2009, Palestinian families were consuming an average of approximately 0.245 kg per month. However, by 2017, this figure had dropped to an average of 0.105 kg per month, indicating a 14% monthly decrease in Freekeh consumption (PCBS, 2009, 2017). Additionally, the researcher identified a lack of awareness among newer generations regarding the high nutritional value of Freekeh. This trend may be attributed to ineffective marketing strategies and mislabeling of Freekeh products.

1.3 Study Objectives

1. To identify the chemical, physical and microbiological properties of freekeh products available in the Palestinian market.

2. To evaluate consumer preferences and purchasing behavior towards locally produced freekeh considering different sociodemographic conditions (such as gender, educational level, income, living place, etc.).

3. To determining the effect of physical properties on consumer preferences and purchase behavior toward freekeh product.

Chapter Two: Literature Review

2.1 Wheat

2.1.1 Domestication and distribution of wheat

The history of domestication of wild wheat cultivation dates back to about 10,000 years ago in the Middle East. In cultivation, they replaced by high-yielding, free threshing tetraploid and hexaploid wheat cultivars. Einkorn wheat is currently cultivated only in a small area of the Mediterranean Sea, but its wild type is naturally distributed in some parts of this region (Zohary, 2012).

In general, wheat domestication has promoted changes in several important wheat traits, including:

- Increased grain size is associated with improved seedling germination and growth in arable land.
- Development of non-fragmented seeds, which reduced the natural dispersal of seeds and allowed people to harvest and collect seeds at optimal times (Damama, 1998)

Recently, wheat has become one of the most widespread and diversely cultivated food crops in the world. It is cultivated at various altitudes from sea level to altitude of more than 4500 m, reflecting its wide growing range and adaptability (Harlan, 1981).

2.1.2 Wheat and Durum wheat in the world

Today, wheat is grown annually on more than 220 million hectares, making it more widely grown than any other cereal (FAO, 2021). It is regarded as the most important food grain since it provides 20% of the total food calories to the global population.

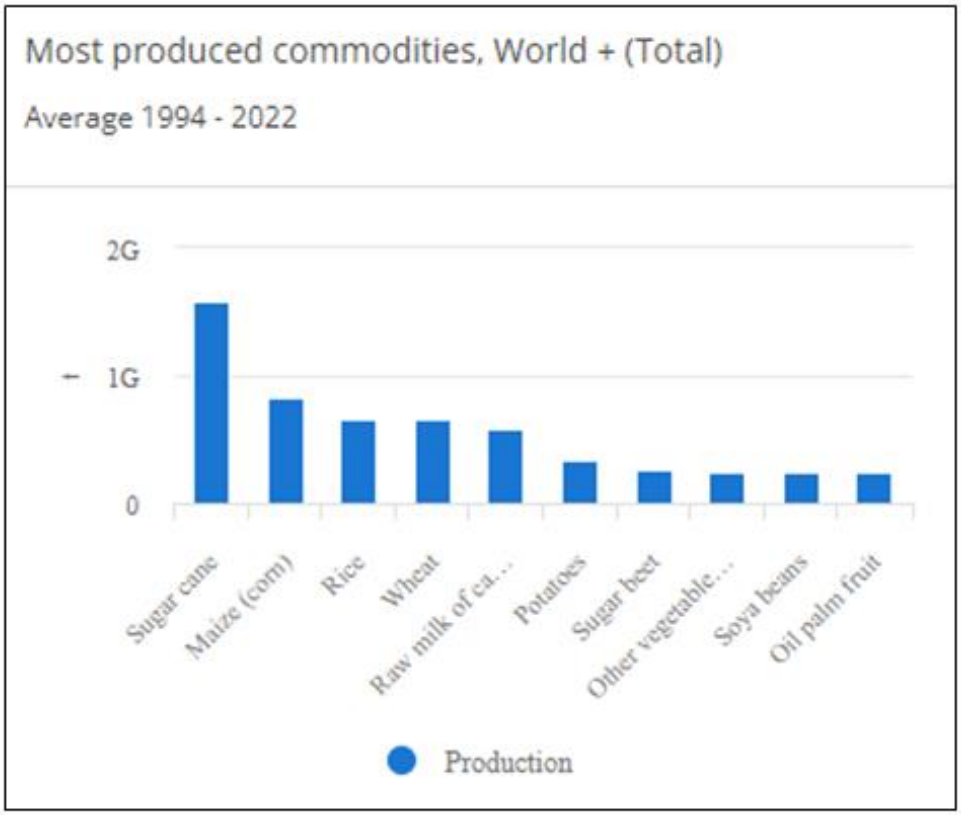


Figure 2.1 Most commonly produced commodities worldwide.

Durum wheat (Triticum turgidum L.) is an important cereal crop, with an estimated 17.7 million hectares cultivated worldwide and an estimated 39.5 million tons produced worldwide (InternationalGrainsCouncil, 2016). Originally grown in the dry regions of the Levant, durum wheat is well adapted to harsh environments and has good resistance to drought and heat. In many Mediterranean countries, it is a favored crop and an important part of the Mediterranean diet (R. Al-Sayaydeh, 2023).

Wheat is the main crop grown in Palestine with about 47%. Much of the wheat produced in the West Bank comes from Jenin, Tubas and Ramallah governorates. Durum wheat is the predominant type of wheat and accounts for more than 70% of total West Bank wheat crop, of which about 96% is grown under a rainwater irrigation system (PCBS, 2021).

It was documented that, average productivity of wheat in the West Bank was around 2300 kg/ha. This productivity is very low as compared to the world productivity which exceeded 3400 kg/he (FAO, 2021).

This large difference in average production may be due to two main reasons. The first is the limitation of cultivation area (Aslan, 2023) and the second is that Palestinian farmers still growing old local durum wheat varieties (landraces) for several reasons. Firstly, the political situation makes it difficult to obtain new improved durum wheat varieties with high yield potential and excellent resistance to biotic and abiotic stresses from regional and international research institutes. Secondly, there is no active national breeding program to produce improved durum wheat lines. In addition, landraces of durum wheat are widely used by farmers and adapted to harsh local environmental conditions (Jaradat, 2013). Therefore, the intensive use of introduced durum wheat varieties with high productivity and excellent agricultural performance puts local varieties endanger of disappearing from the agricultural map of Palestinian farmers. As a result, many useful genes could disappear forever (Jaradat, 2013).

2.1.3 Wheat landraces and its importance

Thousands of years of farming combined with natural and human selection have resulted in the development of very diverse genotypes in wheat species. The traditional management of local wheat varieties by farmers has contributed to the conservation of considerable levels of diversity. Thus, the wheat variety is not a genetically and phenotypically stable, distinct and homogenous unit (Morris & Heisey, 2000).

Throughout the history of wheat, farmers have contributed to the preservation and development of wheat genetic diversity (Zeven, 2000). The landraces and ancient varieties they developed an evolutionary link between the wild emmer wheat, the wild progenitor of all cultivated wheat, and the advanced wheat varieties. In many cases, native species are well adapted to the selection pressures exerted by a particular eco-geographic structure and thus remain undisturbed for decades (Nevo, 1998). Landraces may have developed broad tolerances to a variety of biotic and abiotic threats through long-term adaptations to specific environments, thus they could be more functional as resource for breeding new cultivars with both high yield and stress tolerance.

Nowadays, many local landraces have been disappearing due to retreating of traditional farming systems, genetic erosion, or even the aging or exodus of rural population, and environmental degradation (Mercer, 2010), that have led to the extinction of many local landraces. As a result, most of the unique cereal biodiversity has been lost, and information on landraces and traditional varieties is very scarce today.

2.1.4 Wheat landraces in Palestine

Similar studies in Palestine are limited, especially regarding the morphological characteristics of local durum wheat varieties, although some publications mentioned the evaluation of some agronomic properties for some local varieties. In this context. (Atawnah, 2013) evaluated the growth performance, yield components and genetic variation of six local breed genotypes and showed significant differences in most of the studied traits. Several other studies have used molecular tools for this purpose (Sawalha, 2008) by studying the genetic diversity of local wheat varieties in Palestine using the RAPD marker to phenotypic classification, showing the degree of genetic diversity and similarity shown in the analyzed local varieties.

In another study, the RAPD method was used to estimate the genetic diversity of 10 durum wheat genotypes that are commercially grown in Palestine, although local varieties were classified into group but there are major differences between them (Al-Fares, 2012)

2.2 Freekeh

Freekeh (Firik or freekeh) is a traditional food which is consumed in several countries of the Middle-East and North Africa (Dick & Matsuo, 1988; Williams, 1985). Immature wheats and, preferentially, durum wheats used in the production of freekeh since the best freekeh made from the largest and hardest kernels. Today, there is no large-scale industrial freekeh production. It is generally homemade for domestic consumption or commercially produced by small-scale manufacturers. It is mainly used as a substitute for rice and bulgur (Ozkaya, 1999).

A suitable wheat cultivar, production process, and harvesting period are all important factors that affect the nutritional value and flavor of freekeh. It is generally agreed that the optimal time to harvest freekeh is between the late-milk-ripe and mid-dough-ripe stages, mostly because they have a better flavor than those processed at the full ripe stage since they contain more free simple sugars (Özkaya, 2018).

It is believed that the origin of freekeh making is due to its discovery by chance, thousands of years ago, when one of the countries in the Middle East region invaded. When the local people returned to their homes after the withdrawal of the enemy, they found that it had burned everything. And when they started to inspect their burnt crops, they found some uncharted grains still within the burnt wheat grain, and when they rubbed it in their hands, they found that this roasted grains are edible, and it has a special and delicious taste, completely different from that of wheat, in terms of its taste and flavor. Since then, people have resorted to harvest and burn their grain, especially when under siege and their supplies have run out (Nachit, 2009). Another product like Freekeh "Grönkern" is popular in summer-rainy countries such as Germany and Austria. Farmers are forced to save some of their grain from rotting because of extreme thunderstorms by harvesting and roasting their wheat.

2.2.1 Production of freekeh

Freekeh is produced in two different ways: the first is by roasting, and this is done by burning the green spikes that are not fully ripe, by exposing them to fire flames without causing complete combustion of the grains, and this is called “scorching”, while the straw and the rest of the vegetative matter (such as leaves) are completely burned. The cooked or grilled kernels are dried by exposing them to the sun, so that the moisture content of the kernels decreases to about 10%, after which the kernels are sorted to separate the kernels from the husks. The first method, which is the most common, is preferred, as it gives freekeh a distinctive smoky flavor from the burning process, giving it a unique taste and a pleasant taste that makes it a delicious meal (Dick & Matsuo, 1988)

In Turkey, the study of (Tulbek & Kottapalli, 2004) was conducted on freekeh made by roasting several varieties of durum wheat in order to study the effect of the variety and the manufacturing process (soaking and roasting) on the quality of freekeh grain. Its ability on the formation of dough, protein quality and identifying some of the components of the flavor that characterize it, also to study its microbial load. Freekeh prepared by partially conditioning the wheat grains, by soaking them in water at a temperature of 60° C for 45 min., then the moistened grains entered into an air oven at a temperature of 160°C for 4 min. The study concluded that the hardness of wheat grains decreased in freekeh, and the grains lost their ability to form a dough because of the roasting process, and a significant decrease was observed in the viscosity of starch and the microbial load in freekeh.

(Muchova, 1998) also studied the quality characteristics and manufacturing properties of wheat in three locations in Slovakia. The study showed that there was a significant impact of the prevailing temperature rates during the season. Climate conditions did not affect the production yield only, but also affected all quality characteristics as well. Drought led to an increase in protein by 12% and in gluten content by 30%.

2.2.2 Effect of maturity stage

Changes in grain composition during ripening have a great influence on grain characteristics. Due to the high sugar content of the kernels, spikes harvested at the end of milk stage are preferred over fully ripe kernels. The harvest stage is critical for optimal freekeh production. Early harvesting can lead to the formation of large amounts of carbonic spots on the roasted grains due to the effects of the flame. On other hand, when harvested late, yellow seeds can be obtained instead of green seeds. Growth stages from 75 to 77 on the Zadok's scale seem to be the best time to harvest for freekeh production.

(Özboy, 2001) found in a study on freekeh processed at different maturity stages (13, 16, 19, 22, and 25 days after flowering). By using two different methods (grilling and boiling) from two varieties of durum wheat, it was found that the freekeh content of crude fiber, and total phosphorus tended to decrease with high significance, while its content of phytic acid increased with the progress of

maturity. It showed that the best stage for obtaining freekeh high in fiber content and low in phytic acid was harvested in the early stages (after 13 and 16 days of flowering) .

(Aani, 2008) presented the results of a study conducted with the aim of sensory evaluation (flavor and color) of freekeh produced from durum wheat spikes harvested at different ripening stages. In terms of flavor, (92%) of the people preferred freekeh produced from the beginning of the season (wheat harvested in the early stages). This percentage decreased continuously until it reached (12.5%) at the end of the season (wheat harvested in the late stages), because in the latter case it lost its flavor, and its taste became close to that of bulgur, and similarly the green color was evaluated. (Ozkaya, 1999) found that the processed freekeh in the first two stages of grain development (13 and 16 days after flowering) was the best in sensory terms.

2.3 Study variables

The main study variables represented in the following concepts: Quality Assessment, Consumer Preferences, Local Products, and Freekeh.

2.3.1 Quality Assessment

Food quality is a concept often based on the organoleptic characteristics (e.g., taste, aroma, appearance) and nutritional value of food. Producers reducing potential pathogens and other hazards through food safety practices is another important factor in gauging standards. A food's origin and even its branding, can play a role in how consumers perceive the quality of products (European Union, 2021).

In Palestine, the institution responsible for quality assessment is Palestine Standards Institution (PSI). PSI adopts specific systems of standards, conformity assessment and metrology based on well-established, modern, and scientific principles. In addition, it prepares and adopts Palestinian standards for products, and services; reviews, amends, replaces and publishes them. PSI issued Palestinian standard specifications for freekeh (PPS 4154/2019), prepared from wheat grains intended for human consumption (PSI, 2023).

2.3.2 Consumer preferences

Food quality is an important concept because the food people choose depends largely on quality. Consumer preference is important to the food manufacturer, who wants to gain as wide a share of the market for the product as possible. Quality is difficult to define precisely, though it refers to the degree of excellence of a food and includes all the characteristics of a food, which are significant and make the food acceptable.

Consumers' evaluation of food quality is worthy of investigation because it can help marketers to adjust their strategies to consumers' characteristics. Perceived quality can be an essential marketing tool, used as a segmentation variable (Calvo-Porral & Lévy-Mangin, 2017).

Consumer preference is defined as the subjective (individual) tastes, as measured by utility, of various bundles of goods. They permit the consumer to rank these bundles of goods according to the level of utility they give the consumer. Note that preferences are independent of income and prices. The ability to purchase goods does not determine a consumer's likes or dislikes (Govindarajan, 1982).

Building on the principle that consumer perceptions shape food quality, it is essential to recognize that a crucial aspect of understanding food quality evaluation lies in identifying the cues employed by consumers in the assessment process. This comprehension of consumers' perceptions of food quality holds significant relevance, as their purchasing choices are intricately linked to these frameworks.(Baiardi, 2016)

2.3.3 Local product

Local food is a growing trend for various reasons. The globalization of food supply chains and the will to support the local economy, as well as several food scandals, can account for the increasing number of concerned consumers who prefer to obtain their food from a local source (Vermeer, 2006). Additionally, local food products are associated with freshness, higher quality, and healthiness (Khan& Prior, 2010). Therefore, more sustainable and alternative food networks such as the Slow Food movement (a movement to support traditional and regional cuisine, which encourages farming in local ecosystems), community-supported

agriculture, and farmers' markets (where farmers sell directly to consumers) have become increasingly popular in many Western countries (Sirieix et al, 2013).

There is no standard definition for local food (Onozaka, 2010). Therefore, it is difficult to differentiate local food from non-local food. Generally, different players in the food market have different perceptions of what understood as local food. Local food described in the literature according to a variety of criteria. Distinctions can be made based on geographic or perceived areas, cultural criteria, natural history, and municipal boundaries or distances, but these distinctions are not mutually exclusive (Wenzig & Gruchmann, 2018).

Food local industries are extremely important in the Palestinian economy. Due to its ability to support political, social and economic development through the export of many food products manufactured in Palestinian industrial facilities. In addition to the fact that it works to meet a large part of the Palestinian consumer needs, also for being a strong supporter that can be relied on to provide the Palestinian economic sectors with the capital necessary for growth and development. Local industries provide the Palestinian market with many job opportunities necessary to employ the Palestinian labor force and combat unemployment (Palestinian Ministry of National Economy, 2021).

2.4 Physical and Nutritional properties of Freekeh

Pekkirişci (2023) evaluated the physical and nutritional properties of einkorn bulgur and firik (bulgur produced from immature wheat) samples sold in the market. The firik samples had higher ash, fat and free, bound and total phenolic content, antioxidant activity and lower protein content than einkorn bulgur. Low phytic acid content of firik obtained from immature wheat was found to be remarkable. The total yellow pigment, Ca and Mg contents were found to be 5.4, 1.3, and 1.3 times higher in firik samples than in einkorn bulgur

Carsanba (2017) examined nutritional value of Firik produced in Hatay region using four Firik samples collected from local farmers. Amount of protein, ash, moisture, total sugar, fat, salt, raw cellulose and fatty acid profile were determined and estimated values were compared with similar foods such as bulgur and rice. Protein and ash contents of Firik samples were higher than bulgur and rice, while

sugar and fat contents were lower. In addition, higher amount of linoleic acid and remarkably adequate amount of linoleic acid generally known as essential fatty acids were obtained. The results showed that Firik produced in Hatay could be considered to use as a reinforcement ingredient for improving nutritional value of daily meals, as it has better nutritional properties than the other does resemble carbohydrate-based foods.

Chapter Three: Material and Methods

3.1 Samples collection and preparation

About 9 kg of freekeh collected from markets for nine different commercial Palestinian companies (coded as SkF, SkC, Mn, SnN, KS, LZ, Aq, Shq, Nkh), 700-800 g from each company, both types fine and coarse. Only two companies' offers fine freekeh, the seven other companies offer coarse freekeh.

Samples of freekeh were ground using a stainless-steel rotary mill. The samples were placed sequentially and slowly in the mill, with careful attention to prevent an increase in the sample temperature during milling. The grinding machine was thoroughly cleaned (with a brush) after each sample to avoid mixing between different types. Subsequently, the ground products were packed into securely sealed plastic bags, labeled, and then stored in a dry and clean place for upcoming tests. As for the tests (impurity, color, microbial tests), they were conducted on whole and unground grains.

3.2 Package information of freekeh products

As known that any product's package contains general information about the product, such as weight, type and shelf life. The following table (table 2.1) shows this information for our samples.

Table 3.1 Some labelling information for freekeh products collected from the market

No.	Code	Type	Shelf-life		Weight
			Pro. Date	Exp. Date	
1	SkF	Fine	10/2022	10/2024	700
2	SkC	Coarse	10/2022	10/2024	700
3	Mn	Coarse	5/2022	2 yrs.	700
4	SnN	Coarse	01/02/2023	01/02/2025	700
5	KS	Coarse	19/09/2021	18/09/2023	700
6	Lz	Coarse	5/2022	2 yrs.	700
7	Aq	Coarse	1/2023	1/2025	700
8	Shq	Fine	5/2022	2 yrs.	800
9	Nkh	Coarse	15/12/2022	15/06/2024	800

3.3 Chemical analysis

Nearly 200 g of milled freekeh from each company dedicated to proximate chemical analysis (Moisture content, fat content, protein content, fiber content, and ash content).

3.3.1 Determination of moisture content

Moisture analysis was conducted on milled freekeh using the established procedures outlined in (AOAC 1999). Approximately 5 g of freekeh were accurately weighed and placed into pre-dried and pre-weighed aluminum containers (the containers heated for 1 hour at 105°C and subsequently cooled in desiccators to achieve a consistent weight). The samples then subjected to a 16-hour drying process in an air oven at 105°C, followed by cooling in desiccators. The dried samples were weighed to ascertain their moisture content, as follows:

$$\text{Moisture content (\%)} = \frac{(w2 - w3)}{(w2 - w1)} \times 100$$

W1 = Weight of the empty container

W2 = Weight of the container with the sample before drying

W3 = Weight of the container with the sample after drying

3.3.2 Determination of Ash contents

Ash content were determined according to American Association of Cereal Chemists International (AACCI) approved method 08-01.01. The crucibles underwent a pre-cleaning process with 2M HCl, followed by rinsing with distilled water. Subsequently, they were placed in the muffle furnace (CARBOLITE) for one hour at 600°C. Following this, the furnace turned off, and the crucibles remained in it until the temperature dropped to 250°C. The crucibles then moved to desiccators to cool at room temperature. After cooling, the crucibles were weighed [w1]. Approximately 3 grams of freekeh carefully measured weighed into the crucibles [w2] and subjected to the muffle furnace for 5 hours at 525°C. The crucibles once again left in the furnace until the temperature reached 250°C, then transferred to

desiccators for cooling at room temperature, and subsequently weighed [w3]. The ash content was determined using the following calculation:

$$\text{Ash content (\%)} = \frac{(w3 - w1)}{w2} \times 100$$

3.3.3 Determination of crude fat content

ANKOM crude fat analyzer used in this study following American Oil Chemists' Society (AOCS) Standard Procedure Am 5-04 (AOCS, 2004). The filter bags (ANKOM) were initially weighed [w1]. Approximately 1 g of milled freekeh then carefully placed into the filter bags, and the subsequent weight was recorded [w2]. Following this, the filter bags securely sealed to isolate the sample and introduced into the extraction vessel. A volume of 350 ml petroleum ether introduced into the extraction vessel, and the extractor operated for a duration of 60 min. and at 90°C. At the conclusion of the extraction process, the samples underwent a brief drying period at 102°C for 30 min. to eliminate the extraction solvent, and the sample weight was measured [w3]. The lipid content was determined using the following calculation:

$$Crude\ fat\ content\ (\%) = \frac{(w2 - (\ w3 - w1))}{w2} \times 100$$

3.3.4 Determination of crude fiber content

At this study ANKOM crude Fiber analyzer used following AOCS Approved Procedure Ba 6a-05 (AOCS, 2005). The filter bags were weighed [w1]. Then, approximately 1 g of milled freekeh carefully added to the filter bags, and the subsequent weight was recorded [w2]. Following this, the filter bags securely sealed to encase the sample and positioned in the fiber analyzer (ANKOM) within the suspender tray. The suspender tray weight added to the tray, to ensure the samples were fully immersed, and placed into the vessel. Acidic solution (0.255N H_2SO_4) poured into the vessel, for the first stage of digestion which last for 40 min. following with the second stage of digestion using (0.313N NaOH) basic solution with the same period (40 min). When the digestion and washing with distilled water completed, samples rinsed in acetone for 5 min to remove remaining insoluble

substances in water, then dried and weighed [w3]. The fiber content was determined using the following calculation:

$$\text{Crude Fiber content (\%)} = \frac{(\text{w3} - \text{w1})}{\text{w2}} \times 100$$

3.3.5 Determination of protein content

The protein content was assessed following the Kjeldahl method procedure as outlined in AOAC (1990). In this process, a digestion tube is employed, about 0.5 g of milled freekeh was accurately weighed, along with a catalyst (containing 3.5 g of K2SO4 and 3.5 mg of selenium) and boiling chips, all added to the digestion tube (Gerhardt, Germany). The samples underwent digestion for a duration of 3 hours at 420°C, during the digestion, temperature gradually increased (50°C/15 min) from 80 to 420°C. In cases where the sample was not clear, the tube subjected to an additional hour in the digestion unit. Following the completion of the process, the sample allowed to cool to room temperature. A 250 ml flask, containing 30 ml of boric acid along with the digestion tube, then positioned in the distillation unit (Gerhardt, Germany). The solution was titrated using 0.1 M HCl. The protein content subsequently calculated as:

$$protein\ content\ (\%) = \frac{[(ml\ of\ HCl - ml\ of\ blank) \times N\ of\ HCl\ \times 1.4007]}{weight\ of\ sample\ (g)} \times 100$$

3.3.6 Determination of mineral content:

Flame-photometer was used for determination of Sodium & Potassium content following AOAC 969.23 (AOAC, 1971). After the completion of ash content calculation, 10 ml of 1M HCl should be added to the crucibles, and the mixture heated on a hot plate until boiling. Subsequently, transfer the sample to a 100 ml volumetric flask, filling it to the mark with distilled water and thoroughly mixing the solution.

For the preparation of the standard curve for each mineral, six concentrations (0, 10, 20, 40, 75, & 100 ppm) have been meticulously prepared and measured using

a Flame-photometer (Sherwood) for each mineral (Na, K). Utilizing the calibration curve, the concentration of Na and K in the solution of the food sample ash can be determined by identifying the corresponding emission intensity.

Finally, the amount of Na and K in the food sample can be expressed as follows:

- Na mg/100g sample
- K mg/100g sample.

3.4 Physical analysis

3.4.1 Color measurement

The CIE system (Commission Internationale de l'Eclairage) employed for the measurement of color parameters, following globally recognized standard values. Within the CIE system, as shown on Figure 3.1, the utilized values include:

- L* (Lightness): Signifying the contrast between light (where L* = 100) and dark (where L* = 0).
- a*: Representing the distinction between green (-a*) and red (+a*).
- b*: Representing the contrast between yellow (+b*) and blue (-b*).

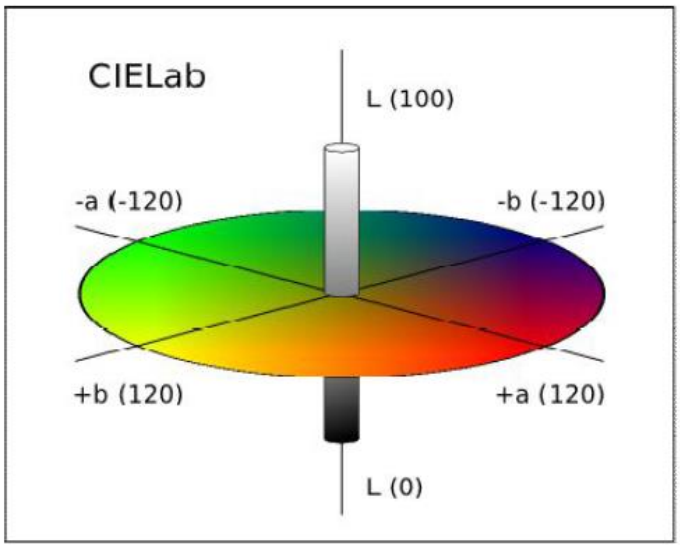


Figure 3.1 A three-dimensional representation of L, a, b CIE Lab system used to measure the color parameters.

For each main sample, a clean and new petri dish filled with completely unground freekeh grains, color indexes assessed in triplicate for three regions of each main sample, and the average value was calculated. The colorimeter calibrated with a reference white ceramic tile before measurement.

3.4.2 Determination of impurities content

Following the Palestinian Standard for Freekeh (PS 4154/2019) which approved and published by Palestinian Standards Institute (PSI) the impurities test achieved.

A random three samples (5 g for each) taken from each main sample, placed on a clean white background and sorted by naked eye. Then, impurities sorted again and weighed based on the Compositional Standard which divided them in:

a. Stones, sand and dirt.
b. Dead insects and/or their parts.
c. Other grains and stems.

Figure 3.2 shows the process for only one main sample (SKF for example).

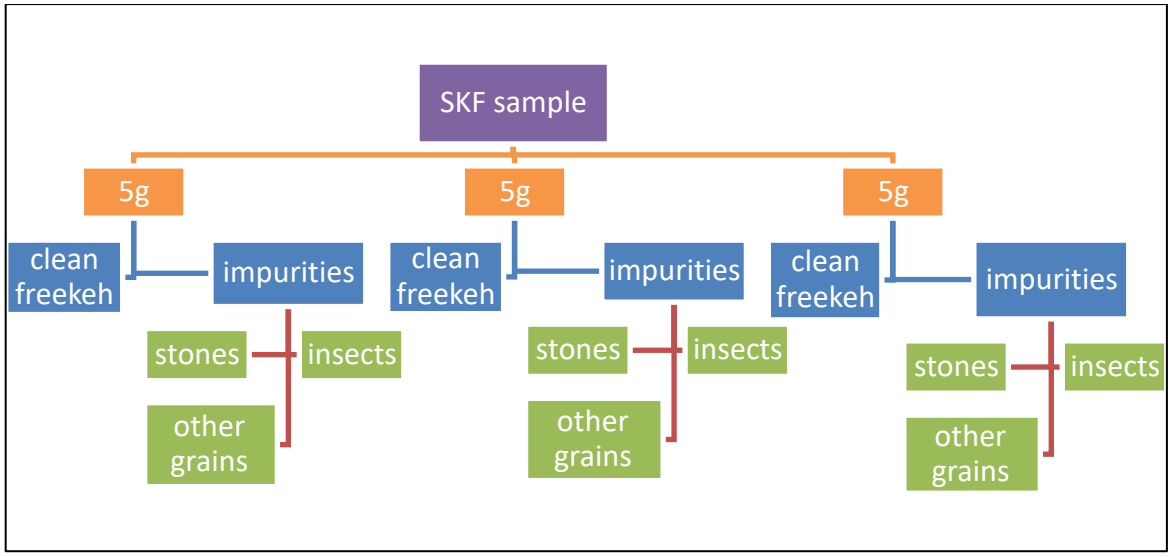


Figure 3.2 Flow diagram for impurities test for one main sample.

3.5 Microbiological analysis

A 10 g of completely unground freekeh samples are took with 90 ml of sterilized peptone water and placed into the stomacher for 1 min to extract and wash intact microbes into solution. Three dilutions (10^{-1} to 10^{-3}) using spreading technique of cultivation are used to bacteria, mold and yeast growth following Food and Drug Administration FDA approved method. Microbiological growth calculated in triplicate for each dilution of each main sample, and the mean value recorded.

3.5.1 Total plate count

Plate Count Agar (PCA) served as the microbiological growth medium for evaluating the total viable bacterial growth. The incubation conditions for total bacteria included a temperature of 37°C with a duration of 24-48 hours.

3.5.2 Yeast and mold

Potato Dextrose Agar (PDA) utilized as the microbiological growth medium to assess the total viable yeast and mold growth. The incubation conditions for these microorganisms involved room temperature, with a duration of 5-7 days.

3.6 Evaluation of consumer preferences and purchase behavior using online survey

The data used in this research are drawn from responses of online survey by using structured questionnaire filled by 511 consumers from different geographical regions of north Palestine during summer 2023. The questionnaire was designed to analyze consumer preferences and purchase behavior toward locally produced freekeh (green wheat). It was developed after to explore literature review on freekeh. Respondents were asked questions concerning different aspects, grouped in three different sections.

The questions in the first section of the questionnaire contained questions on socio-demographic characteristics of respondents (e.g., sex, age, marital status, education level, and income). These questions were included to determine if these characteristics influenced their attitudes toward locally freekeh products. The second section consisted of questions related to consumers' purchase behavior toward freekeh. Based on the most recent literature, respondents were asked about:

a. Their shopping habits toward local foods (e.g., buying behavior, frequency of purchasing, place of purchase)
b. Attributes influencing consumer purchase behavior of freekeh

The last section of the questionnaire contained questions on consumer awareness and attitudes toward local freekeh.

3.7 Statistical analysis

The data was tested using the SPSS (Statistical Package for Social Sciences) version 21.0 program, Comparing the arithmetic mean values for both (laboratory tests and questionnaire) to ensure the presence of significant differences and statistical significance at the confidence level of 0.05

The differences in quality traits (chemical, physical, and microbiological properties) between different companies have been evaluated by ANOVA. Means were separated using Tukey's test with P-value ≤ 0.05 considered as significant.

The structured questionnaire underwent rigorous assessments to ensure both content validity and reliability. Regarding validity, the questionnaire was examined by three specialists who verified its elements and assessed their

suitability for measuring the notion that the study aims to test. These were done to guarantee content authenticity as well as face validity. The reliability of the questionnaire was assessed using Cronbach alpha, with reliability values of 0.70 or above regarded accepted. 25 questionnaires were gathered as a pilot test to measure reliability, and the results indicated that the Cronbach alpha result was 0.84. SPSS was used to analyze the data. The subsequent analyses were carried out including analysis: Pearson correlations and descriptive statistics (such as means, frequencies, and standard deviations) were acquired when needed. Analysis of Variance (ANOVA) were applied to evaluate the effect of geographical conditions on consumer preference and purchase behavior.

Chapter Four: Results and Discussion

4.1 Chemical analysis

The data was analyzed using the (SPSS) program to comparing the actual and labelled mean values of proximate analysis to ensure compliance between labelled and actual values and if these differences between two values are reasonable in respect to Palestinian standards.

Table (4.1) illustrates the actual chemical analysis of freekeh products (including moisture, fat, protein, fiber, and ash content) in comparison to labelled values. Our study showed that not all companies declared the nutritional value where some values of proximate chemical properties can be extracted. The most frequently labelled values were protein and fat contents. The products from seven companies out of nine mentioned content of protein and fat. On other hand, only products from two companies (LZ and SNN) out of nine mentioned ash and moisture content on product labels. Regarding fiber content, five companies out of nine mentioned it on label.

Our findings showed that the actual moisture content in freekeh products from different companies varied from 8.41 to 9.77% but without significant differences between companies. If the actual moisture content compared to labeled value, there was no significant differences. All values of moisture content for all products were in compliance to Palestinian standards (moisture content should be below 13%) (PSI, 2019). The results of moisture content were in agreement with previous studies (Al-Mahasneh & Rababah, 2007; Carsanba, 2017). In this context, moisture content in different firik products in turkey found that its ranged from 10 to 11%.

In respect to actual fat content, the measured values were varied from 2.54 to 5.13% in which there were a big difference in some companies between measured and labelled values (ranged from 0.78 to 3.54%). Products from company SNN had significantly the highest value compared to other companies. Moreover, products from company NKH showed significantly the lowest fat content when compared with other companies. Overall, the obtained results of fat content were in agreement with previous studies (Abbadi, 2015; M. Bayram, 2008). On other hand, it was found that fat content in firik products was ranged from 1.56% to 1.90% (Carsanba et al., 2017) which disagreed with our obtained results. This confusion might be due to the fact that the amount of fat content gradually decreased with the ripening process in wheat. In

which harvesting freekeh on an early stage result in higher fat content than harvesting it on late stage.(Pekkirişci, 2023)

Ash contents vary significantly between different products from different commercial sources. In particular, the measured ash content varied from 1.5 to 2.15% but at the same time was far from labelled value (6.22%). In a previous study, different freekeh products had a range of ash content 1.61-2.01% (Carsanba, 2017). Company MN exhibited significantly the highest ash content and company SKF showed significantly the lowest ash content compared to remaining companies. The big difference between measured and labelled values of ash may be attributed to bias in the labelled value because the variance in measured values is very low. Moreover, in a previous study, ash content range for freekeh products was 1.75 – 2.57% (Bayram, 2008) which also near the obtained results. In addition, all ash content results follow the Palestinian standards (ash content should be below 2.5%). (PSI, 2019)

There were noticeable differences in the mean values of measure fiber content (FC) ranging from 4.40 to 12.43%. Samples which were drawn from company LZ had significantly the highest fiber content (12.43%, $p<0.05$) compared to other samples from all remaining companies. On contrary, samples from company SNN exhibited significantly the lowest value (4.4%, $p<0.05$) if compared to other companies. There was a big variance in fiber content between measured values and labelled value. For example, company SNN, ΔFC between measured and labelled values was 9.4%. (Aani, 2008; M. Bayram, 2008) showed in their studies that fiber content range 3.00-4.66% which is far from the obtained results. This variation may due to loss of bran or part of it, where most of fiber locate, through manufacturing process.

There were significant differences in the mean values for measured protein content between different products from different companies. There was wide variation in protein content between products ranging from 9.65 to 16.88. Company AQ exhibited significantly the highest protein content (16.88%, $p<0.05$) compared to other products. On the contrary, products from company SKC had significantly the lowest protein content (9.65%, $p<0.05$) compared to other products. In general, our findings were in agreement with previous studies (Bayram, 2008; Ozkaya, 1999; Pekkirişci, 2023) where the values of protein contents in freekeh products ranged from 8.9 to 12.2% (Carsanba et al., 2017).

In general, there was an agreement between measured value and labelled value of protein some companies had such as SNN, SHQ, NKH, and LZ where the difference was less than 1%. On other hand, there was high variation between measured and labelled values of protein in products of company KS and SKF and this may be attributed due to mislabeling because measured values were in agreement with previous studies.(Bayram, 2008; Carsanba, 2017; Ozkaya, 1999)

Table 4.1: Chemical analysis of the study sample.

Product	Moisture analysis %		Ash content %		Crude fat content %		Crude fiber content %		Protein content %	
	Measured	NV	Measured	NV	Measured	NV	Measured	NV	Measured	NV
	Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD	
AQ	9.26 ± 0.32	NA	1.56 ± 0.03^{ab}	NA	3.79 ± 0.11^{bc}	NA	6.50 ± 0.41^{bc}	NA	16.88 ± 1.01^{a}	NA
KS	8.97 ± 0.50	NA	2.09 ± 0.06^{ab}	NA	3.22 ± 0.12^{bcd}	1.77	7.84 ± 0.29^{b}	4.42	14.61 ± 1.14^{a}	3.54
LZ	9.75 ± 0.11	10	1.77 ± 0.03^{ab}	6.22	4.13 ± 0.19^{ab}	0.78	12.43± 1.80^{a}	14	15.70 ± 0.97^{a}	15
MN	8.46 ± 1.76	NA	2.15 ±0.13^{a}	NA	3.92 ± 0.23^{ab}	NA	7.53 ± 0.14^{b}	NA	11.51 ± 0.72^{b}	NA
NKH	8.41 ± 0.48	NA	2.05 ± 0.32^{ab}	NA	2.53 ± 0.16^{d}	2.7	6.97 ± 0.64^{b}	16.5	11.99 ± 0.33^{b}	12.6
SHQ	9.38 ± 0.33	NA	1.54 ± 0.19^{b}	NA	3.43 ± 0.09^{bcd}	2.5	5.82 ± 0.51^{bc}	10	15.30 ± 1.14^{a}	15
SKC	8.68 ± 0.50	NA	1.86 ±0.11^{ab}	NA	2.54 ± 0.11^{cd}	3.57	6.99 ± 0.65^{b}	NA	9.65 ± 1.20^{b}	14.29
SKF	9.73 ± 0.18	NA	1.50 ± 0.47^{b}	NA	4.42 ± 0.84^{ab}	3.57	7.76 ± 1.01^{b}	NA	10.12 ± 0.65^{b}	14.29
SNN	9.77 ± 0.22	10	2.02 ± 0.04^{ab}	6.22	5.13 ± 0.93^{a}	0.78	4.40 ± 0.76^{c}	14	10.59 ± 0.54^{b}	15
P value	0.11		<0.05		<0.05		<0.05		<0.05	

[1]NV: Nutritional Value

[2]NA: Not available

[3]SD: Standard deviation

Different superscript letters in the same column are different statistically ($p<0.05$)

Table 4.2: Mineral Analysis.

Product	Mineral			
	mg Na / 100g sample		mg K / 100g sample	
	Measured Mean ± SD	NV	Measured Mean ± SD	NV
AQ	1.37±0.35	NA	453.30 ± 19.05	NA
KS	1.91 ± 0.54	720	476.61 ± 115.90	NA
LZ	1.73 ±0.31	NA	448.94± 91.21	NA
MN	2.32±0.062	NA	464.62 ± 36.04	NA
NKH	1.83±0.39	6	591.09 ± 313.88	NA
SHQ	1.02±0.012	NA	295.49 ± 75.49	NA
SKC	1.74±0.35	NA	456.38 ± 69.38	NA
SKF	1.34±0.88	NA	355.92 ± 69.81	NA
SNN	1.95±0.71	NA	376.73± 26.55	NA
P value	0.65		0.26	

[1]NV: Nutritional Value

[2]NA: Not available

[3]SD: Standard deviation

Table (4.2) presents the measured mineral content of freekeh products in comparison to labelled values. Almost all companies did not declare Na content on the nutritional value except for NKH and KS. On other hand, for K content none of them mentioned it.

Our results indicated a range of actual Na content in freekeh products from 1.02 to 2.32 Na mg/100g sample. However, there were no significant differences observed between the companies in this regard. Products from MN had the highest mean value compared to other companies. The lowest mean value was for SHQ company. In contrary, measured values notably differed from the labeled one. The labelled value for KS company reach around seven hundred time more than the

measured. This variation could be due to mislabeling, given that the measured values aligned with findings from earlier studies (Ozkaya, 1999).

The mean values for measured potassium (K) content did not indicate significant differences among the various products from different companies. Although there was a slight variation between companies actual content, as the highest value for K content was 591.09 mg/100 g sample for NKH company, and the lowest was 295.49 mg/100g sample for SHQ. Overall, our findings concurred with prior studies, indicating that K contents in freekeh products typically ranged between 370 – 458 K mg/100 g sample.(Ozkaya, 1999)

4.2 Physical analysis

Three samples were taken from the main sample of each company, and an analysis of variance (ANOVA) test was conducted using the SPSS program. The mean values for both color and impurities were calculated. Subsequently, a statistical analysis was performed to confirm the presence of significant differences and ensure statistical significance at a confidence level of 0.05.

Table 4.3: Physical analysis (color measurement).

Product	**Color**		
	L	**a**	**B**
	Mean ± SD[1]	**Mean ± SD**	**Mean ± SD**
AQ	49.012 ± 0.82^{c}	0.67 ± 0.46^{bc}	14.02 ± 1.34
KS	55.91 ± 1.71^{a}	2.35 ± 0.14^{a}	17.69 ± 0.15
LZ	50.84 ± 2.09^{bc}	0.98 ± 0.16^{bc}	15.96 ± 1.39
MN	50.70 ± 0.95^{bc}	0.30 ± 0.27^{c}	15.57 ± 0.82
NKH	49.61 ± 1.20^{bc}	-1.07 ± 0.62^{d}	14.48 ± 0.83
SHQ	48.09 ± 0.73^{c}	1.05 ± 0.18^{bc}	15.19 ± 1.20
SKC	49.36 ± 1.37^{bc}	1.43 ± 0.35^{abc}	14.25 ± 0.57
SKF	52.68 ± 0.99^{ab}	1.48 ± 0.73^{ab}	16.47±0.84
SNN	47.58 ± 0.86^{c}	0.55 ± 0.30^{bc}	14.57 ± 1.30
P value	<0.05	<0.05	0.47

[1]SD: Standard deviation

Different superscript letters in the same column are different statistically ($p<0.05$)

Table (4.3) shows the color L*,a*,b* values for freekeh products from different companies. There is a significant difference between companies for L* value. SNN company had the darkest product which is the lowest mean value (47.58, $p<0.05$). conversely, KS company had the brightest freekeh product that had the highest mean value (55.91, $p<0.05$). There was no agreement between the present study and the previous findings for L* values. (Yang, 2012) found that the L* value for immature wheat is around 37.4 and the L* value for the mature wheat is around 45.4 . However, (Yıldırım, 2020) agreed with our obtained result as they rank 53.50 as the best L* value.

Significant variations were observed in the mean values of measured a* value, ranging from -1.07 to 2.35. Notably, samples obtained from company KS displayed the highest a* value (2.35, $p<0.05$), significantly different than those from all other companies. On contrary, samples from company NKH showcased the lowest value (-1.07, $p<0.05$) in comparison with the other companies. It is an expected result that the a* value of the freekeh samples is low, indicating a green color, due to the fact that freekeh is harvested and produced before maturity.

Our findings indicated a range of b* value results in freekeh products across different companies, ranging from 14.02 to 16.47. Nevertheless, no notable differences in these values were observed between the assessed companies. Moreover, they are compliance with the previous findings. (Ozberk, 2023)

Taking everything into consideration, it could be reach upon that freekeh products used for our study could be harvested on an early stage of maturity, due to the increase of L* value and positive a* value for most of the results, making them not far from mature wheat values.(Yang, 2012)

Impurities existence plays an important role in consumers purchasing decision, in which there was no significant difference through all demographic characteristics in evaluating the importance of "Free from impurities" attribute, where the all answers were between 8-9 in a scale from 1-10 (where 1 is less important and 10 is very important). Based on Palestinian standards, all freekeh products goes with its compositional standard for stones, where all the results are below 0.5% and had no significant difference as shown on table 4.4

Other impurities such as stems, straws and other seeds had a significant difference between freekeh products. NKH had zero result which make it the lowest value. Otherwise, MN company had the highest value (2.05%, $p<0.05$) making it not approved from Palestinian Standard Institute (PSI) and had the least chance in Palestinian market.

Table 4.4: Physical Analysis (Impurities).

Product	**Impurities**	
	Stones %	**Other impurities %**
	Mean ± SD	**Mean ± SD**
AQ	0.00	0.75 ± 0.530^{ab}
KS	0.00	0.21 ± 0.22^{ab}
LZ	0.00	0.59 ± 0.48^{ab}
MN	0.38 ± 0.53	2.05 ± 1.44^{a}
NKH	0.02 ± 0.03	0.00^{b}
SHQ	0.00	1.01 ± 0.36^{ab}
SKC	0.00	1.26 ± 0.98^{ab}
SKF	0.00	0.04 ± 0.06^{b}
SNN	0.00	1.07 ± 0.36^{ab}
P value	0.23	<0.05

[1]SD: Standard deviation

Different superscript letters in the same column are different statistically ($p<0.05$)

4.3 Microbiological analysis

Microbiological analysis was conducted to assess the growth of microorganisms (total aerobic count and yeast & mold) in three replicates (three dilutions, 10^{-1} to 10^{-3}) for each sample of the non-ground wheat product of each of the nine companies. An analysis of variance (ANOVA) test was performed using the SPSS program, and the mean values (average growth) were calculated to ensure statistical significance at a confidence level of 0.05.

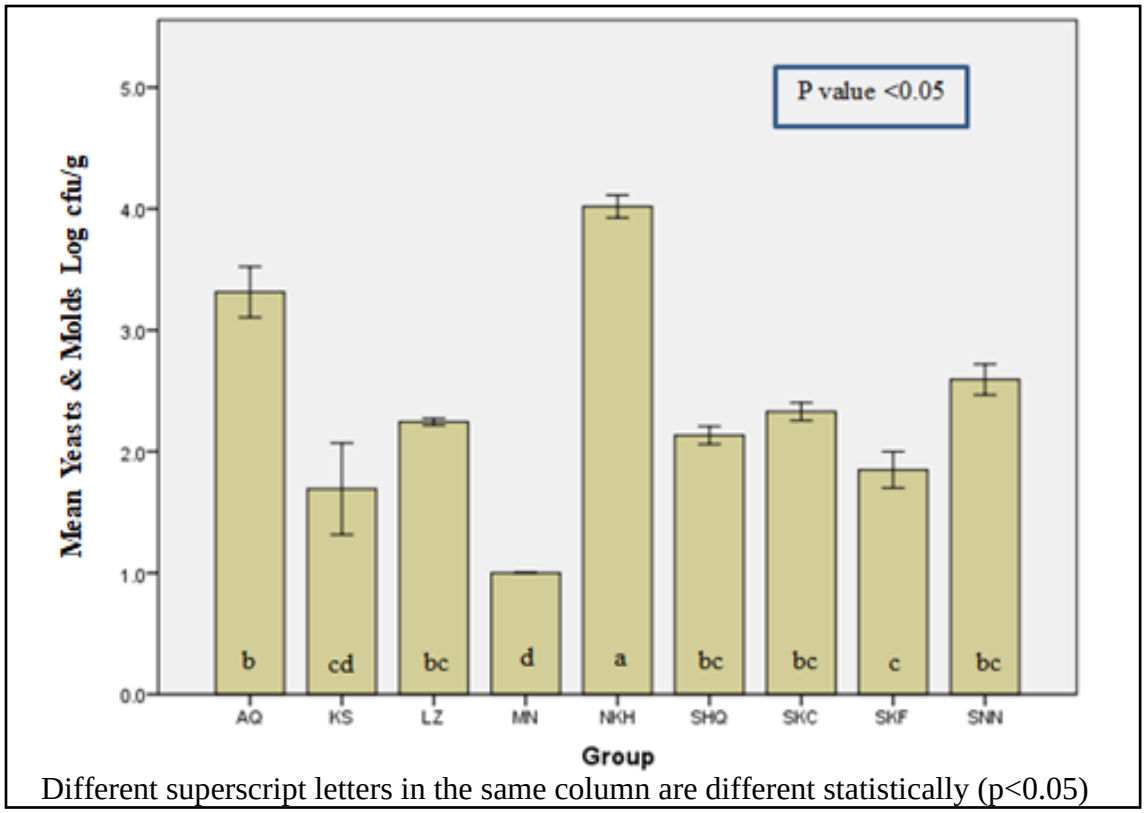


Figure 4.1: Statistical analysis of fungal growth (mold and yeast).

Yeast and molds count of freekeh products were showed in figure 4.1. All samples had lower yeast and molds count than the accepted limit (10^2 to 10^4 cfu/g) that approved by Food and Drugs Administration (FDA, 2013). Obtained freekeh results had a significant difference between products. NKH company induced the highest yeast and mold content, while MN had the lowest.

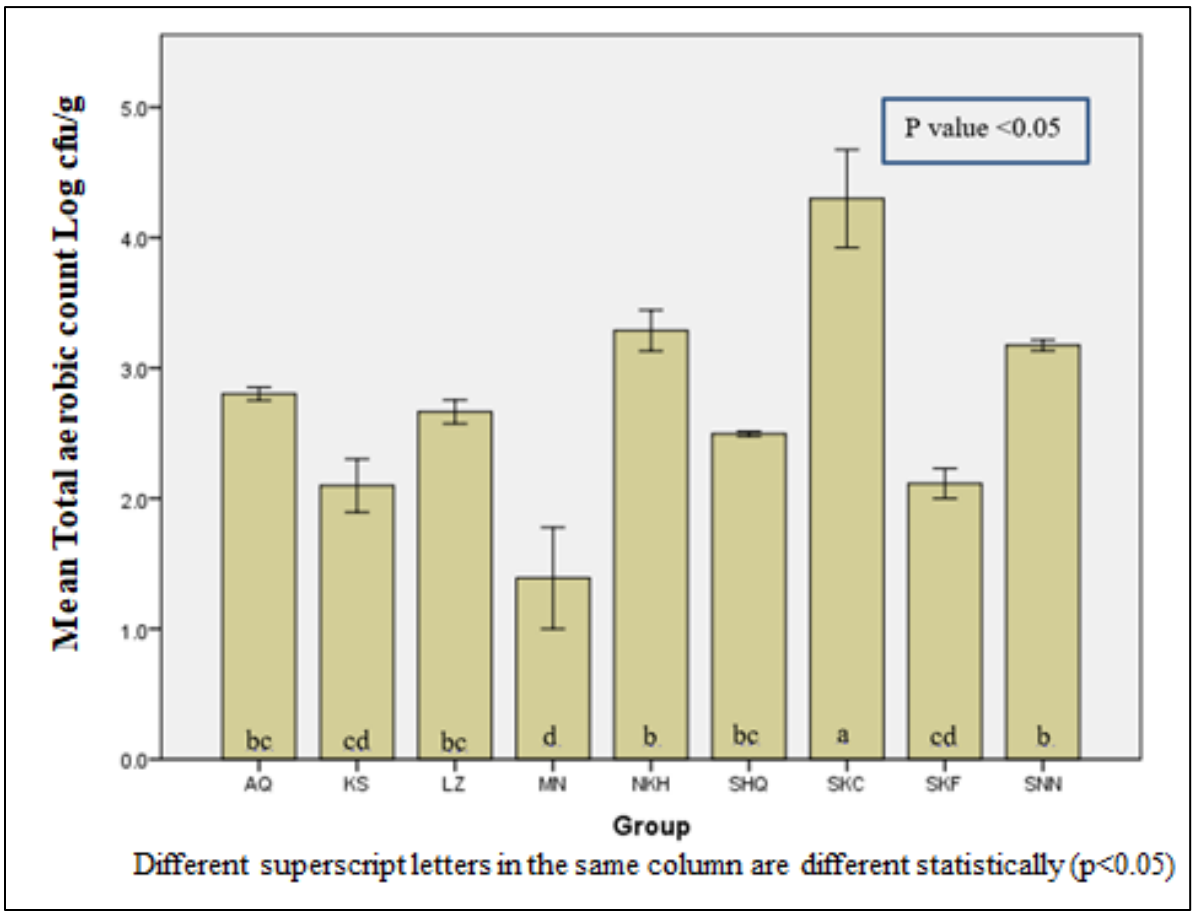


Figure 4.2: Statistical analysis of bacterial growth.

The total bacterial count for all freekeh samples is detailed in figure 4.2. Each sample counts followed the limitation threshold approved by the FDA for wheat (FDA, 2013).

There were significant differences in the mean values for total aerobic count between different products from different companies. Company SKC exhibited significantly the highest total aerobic count (~4 cfu/g, $p<0.05$) compared to other products. On contrary, products from company MN had significantly the lowest total aerobic count (~1.5 cfu/g $p<0.05$) compared to other products. In general, our findings were in agreement with previous study conducted in Iraq where the values of total aerobic count in freekeh products ranged from <100 to 10^5 cfu/g.(AlHendi, 2018)

4.4 Questionnaire analysis

A questionnaire was prepared to collect information about consumer preferences and purchasing behavior towards locally produced freekeh (green wheat). It comprises three sections:

1. Demographic information: includes social and demographic details of the study sample, such as (gender, age, educational level, marital status, place of residence, and income in Shekels).
2. Purchase behavior and characteristics: delves into several aspects exploring purchasing behavior and the characteristics influencing consumers' freekeh buying decisions.
3. Consumer awareness and behavior: involves a series of questions about consciousness and conduct of consumers towards locally produced freekeh.

It was distributed to a random sample of 511 individuals through an online survey on Google form in Palestine. Statistical analysis using SPSS was employed to analyze the questionnaire data, aligning with the research content and hypotheses used in the study, the graphical representations illustrate the data inputs collected through the questionnaire.

4.4.1 Descriptive analysis of the demographic characteristics of the study sample

Figure 4.3 gender distribution of the study samples that included 511 respondents. Our study showed that the percentage of females was 71.8%, and males was 28.2%, it is noticeable that the percentage of females is significantly higher than that of males.

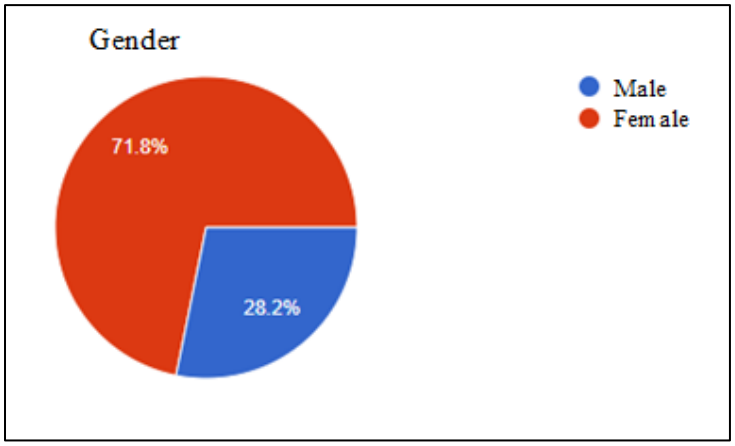


Figure 4.3: Demographic Characteristics Variable (Gender).

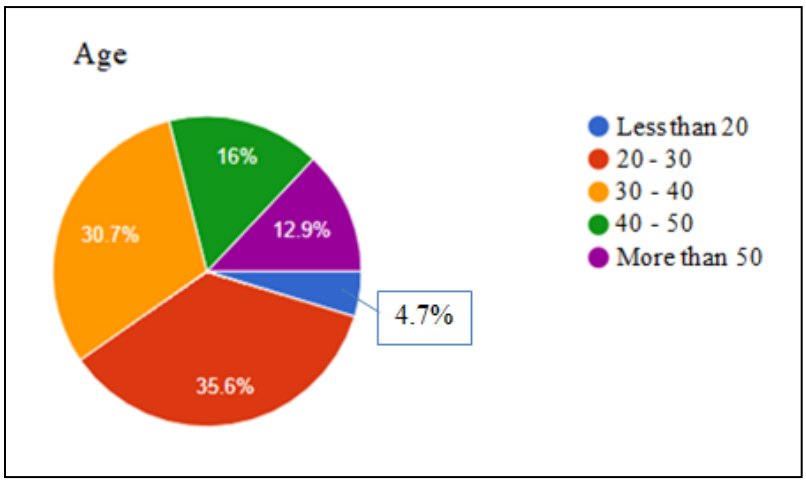


Figure 4.4: Demographic Characteristics Variable (Age).

Figure (4.4) illustrates the distribution of the questionnaire respondents among different age groups. The highest percentage was for the age group of 20-30 years, with a slight difference from the 30-40 years age group. This could be due to the fact that Palestinian population is a youth population, also as the survey was distributed on internet, this age groups reach it easily. On other hand, the lowest percentage was for age group less than 20 years whose still dependent, mostly do not contribute in purchasing process.

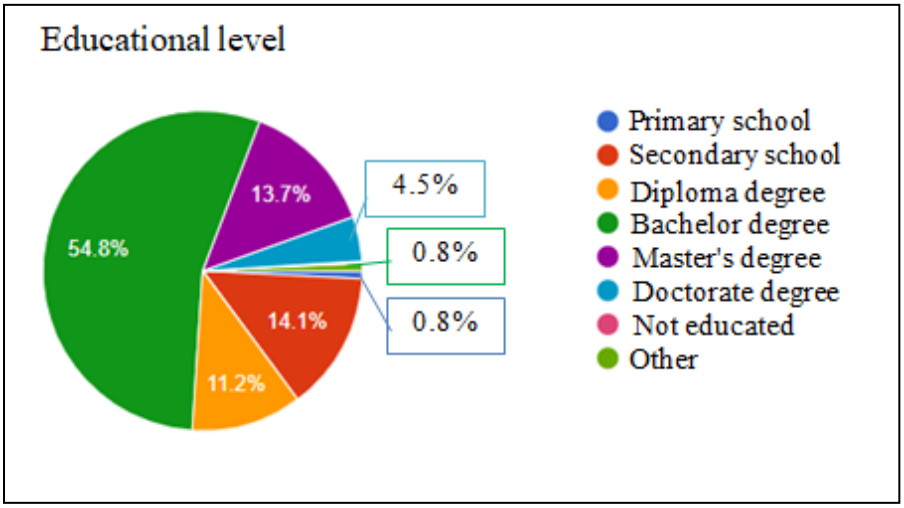


Figure 4.5: Demographic Characteristics Variable (Educational level).

Educational level for the respondents across all categories displayed in figure 4.5. More than half of respondents 54.8% was for bachelor's degree, making a significant different between this category and the rest of categories. Followed with Secondary school, Master's degree and Diploma

degree where the difference between these three categories was only around 2%. The percentage of educated participants was notably high.

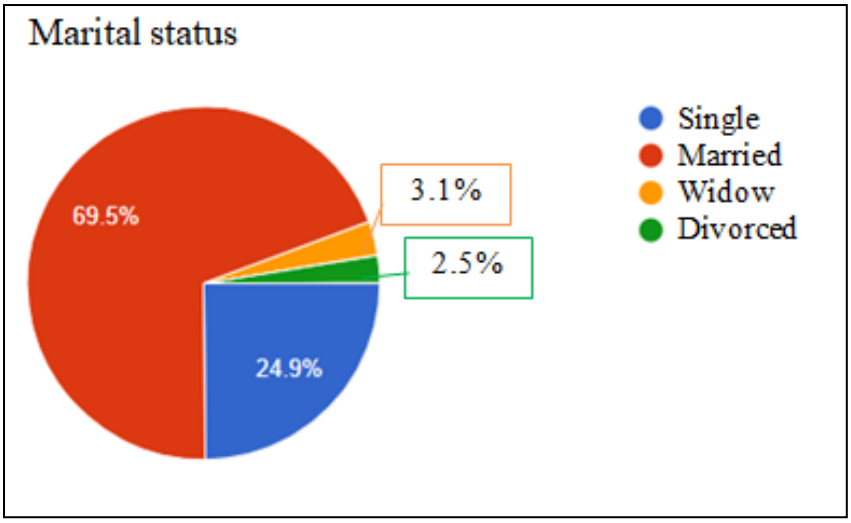


Figure 4.6: Demographic Characteristics Variable (marital status).

Figure (4.6) represents the marital status. Our study showed that the percentage of married respondents were 69.5%, and for single respondents were 24.9%, it is noticeable that the percentage of married is significantly higher than other marital status. That is expected as the Palestinian people tends to settle and start a family.

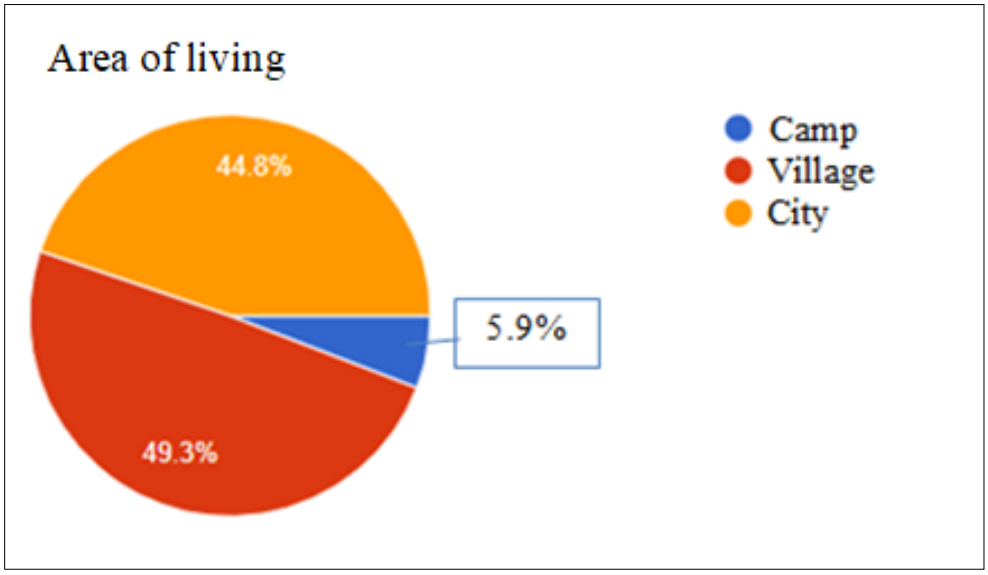


Figure 0.7: Demographic Characteristics Variable (area of living).

Figure (4.7) display the area of living for the questionnaire respondents. The highest percentage lives in villages, followed by cities with slight difference, where camps had the lowest percentage with a big difference in percentages of respondents lives in cities and villages.

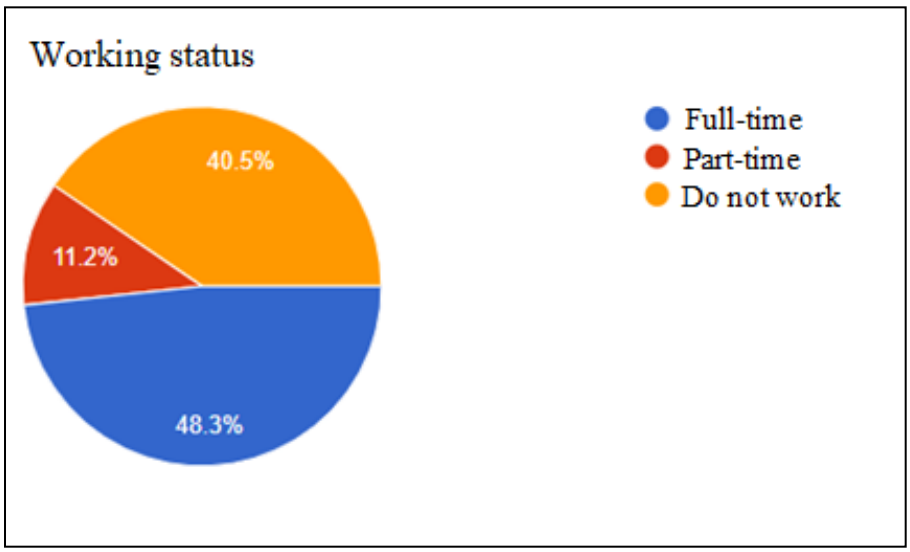


Figure 04.8: Demographic Characteristics Variable (working status).

Due to the fact that Palestinian women acquire only 19% of workforce (PCBS, 2022), and on our study 71.8% of respondents were females, "Do not work" had a high percentage (40.5%). However the highest percentage was for the full-time work. Part-time word had significantly the lowest percentage.

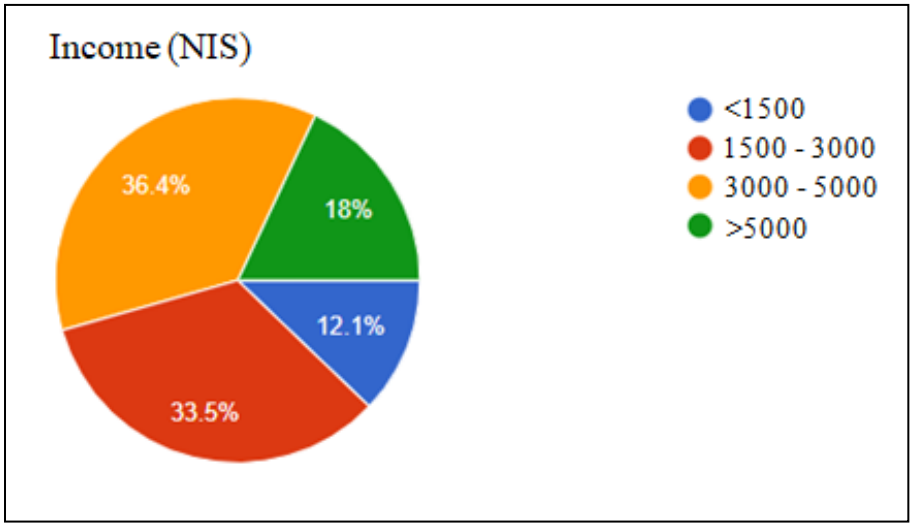


Figure 4.9: Demographic Characteristics Variable (income (NIS)).

Figure (4.9) displays the income in shekels for surveyed individuals. Most of the participants had an income between 3000-5000 NIS, followed with a slight difference for participants who had an income between 1500-3000 NIS. Less than 1500 NIS had the lowest percentage in comparison with other categories.

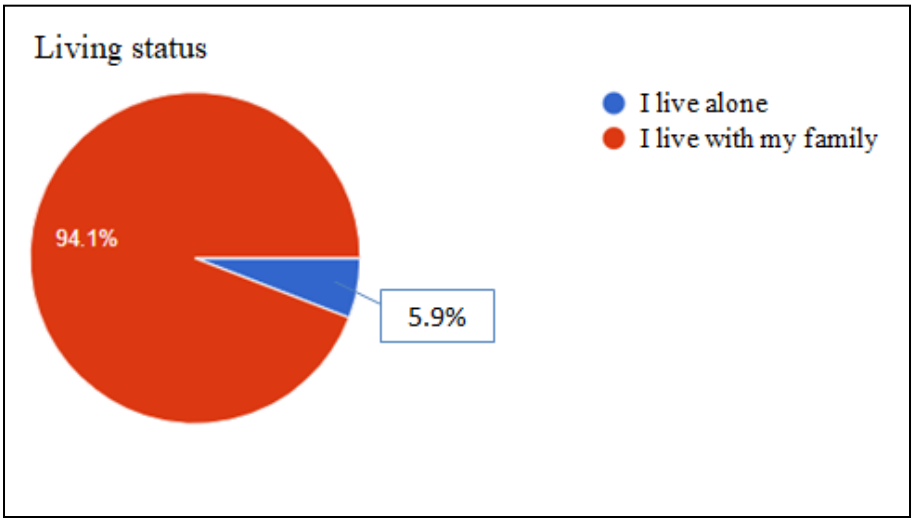


Figure 4.10: Demographic Characteristics Variable (living status).

Figure (4.10) shows that the vast majority of individuals in the sample live with their families, which is an indicator of the familial nature of the living situation. Participants who lives alone acquire only 5.9% of the whole sample.

4.4.2 The Descriptive Analysis (Purchase Behavior) of the Study Sample

In this section, the data is analyzed to understand the Purchasing behavior of freekeh product by answering a set of questions. The analysis is presented through (pie-chart) graphical representations.

Figure 4.11: Analysis Question 1 Purchasing behavior.

It is noticeable in figure 4.11 that the percentage of surveyed participants who do more than 50% of shopping significantly higher than the other options, it is acquire almost the half of individuals (49.9%). However, those who rarely do the shopping process had the lowest percentage (19.2%).

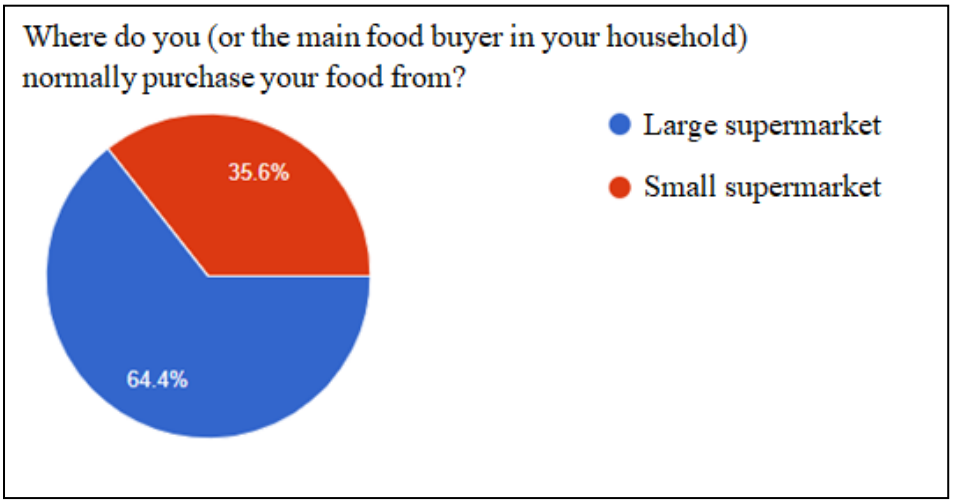


Figure 4.12: Analysis Question 2 Purchasing behavior.

Figure (4.12) displays that the highest percentage for the response to the question "Where do you usually shop for household items?" was for "Large stores" at 64.4%, while 35.6% shop from small stores. There is a significant variation, with the majority purchasing from large stores which mostly sold branded freekeh products.

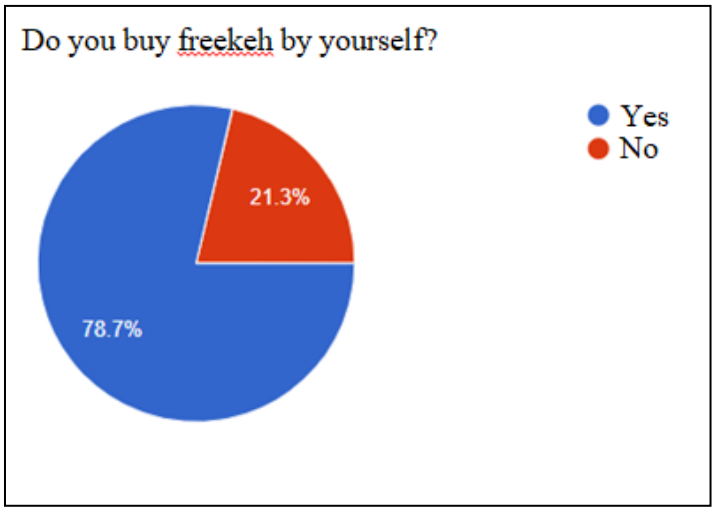


Figure 4.13: Analysis Question 3 Purchasing behavior.

Figure 4.13 present answers percentage of the question "Do you buy the freekeh product yourself?". It is noticed that participants who buy freekeh products by themselves had the highest percentage (78.7%). However, the participants who answered "No" had only 21.3%.

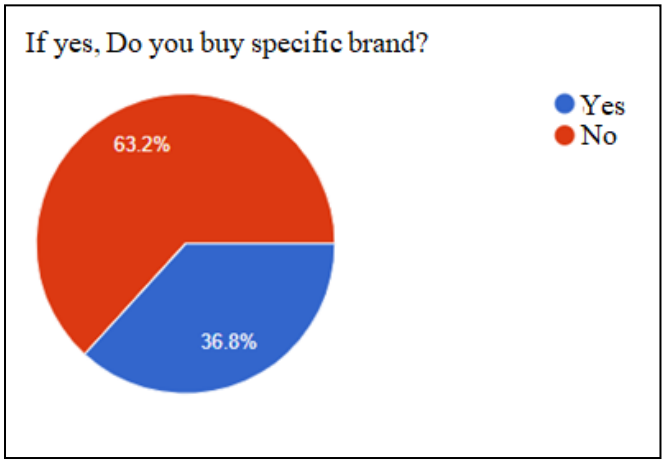


Figure 4.14: Analysis Question 4 Purchasing behavior.

If the response to the previous question in figure (4.13) was "Yes, I buy the freekeh product myself," figure 4.14 displays the response to question "Do you buy a specific brand?". The majority (63.2%) answered "No" to buying a specific brand, This shows the importance of product quality in the purchasing decision-making process. On other hand, 36.8% of those who answered "Yes" buy a specific brand. There is a significant variation, with most not buying a specific brand. This suggests that interest may be more directed toward general product characteristics rather than loyalty to a specific brand.

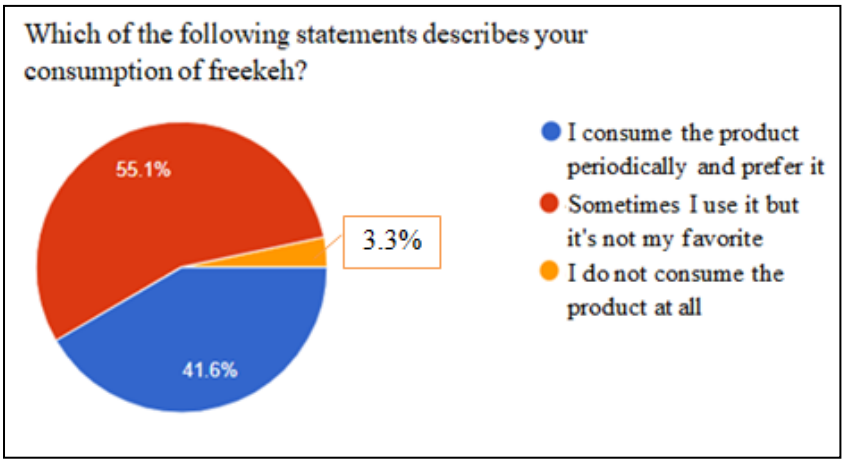


Figure 4.15: Analysis of Question 5 Purchasing behavior.

Figure (4.15) present those respondents who do not consume freekeh products had significantly the lowest percentage (3.3%). On contrary, individuals who sometimes consume freekeh product but it's not their favorite had the highest percentage (55.1%). However, those who prefer and

consume freekeh product had a slight difference with the later acquiring 41.6%. In conclusion freekeh is not the preferred product for more than half of the individuals, but there is a portion that prefers the product and consumes it regularly. This shows the presence of a group of consumers who prefer diversity in their consumption, and also that the percentage of freekeh consumption is average.

4.5 Photos analysis

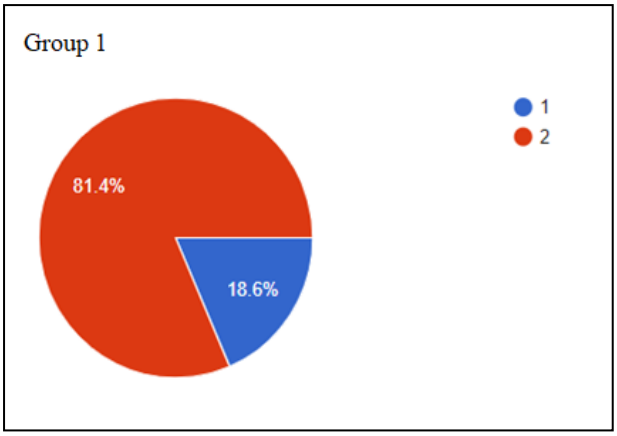
A set of images were captured and presented to the study participants to answer which image they prefer to purchase and the reason for choosing that image. In which through each group all factors are constant only one targeted factor was changed. The images were divided into three groups as follows:-

1. Group (1): constant factors are grading degree and color, changed factor is existence of impurities or not.
2. Group (2): constant factors are color and impurities, changed factor is grading degree.
3. Group (3): constant factors are impurities and grading degree, changed factor is color.

Group 1 (impurities)

(1)
(with impurities)

(2)
(without impurities)



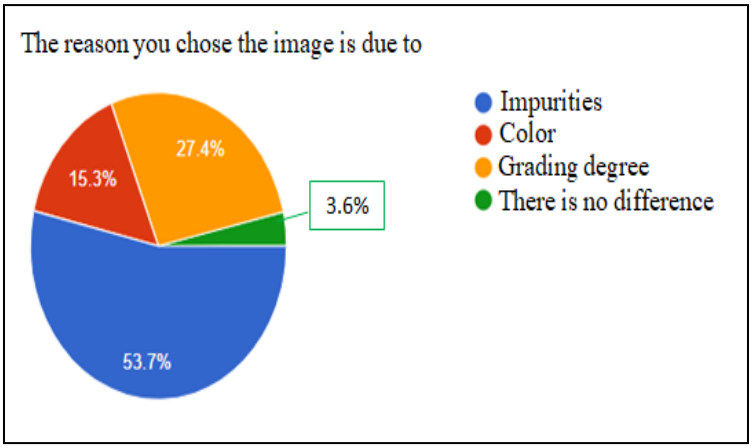


Figure 0.16 Analysis of Question 1 Image (group 1).

It is noticeable on figure 4.16 that the percentage of participants who chose Image 2 (without impurities) is noticeably higher than that Image 1 (with impurities). The reason for choosing Image 2 was attributed to impurity factor, and this was obvious for participants as the major percentage (53.7%) answered that they would buy the product from Image 2 due to impurity factor.

This high percentage of choosing the impurities factor shows that existence of impurities affect purchasing decision significantly. Consequently, NKH company could have the higher selling opportunity as it had the lowest mean content of impurities based on our study findings.

Group 2*(Refined or not)*

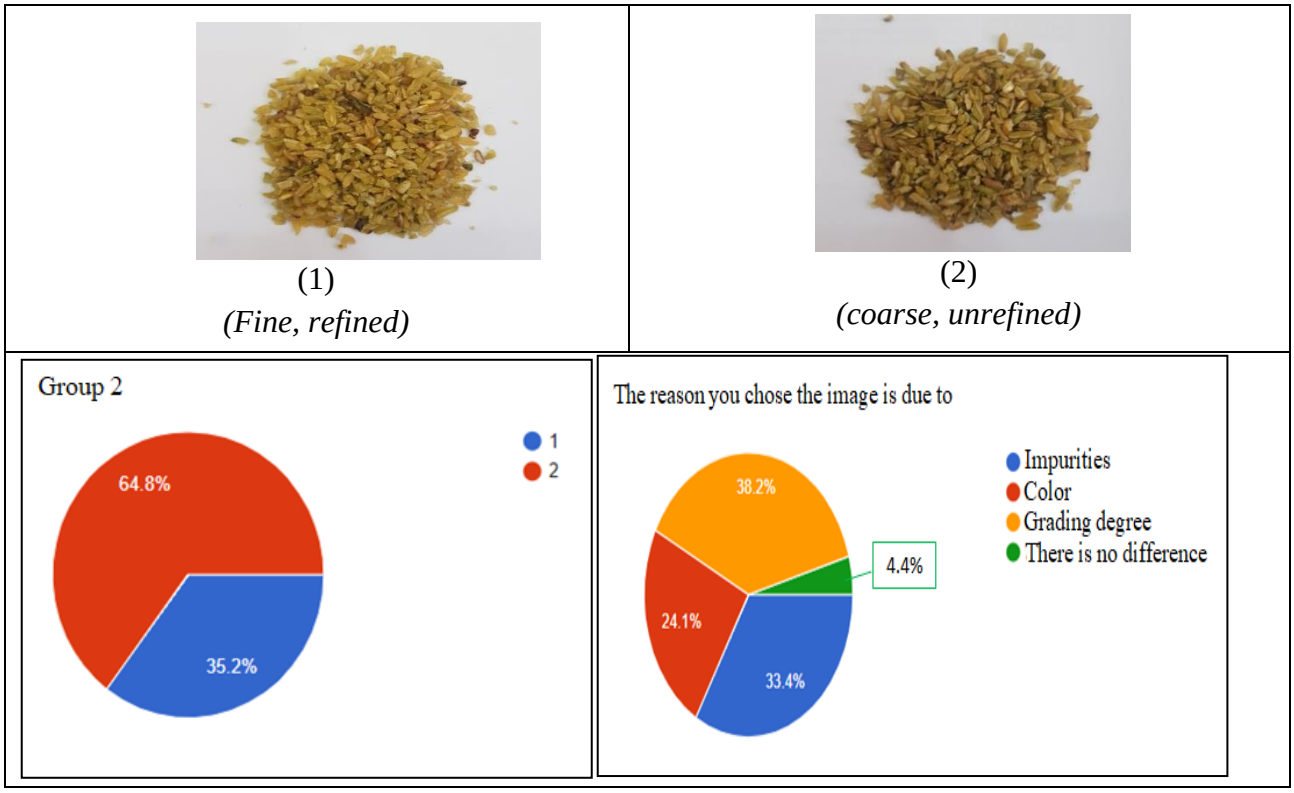


Figure 4.17: Analysis of Question 2 Image (group2).

As shown in Figure 4.17, 64.8% chose Image 2 (unrefined), compared to 35.2% who chose Image 1 (refined). There was a significant different between the two options. On the next question that asked about the reason of choosing, the results were diversified and close to each other for three factors: grading factor (38.2%), impurities (33.4%) and color (24.1%). However, the results were close maybe due to the fact that consumers do not differentiate between the degrees of grading. Also, as shown on Figure 4.21 the last question of the questionnaire (Which type of Freekeh do you consume?), 32.1% answered (any type, it does not matter) which indicate that even if they differentiate it does not affects the purchasing decision highly.

Group 3 (color)

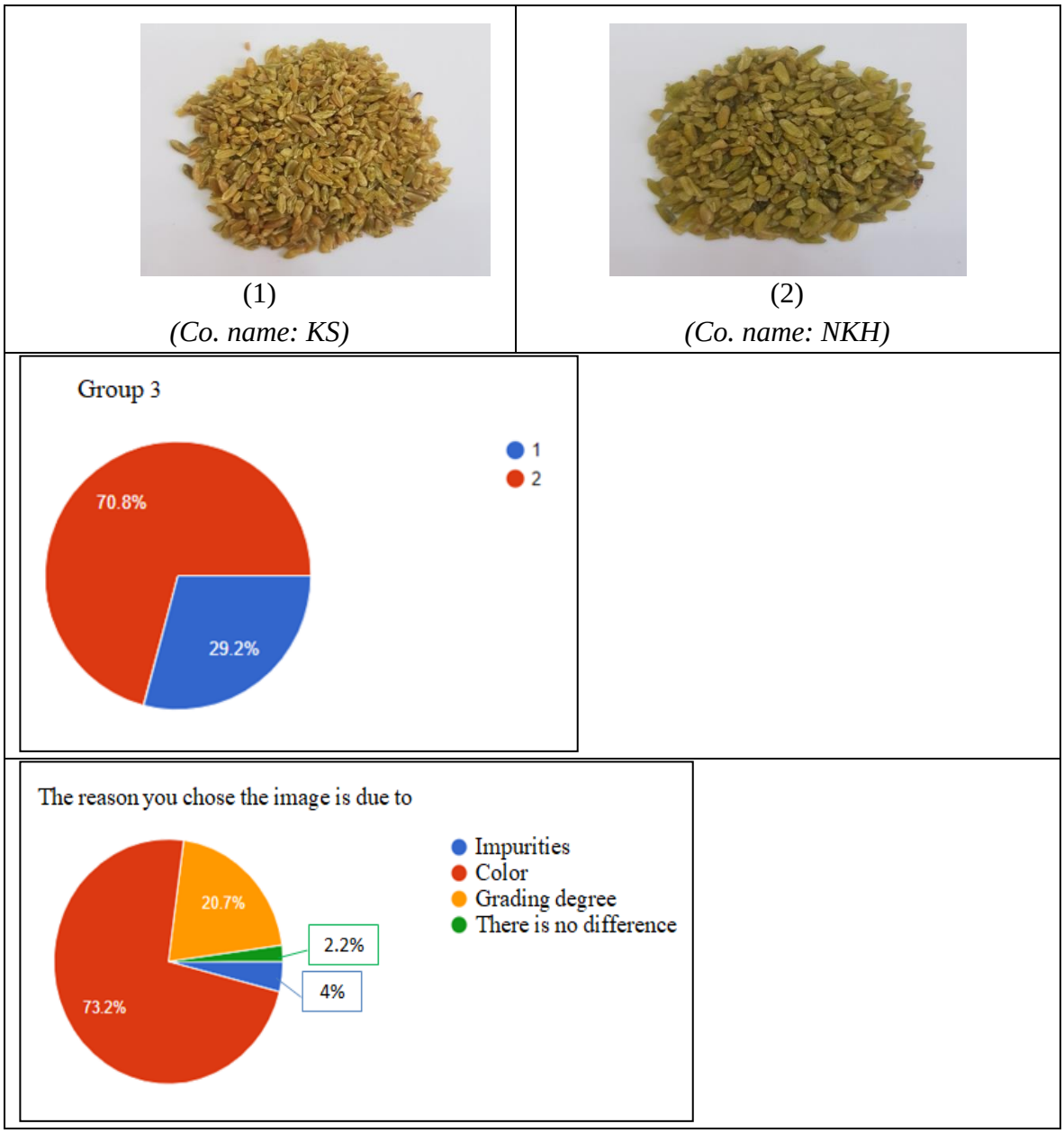


Figure 4.18: Analysis of Question 3 Image (group 3).

There is a significant variation between the participants choosing image 1 and participants choosing image 2. The highest percentage was for image 2 with 70.8% which is for NKH company. On other hand, image 1 which is for KS company, had only 29.2% responses. It is noticeable that the reason for most respondents was color, which had the highest percentage (73.2%) of the next question (the reason of choosing the image).

Based on previous studies, NKH pose the best color of freekeh product, as shown in table 4.3 , L* value is lower than the other freekeh product and a* value is the only negative value, indicating that freekeh product had been harvested on time. (Ozberk, 2023; Yang, 2012) Conversely, KS

company had the highest values for both L* and a* value indicating that their freekeh product harvested on a late time which make its results near mature wheat.

4.6 Consumer awareness and attitudes toward local freekeh

Analysis of the third section of the questionnaire on consumer awareness and behavior towards local Freekeh products involved presenting a set of questions and analyzing them.

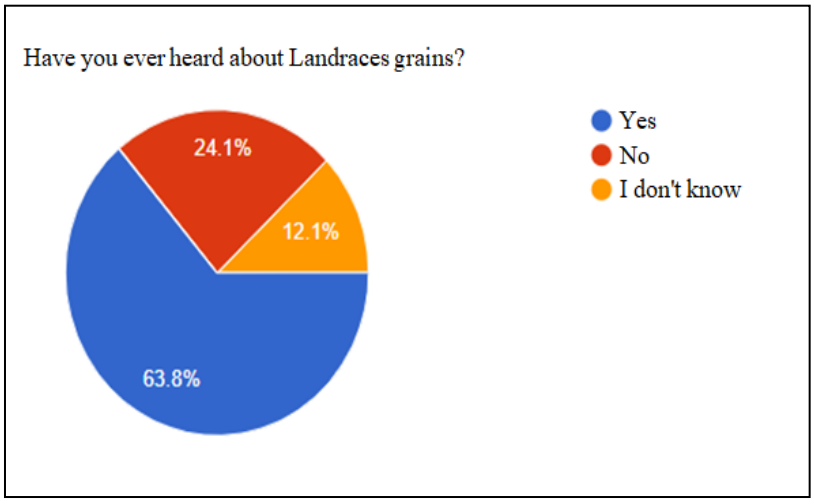


Figure 4.19: Analysis of Question 1 consumer awareness.

Figure (4.19) illustrates consumer awareness of landraces freekeh. The question 'Have you heard about landraces grains?' received a significantly high percentage of 63.8% (yes) response. The answer (I do not know) had the lowest percentage. The analysis shows that there is a good awareness among consumers about the landraces grains, with more than half having heard of it.

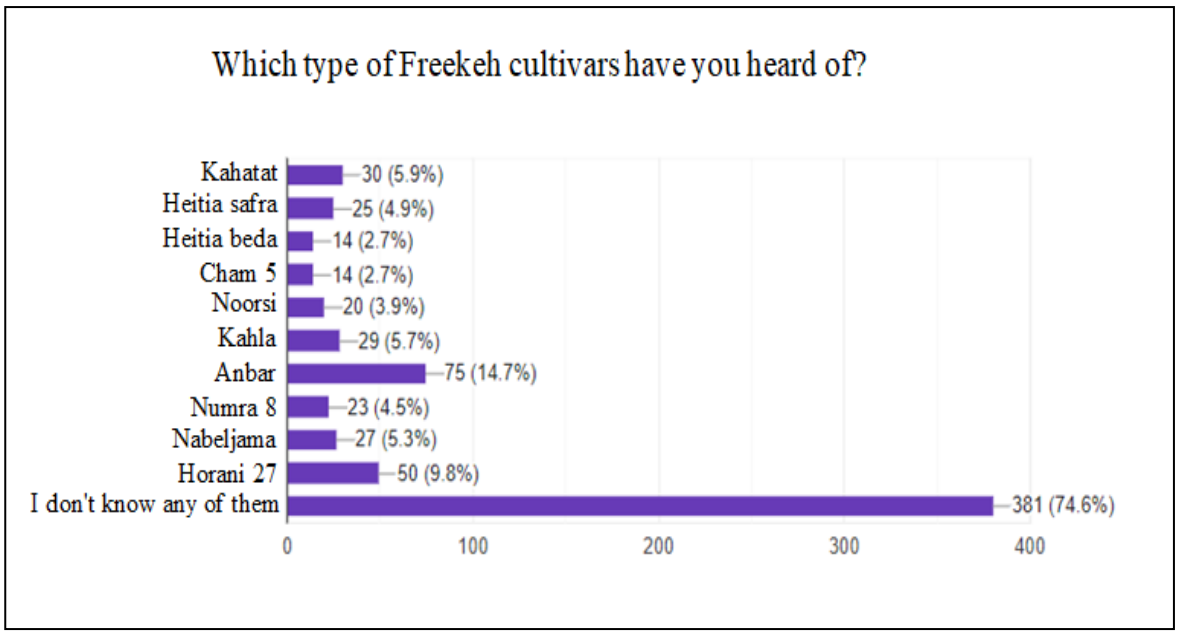


Figure 4.20: Analysis of Question 2 consumer awareness.

Figure (4.20) display the percentage of participants heard about each mentioned freekeh cultivars. It is significantly noticeable that the majority (74.6%) did not know any of them indicating that many individuals are not familiar with Freekeh cultivars (landraces or introduced). All freekeh cultivars had relatively low percentage. However, the highest percentage for freekeh cultivars (both landraces and introduced) was for Anbar 14.7% which is an introduced cultivar. While the lowest percentage for introduced cultivars (which are: Anbar, Horani 27, Numra 8, Noorsi and Cham 5) was 2.7% for Cham 5 cultivar. Regarding landraces cultivars (which are: Kahatat, Kahla, Nabeljamal, Heitiasafra and Heitiabeda) the highest percentage for them was for Kahatat 5.9%, while the lowest was for Heitiabeda 2.7%.

The results show a significant lack of awareness of the varieties of freekeh. However, the answer here is not important for consumers because the classification does not play an important role in purchasing freekeh.

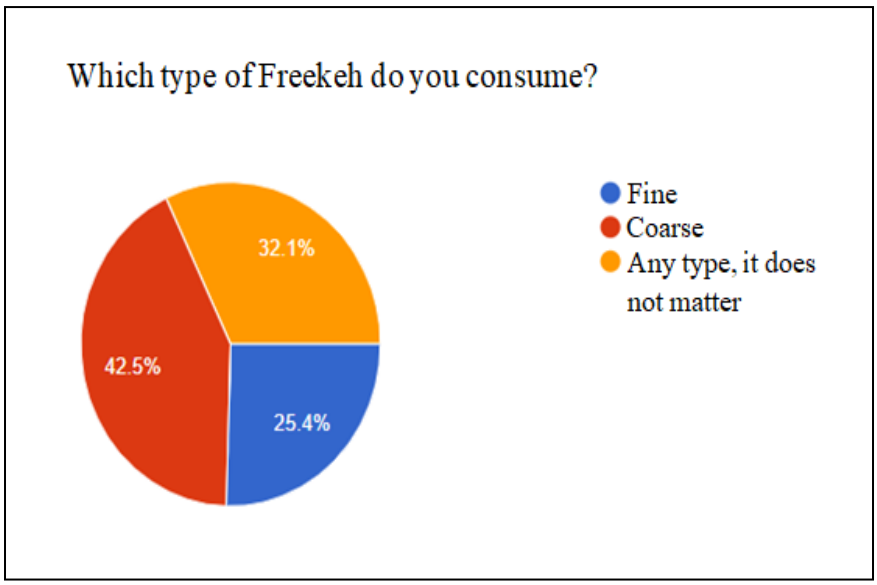


Figure 4.21: Analysis of Question 3 consumer awareness.

Figure (4.21) show the answers for this question (‘which type of Freekeh do you consume?'). The highest percentage was for coarse type with 42.5%, while the lowest percentage was for Fine type with 25.4%.
The results indicate that the difference between coarse and fine freekeh does not plays an important role in purchasing decision, as a high percentage of participants (32.1%) do not matter about the type of freekeh.

4.6.1 Pearson correlation

In this section, the Pearson correlation coefficient is computed for study variables. This coefficient reflects the degree and direction of the relationship between variables, ranging between +1 and -1.

The second part of the survey, focusing on purchasing behavior, has been analyzed. Specifically, the "Attributes influencing consumer purchase behavior of Freekeh” were examined to answer the question, "Which of the following attributes do you consider most important and less important when buying Freekeh?" These attributes were analyzed using correlation coefficients, means, and significance levels extracted through p-values.

Table 4.5: Pearson correlation coefficient (age, educational level, income, purchase behavior).

	Age	Educational level	Income (ILS)	Purchase behavior
Educational level	0.119*			
Income (ILS)	0.264*	0.310*		
Purchase behavior	0.218*	0.078	0.208*	
Naturalness	0.119*	0.033	0.183*	0.025
Size & weight of product	0.155*	-0.048	0.062	0.096*
Product's safety	0.089*	0.053	0.146*	0.055
Grain shape & appearance	0.093*	0.049	0.072	0.031
Nutritional value	-0.003	-0.010	-0.035	-0.038
Grains color	0.143*	-0.033	0.063	0.013
Free from impurities	0.066	0.018	0.059	0.058
Price	0.013	-0.156*	-0.126*	-0.078
Flavor	-0.016	-0.055	0.043	-0.001
Hardness (maturation stage)	0.099*	-0.059	-0.025	-0.036
Free from pesticide residue	0.058	-0.022	0.068	-0.010
Package design	0.034	0.015	-0.039	-0.016
Ease of use	-0.017	-0.083	-0.080	-0.039

*: Correlation is significant at the level 0.05

Table (4.5) shows the results of Pearson correlation coefficients between demographic characteristics. It can be summarized as the following:

1. Age: almost all characteristics shows a weak to very weak direct correlation except for some of them (ease of use, flavor and nutritional value) shows a very weak inverse correlation.
2. Educational level: had a weak positive relationship with age and a very weak direct correlation with purchase behavior, naturalness, product's safety, grain shape and appearance, free from impurities and package design. For the rest of characteristics, it had a weak negative relation.
3. Income: almost all relationship can be described as very weak and direct, except for ease of use, package design, hardness, price and nutritional value had also a weak but inverse relationship.

4. Purchase behavior: a very weak negative correlation with all characteristics except for naturalness, product's safety, size and weight, grain shape and appearance, grain color and free from impurities had weak positive relationship.

Table 4.6: Pearson correlation coefficient (naturalness, size & weight of product, product's safety, grains shape and appearance).

	Naturalness	**Size & weight of product**	**Product's safety**	**Grains shape and appearance**
Size & weight of product	0.463*			
Product's safety	0.554*	0.325*		
Grains shape and appearance	0.434*	0.367*	0.663*	
Nutritional value	0.437*	0.314*	0.534*	0.561*
Grains color	0.420*	0.336*	0.520*	0.683*
Free from impurities	0.405*	0.276*	0.660*	0.591*
Price	0.097*	0.365*	0.220*	0.225*
Flavor	0.461*	0.301*	0.627*	0.585*
Hardness (maturity stage)	0.310*	0.322*	0.493*	0.571*
Free from pesticide residue	0.486*	0.287*	0.678*	0.560*
Package design	0.114*	0.242*	0.063	0.199*
Ease of use	0.173*	0.198*	0.203*	0.308*

*: Correlation is significant at the level 0.05

The table (4.6) illustrates the correlation between the characteristics influencing consumer buying behavior for Freekeh. These results suggest the following:

1. Naturalness: had a weak to moderate direct relationship with all characteristics.
2. Size & weight of product: almost all characteristics had weak positive relationship.
3. Product's safety: there is variation in correlations through different characteristics, in which it had weak positive relationship with ease of use, package design and price. While it had a positive weak to moderate relationship with the rest of them.

4. Grains shape & appearance: had a weak to moderate positive relationship with all the characteristics.

Table 4.7: Pearson correlation coefficient (nutritional value, grains color, free from impurities, price).

	Nutritional value	**Grains color**	**Free from impurities**	**Price**
Grains color	0.610*			
Free from impurities	0.492*	0.519*		
Price	0.316*	0.289*	0.302*	
Flavor	0.551*	0.580*	0.649*	0.304*
Hardness (maturity stage)	0.517*	0.644*	0.473*	0.368*
Free from pesticide residue	0.599*	0.564*	0.645*	0.298*
Package design	0.221*	0.233*	0.140*	0.357*
Ease of use	0.356*	0.323*	0.322*	0.267*

*: Correlation is significant at the level 0.05

Table (4.7) shows the correlation between the characteristics influencing consumer purchasing behavior for Freekeh, the correlation values showed the follow:

1. Nutritional value: had positive weak to moderate relationship with all characteristics.
2. Grains color: had a moderate direct correlation with all characteristics.
3. Free from impurities: related to the characteristics with a weak to moderate direct correlation.
4. Price: had a weak positive relationship with characteristics.

Table 4.8: Pearson correlation coefficient (flavor, hardness, free from impurities, package design).

	Flavor	**Hardness (maturity stage)**	**Free from impurities**	**Package design**
Hardness (maturity stage)	0.543*			
Free from pesticide	0.657*	0.593*		
Package design	0.170*	0.278*	0.208*	
Ease of use	0.327*	0.391*	0.349*	0.593*

*: Correlation is significant at the level 0.05

Table (4.8) indicated the correlation between the characteristics influencing consumer buying behavior for freekeh. All the results show a weak to moderate positive correlation.

4.6.2 Variance testing and descriptive statistics

Surveyed individuals were asked to evaluate some freekeh product characteristics that affect's purchasing behavior. On a scale from 1 to 10 (1 less important and 10 very important) for each criterion. The results showed on the following tables.

Table 4.9: Variance testing and descriptive statistics (Gender).

	Male **Mean ± SD**	**Female** **Mean ± SD**	**P-value**
Naturalness	8.56 ± 2.10	8.64 ± 2.26	0.69
Size & weight of product	7.31 ± 2.30	6.91 ± 2.82	0.13
Product's safety	9.20 ± 1.62	9.22 ± 1.91	0.93
Grains shape and appearance	8.65 ± 1.73	8.90 ± 2.01	0.20
Nutritional value	8.51 ± 1.99	8.88 ± 2.07	0.07
Grains color	8.35 ± 1.93	8.53 ± 2.09	0.38
Free from impurities	9.33 ± 1.31	9.22 ± 1.96	0.54
Price	7.67 ± 2.40	7.32 ± 2.85	0.20

Flavor	8.87 ± 1.64	9.19 ± 1.79	0.06
Hardness (maturity stage)	8.31 ± 1.97	8.51 ± 2.21	0.33
Package design	7.06 ± 2.49	6.27 ± 2.91	<0.05

[1]SD: Standard deviation

Table (4.9) show that there is no significant difference between males and females for most of the criteria that influence consumer's purchase behavior. The highest mean value for both males and females are for "free from impurities" characteristics, (9.33, 9.22) respectively. In addition, both males and female agreed strongly on product's safety criteria in which the difference between their mean value were less than 0.02. On other hand, there was a significant difference between male and female on package design, surprisingly, males showed high interesting in the package design more than females. In general, results showed that there is no significant difference between males and females for all criteria except for package design.

Table 4.10: Variance testing and descriptive statistics (Age).

	Less than 20 Mean ± SD	**20-30 Mean ± SD**	**30-40 Mean ± SD**	**40-50 Mean ± SD**	**More than 50 Mean ± SD**	**P-value**
Naturalness	8.04 ± 2.51	8.36 ± 2.47	8.73 ± 2.05	8.82 ± 2.47	9.05 ± 1.86	0.10
Size & weight of product	6.83 ± 2.87^{ab}	6.59 ± 2.56^{b}	6.92 ± 2.86^{ab}	7.60 ± 2.58^{ab}	7.79 ± 2.43^{a}	<0.05
Product's safety	8.63 ± 2.55^{b}	9.12 ± 1.90^{ab}	9.15 ± 1.98^{ab}	9.66 ± 1.01^{a}	9.29 ± 1.73^{ab}	0.09
Grains shape and appearance	7.96 ± 3.18^{b}	8.82 ± 1.77^{a}	8.71 ± 2.20^{a}	9.10 ± 1.60^{a}	9.12 ± 1.39^{a}	0.08
Nutritional value	8.88 ± 1.65	8.74 ± 2.07	8.80 ± 1.65	8.88 ± 2.05	8.67 ± 2.05	0.97
Grains color	7.92 ± 2.26^{b}	8.22 ± 2.07^{ab}	8.46 ± 2.29^{ab}	8.89 ± 1.72^{a}	8.91 ± 1.45^{a}	<0.05
Free from impurities	8.67 ± 2.60^{b}	9.28 ± 1.80^{ab}	9.12 ± 1.99^{ab}	9.42 ± 1.37^{a}	9.49 ± 1.40^{a}	0.26
Price	8.46 ± 2.19^{a}	7.28 ± 2.73^{b}	7.11 ± 2.93^{b}	8.04 ± 2.41^{ab}	7.38 ± 2.66^{b}	<0.05
Flavor	9.25 ± 1.33	9.12 ± 1.74	9.08 ± 1.89	9.07 ± 1.59	9.08 ± 1.81	0.99

Hardness (maturity stage)	8.33 ± 2.20	8.26 ± 2.17	8.40 ± 2.33	8.65 ± 2.12	8.92 ± 1.53	0.24
Package design	6.96 ± 3.01	6.47 ± 2.75	6.18 ± 2.91	6.59 ± 3.03	6.99 ± 2.41	0.32

[1]SD: Standard deviation

Different superscript letters in the same column are different statistically ($p<0.05$)

Table (4.10) shows the analysis of features influencing consumers' freekeh purchasing behavior based on the age variable across different age categories ranging from less than 20 to over 50. The mean values for all age groups varies between 9.49 and 6.18. The highest mean value was observed for the age group over 50 for the criteria "Free from impurities," while the lowest mean value was for the age group 30-40 for the feature "Package design."

The mean values across different age groups do not exhibit significant differences. Moreover, the variables "Size & weight of product," "Grains color," and "Price" suggesting that there is a significant difference between age groups.

Regarding size & weight of products and grain color, their mean value decreased with decreasing the age. Indicating that quality is more important and valuable with increasing age. Conversely, price mean value is varied which affected by income.

Table 4.11: Variance testing and descriptive statistics (marital status).

	Widow Mean ±SD	**Single Mean ± SD**	**Married Mean ± SD**	**Divorced Mean ± SD**	**P value**
Naturalness	8.56 ± 2.94	8.22 ± 2.33	8.74 ± 2.15	9.31 ± 1.11	0.09
Size & weight of product	7.25 ± 3.19	6.76 ± 2.41	7.10 ± 2.76	7.15 ± 2.61	0.64
Product's safety	8.81 ± 2.71	8.97 ± 2.03	9.31 ± 1.73	9.39 ± 0.87	0.24
Grains shape and appearance	9.13 ± 1.45	8.57 ± 2.05	8.91 ± 1.92	8.69 ± 1.93	0.33
Nutritional value	8.19 ± 3.10	8.76 ± 1.87	8.82 ± 2.06	8.39 ± 2.18	0.58
Grains color	8.63 ± 1.86	8.15 ± 2.12	8.60 ± 2.01	8.15 ± 2.41	0.18

Free from impurities	9.56 ± 1.26	9.11 ± 2.04	9.28 ± 1.76	9.46 ± 0.66	0.68
Price	7.25 ± 3.21	7.40 ± 2.29	7.45 ± 2.76	6.92 ± 2.87	0.91
Flavor	9.00 ± 1.83	8.98 ± 1.78	9.16 ± 1.75	8.77 ± 1.42	0.68
Hardness (maturity stage)	8.63 ± 2.00	8.14 ± 2.14	8.56 ± 2.17	8.54 ± 1.66	0.31
Package design	6.19 ± 3.33	6.65 ± 2.70	6.41 ± 2.86	7.54 ± 2.15	0.45

[1]SD: Standard deviation

From Table (4.11), we observe the analysis of features influencing consumer purchasing behavior of freekeh, according to the variable of marital status. The results of the mean values for all categories varied between 9.56 and 6.19. The highest value is for the married status in the "Free from impurities" feature, while the lowest value is for the married status in the "Package design" feature.

In general, there is no significant difference between marital status. Indicating that all features play an important role in purchasing behavior neglecting the marital status.

Table 4.12: Variance testing and descriptive statistics (Area of living).

	Village Mean ± SD	**Camp Mean ± SD**	**City Mean ± SD**	**P value**
Naturalness	8.77 ± 2.06	8.40 ± 2.25	8.49 ± 2.36	0.33
Size & weight of product	7.08 ± 2.72	6.33 ± 2.73	7.04 ± 2.64	0.35
Product's safety	9.17 ± 1.85	9.13 ± 2.03	9.27 ± 1.79	0.81
Grains shape and appearance	8.72 ± 2.13	9.03 ± 1.30	8.92 ± 1.78	0.46
Nutritional value	8.80 ± 2.10	9.17 ± 1.66	8.70 ± 2.05	0.49
Grains color	8.54 ± 2.01	8.83 ± 1.32	8.35 ± 2.15	0.37
Free from impurities	9.20 ± 1.90	9.27 ± 1.96	9.30 ± 1.67	0.85
Price	7.48 ± 2.78	7.40 ± 2.95	7.35 ± 2.66	0.86
Flavor	9.15 ± 1.76	9.40 ± 0.89	9.00 ± 1.82	0.40

Hardness (maturity stage)	8.51 ± 2.20	8.83 ± 1.37	8.34 ± 2.17	0.42
Package design	6.46 ± 2.94	6.40 ± 2.98	6.53 ± 2.68	0.95

From Table (4.12), the analysis of features influencing consumer purchasing behavior of freekeh, according to the area of living (village, camp, city), reveals that the results of the mean values for all regions varied between 9.40 and 6.33. The highest mean value is for the camp in the "Flavor" criteria, while the lowest mean value is for the camp in the "Size & weight of product" criteria. Furthermore, p-value for all criteria for different residence were greater than 0.05, indicating that all criteria influencing purchasing behavior had no significant difference between area of living.

Taking everything into consideration, it could be reach upon the final analysis that the most powerful criteria influence the purchasing decision for all groups (gender, age, marital status and area of living) are free from impurities, product's safety and flavor. On contrary, the least criteria that affect the purchasing decision are package design, size & weight of product and slightly price.

Chapter Five: Conclusion and Recommendation

5.1 Conclusion

In conclusion, freekeh products marketed commercially in Palestine vary in their chemical properties according to the source. This indicates that the product practices for freekeh in Palestine are not similar and may vary according to pre- and post-harvesting conditions. It is common in Palestine that freekeh products are categorized commercially based on particle size and harvesting stage. One of the main quality limitations of freekeh products that are available in the Palestinian market is the presence of physical impurities from the field, such as stones, soils, straw, husk, etc. This aspect greatly affects purchase behavior and buying decisions. Therefore, it is important to improve the agricultural practices in freekeh production to enhance the marketability of the products.

5.2 Recommendation

1. Implement a comprehensive quality control system for the production of Freekeh, encompassing the entire process from harvest to packaging.
2. Manufacturers must ensure that the nutritional information stated on the final Freekeh product accurately reflects its actual values. Additionally, the nutritional profile should be expanded to provide more detailed information.
3. Given the heightened emphasis on health concerns in contemporary society, it is imperative to capitalize on consumer behavior trends by incorporating health claims on Freekeh packaging. This strategy will enhance awareness of Freekeh's significant nutritional benefits.

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Appendixes

Appendices A: Questionnaire

Consumer preferences and purchase behavior toward locally produced Freekeh (green wheat) questionnaire

استبيان لدراسة تفضيلات المستهلك وسلوك الشراء تجاه الفريكة المنتجة محليًا (القمح الأخضر)

1. Socio- demographic Information المعلومات الاجتماعية والديموغرافية

Gender الجنس	☐ Male ذكر ☐ Female أنثى
Age العمر	☐ Less than 20 years أقل من 20 عام ☐ 20-30 ☐ 30-40 ☐ 40-50 ☐ More than 50 أكثر من 50 عام
Educational Level المستوى التعليمي	☐ Primary school ابتدائي ☐ Secondary school ثانوي ☐ Diploma Degree دبلوم ☐ Bachelor Degree بكالوريوس ☐ Master's Degree ماجستير ☐ Doctorate Degree دكتوراه ☐ Not educated غير متعلم ☐ Other غير ذلك
Marital status الحالة الاجتماعية	☐ Single أعزب/عزباء ☐ Married متزوج/ متزوجة ☐ Widowed أرمل/ أرملة ☐ Divorced مطلق/مطلقة
Area of living مكان السكن	☐ Camp مخيم ☐ Village قرية ☐ City مدينة
Your city origin المنطقة	☐ Gaza strip قطاع غزة ☐ Ramallah رام الله ☐ Jericho أريحا ☐ Hebron الخليل ☐ Bethlehem بيت لحم

	☐ Nablus نابلس ☐ Tubas طوباس ☐ Salfit سلفيت ☐ Jenin جنين ☐ Tulkarem طولكرم ☐ Qalqilia قلقيلية ☐ Jerusalem القدس
Working status العمل	☐ Working full عمل بدوام كامل ☐ Working part time عمل بدوام جزئي ☐ Not working لا أعمل
Income الدخل (بالشيكل)	☐ <1500 ☐ 1500-3000 ☐ 3000-5000 ☐ >5000
Living status الحالة المعيشية	☐ I live alone أعيش لوحدي ☐ I live with my family أعيش مع عائلتي

2. Purchase behaviour سلوك الشراء

2.1 Purchase frequency and shopping places وتيرة الشراء و أماكن التسوق

2.1.1 Which of the following best describes your purchase behaviour?
أي من التالي يصف سلوك الشراء لديك؟

☐ I do the majority (more than 50%) of the shopping in my household

أقوم بمعظم عمليات التسوق للمنزل (أكثر من ٥٠٪ من المرات)

☐ I purchase food for my household occasionally, but am not the main food shopper only

أقوم بعملية التسوق للمنزل أحياناً فقط

☐ I rarely purchase food for my household
نادراً ما أقوم بعملية التسوق

2.1.2 Where do you (or the main food buyer in your household) normally purchase your food from?

أين تقومون عادة بعملية التسوق لأغراض المنزل؟

- ☐ Large supermarket المحال التجارية الكبيرة / سوبرماركت (المولات مثل برافو وشني وغيرها)
- ☐ Small supermarket البقالات الصغيرة

2.1.3 Do you buy freekeh by yourself? هل تشتري منتج الفريكة بنفسك؟

- ☐ Yes نعم
- ☐ No لا

If yes, Do you buy specific brand? إذا نعم، هل تشتري علامة تجارية معينة؟

- ☐ Yes نعم
- ☐ No لا

2.1.4 Which of the following statements describes your consumption of freekeh? أي من العبارات التالية تصف استهلاكك لمنتج الفريكة؟

- ☐ I consume the product periodically and prefer it أنا استهلك المنتج بشكل دوري وأفضله
- ☐ Sometimes I use it but it's not my favorite product أحيانا استهلكه ولكنه ليس المنتج المفضل لدي
- ☐ I do not consume the product at all لا أستهلك المنتج نهائياً

2.2 Attributes influencing consumer purchase behaviour of Frekeh
السمات التي تؤثر على سلوك شراء المستهلك للفريكة

2.2.1 Which of the following attributes do you consider most important and what less important when buying Frekeh?

أي من السمات التالية تعتبرها أكثر أهمية وأيها أقل أهمية عند شراء الفريكة؟

	Very low importance		أقل أهمية					أكثر أهمية	Very high importance	
Naturalness منتج طبيعي	1	2	3	4	5	6	7	8	9	10
Product size and weight حجم و وزن المنتج	1	2	3	4	5	6	7	8	9	10
Safety سلامة المنتج	1	2	3	4	5	6	7	8	9	10
Grains shape and appearance شكل ومظهر الحبوب	1	2	3	4	5	6	7	8	9	10
Nutritional value القيمة الغذائية	1	2	3	4	5	6	7	8	9	10
Color of grains لون الحبوب	1	2	3	4	5	6	7	8	9	10
Free from impurities (such as: straw and stones) خلو المنتج من الشوائب (مثل: القش والحجار)	1	2	3	4	5	6	7	8	9	10
Price السعر	1	2	3	4	5	6	7	8	9	10
Flavor النكهة	1	2	3	4	5	6	7	8	9	10
Degree of hardness (stage of maturity) درجة الصلابة (مرحلة النضوج)	1	2	3	4	5	6	7	8	9	10
Free from pesticide residues خلو المنتج من متبقيات المبيدات الحشرية	1	2	3	4	5	6	7	8	9	10
Package design (in appearance) تصميم العبوة (من الناحية المظهرية)	1	2	3	4	5	6	7	8	9	10
Ease of use (design and package facilitate using the product after opening) سهولة الاستخدام (تصميم الغلاف او العبوة يسهل عملية استخدام وتخزين المنتج بعد الفتح)	1	2	3	4	5	6	7	8	9	10

2.2.2 Which picture would you prefer to purchase from the following groups:

أي صورة تفضل شرائها من المجموعات التالية؟

a. Group 1 المجموعة

 (1)	 (2)

a.1 The reason you chose the image is due to سبب اختيارك للصورة يعود لعامل

- ☐ Impurities الشوائب
- ☐ Color اللون
- ☐ Grading degree درجة الطحن
- ☐ There is no difference لا يوجد فرق

b. Group 2 المجموعة

 (1)	 (2)

b.1 The reason you chose the image is due to سبب اختيارك للصورة يعود لعامل

- ☐ Impurities الشوائب
- ☐ Color اللون
- ☐ Grading degree درجة الطحن
- ☐ There is no difference لا يوجد فرق

c. Group 3 المجموعة

	
(1)	(2)

c.1 The reason you chose the image is due to سبب اختيارك للصورة يعود لعامل

- ☐ Impurities الشوائب
- ☐ Color اللون
- ☐ Grading degree درجة الطحن
- ☐ There is no difference لا يوجد فرق

3. Consumer awareness and attitudes toward local Freekeh

وعي المستهلك وسلوكه اتجاه الفريكة المحلية

3.1 Have you ever heard about Landraces grains?

هل سمعت عن الحبوب البلدية؟

- ☐ Yes نعم
- ☐ No لا
- ☐ I don't know لا أعرف

3.2 Which type of Freekeh cultivars have you heard of? *(You may choose multiple answers)*
أي صنف من أصناف الفريكة التالية سمعت عنه؟ (تستطيع اختيار أكثر من إجابة)

- ☐ Kahatat كحاتات
- ☐ Heitia safra هيتية صفراء
- ☐ Heitia beda هيتية بيضاء
- ☐ Cham 5 شام
- ☐ Noorsi نورسي
- ☐ Kahla كحلا
- ☐ Anbar عنبر
- ☐ Numra 8 نمرة
- ☐ Nabeljamal ناب الجمل
- ☐ Horani 27 حوراني
- ☐ Do not know any of them لا أعرف أي صنف منها

3.3 Which type of Freekeh do you cosume?
أي نوع من الفريكة تستهلك؟

- ☐ Fine (Refined) ناعمة
- ☐ Coarse (Unrefined) خشنة
- ☐ Any type, it does not matter أي نوع، لا يهم

Notes: ملاحظات

……
……
……
……
……
……

Appendices B: Palestinian standard specifications that must met by freekeh prepared from wheat grains intended for human consumption

المواصفات القياسية الفلسطينية الواجب توفرها في الفريكة المحضرة من حبوب القمح المعدة للاستهلاك الآدمي

مواصفة فلسطينية **المسودة النهائية**

م ف 4154-2019

الفريكة

Freekeh

1-المجال

تختص هذه المواصفة القياسية الفلسطينية بالاشتراطات الواجب توفرها في الفريكة المحضرة من حبوب القمح المعدة للاستهلاك الادمي.

2-المراجع التكميلية

- م ف 851 الخاصة بالشروط الصحية الواجب توفرها في مصانع المواد الغذائية.
- م ف 135 الخاصة ببطاقة بيان المنتوجات الغذائية المعبأة والمغلفة والمعدة للبيع.
- م ف 21 الخاصة بالانحراف في اوزان وحجوم المنتوجات الغذائية المغلفة والمعدة للبيع.
- م ف 530-ج1 الحبوب – حبوب القمح.
- م ف 59 الخاصة بمدة صلاحية المنتجات الغذائية.
- التعليمات الفنية الإلزامية الفلسطينية رقم 21 لسنة 2008 الخاصة بوسم وعرض المنتجات الغذائية والإعلان عنها.
- التعليمات الفنية الإلزامية الفلسطينية رقم 25 لسنة 2009 الخاصة بالمواد والسلع المعدة لملامسة الغذاء والتعليمات الفنية الإلزامية الاخرى الصادرة بموجبها.
- التعليمات الفنية الإلزامية الفلسطينية رقم 33 لسنة 2011 الخاصة بالشروط الصحية للغذاء.
- التعليمات الفنية الإلزامية الفلسطينية رقم 72 لسنة 2017 الخاصة بالمعايير الميكروبيولوجية للمواد الغذائية.
- التعليمات الفنية الإلزامية 81 لسنة 2019 الخاصة بالمضافات الغذائية على الأغذية.
- التعليمات الفنية الإلزامية الفلسطينية رقم 83 لسنة 2019 الخاصة بالحدود العليا لملوثات معينة في المواد الغذائية.
- التعليمات الفنية الإلزامية الفلسطينية رقم 31 لسنة 2011 الخاصة بالملوثات في الأغذية.

3- التعريفات

3-1 الفريكة: حبوب القمح الخضراء الكاملة أو المجروشة الناتجة عن تعريض سنابل القمح من صنف Triticum aestivum L. أو Triticum durum Desf في مرحلة النضج الشمعي (العجيني القاسي) لحرارة النار بشكل مباشر ثم معاملتها بطريقة ميكانيكية لاستبعاد القشور المحروقة والمواد الغريبة.

3-2 المواد الغريبة: أي مادة عدا المنتج ويمكن التعرف عليها بسهولة مع أو بدون أدوات أو معدات التكبير التي يعطي وجودها مؤشرا يدل على عدم التوافق مع الممارسات التصنيعية والصحية الجيدة.

4- المتطلبات العامة

يجب ان تتوفر الاشتراطات القياسية التالية في المنتوج النهائي:

4-1 أن يكون لون الفريكة اخضر مصفر.

4-2 أن يكون المنتوج خاليا من أي طعم أو رائحة غريبة.

4-3 أن يكون المنتوج خاليا من العفن الظاهري.

4-4 أن يكون المنتوج خاليا من أي مضافات غذائية بما فيها الألوان الطبيعية والصناعية.

4-5 أن يكون المنتوج خاليا من البذور والاعشاب السامة أو الضارة بالصحة.

4-6 أن يكون المنتوج خاليا من الحشرات الحية والسوس.

4-7 أن يكون المنتوج خاليا من مخلفات القوارض والطيور واثارها.

4-8 أن يكون المنتوج خاليا من الشوائب غير العضوية مثل: المعادن، الزجاج، البلاستيك، ...الخ.

5- المعايير التركيبية والمضافات الغذائية

يجب ان تتوفر الاشتراطات التركيبية التالية في المنتوج النهائي:

5-1 أن لا تزيد نسبة الرطوبة عن 13% كتلة\كتلة.

5-2 أن لا تزيد نسبة الرماد الكلي عن 2.5% كتلة\كتلة على أساس الوزن الجاف.

5-3 أن لا تقل نسبة الحبوب السليمة عن 90% كتلة\كتلة كحد ادنى.

5-4 أن لا تزيد نسبة الحصى والرمل والتراب عن 0.5% كتلة\كتلة.

5-5 أن لا تزيد نسبة الحشرات الميتة و\أو اجزائها عن 0.1% كتلة\كتلة.

5-6 أن لا تزيد نسبة الحبوب الأخرى والسيقان عن 2% كتلة\كتلة.

7-5 في حال استخدام المضافات الغذائية على الأغذية. يجب أن تلبي الحدود الواردة في التعليمات الإلزامية رقم 81 لسنة 2019 وتعديلاتها، الخاصة بالمضافات الغذائية على الأغذية.

6-أشكال التجهيز

يتم تجهيز المنتوج طبقاً لما يلي:

1-6 الفريكة الكاملة.

2-6 الفريكة المجروشة وتشمل كل من:

1-2-6 الفريكة المجروشة الخشنة.

2-2-6 الفريكة المجروشة الناعمة.

7- المتطلبات الصحية

1-7 يجب أن يلبي انتاج الفريكه المتطلبات الواردة في التعليمات الفنية الإلزامية الفلسطينية رقم 33 لسنة 2011 الخاصة بالشروط الصحية للغذاء.

2-7 يجب أن يلبي المنتوج المعايير الميكروبيولوجية ذات العلاقة الواردة في التعليمات الفنية الإلزامية الفلسطينية رقم 72 لسنة 2017 الخاصة بالمعايير الميكروبيولوجية للمواد الغذائية.

3-7 يجب أن يلبي المنتوج الحدود العليا للموثات ذات العلاقة الواردة في التعليمات الفنية الإلزامية الفلسطينية رقم 83 لسنة 2019 الخاصة بالحدود العليا لملوثات معينة في المواد الغذائية.

4-4 يجب أن يلبي المنتوج تراكيز متقبيات المبيدات الواردة في التعليمات الفنية الإلزامية الفلسطينية رقم 31 لسنة 2011 الخاصة بالملوثات في الأغذية.

8- التعبئة والنقل والتخزين والتسويق

يجب مراعاة ما يلي:

1-8 التعبئة: يجب أن يعبأ المنتوج بعبوات صحية مناسبة ونظيفة وسليمة ومحكمة الاغلاق تحمي المنتوج من التلوث والتلف والفساد ودخول أي روائح أو طعم أو ألوان وآية مواد غريبة ومن أي تغيير في طعمه أو أي من خواصه الطبيعية وكذلك حمايته من فقدان الرطوبة.

1-1-8 يجب ان تحافظ العبوات على الخواص المميزة للمنتوج ولا تعطي ولا تضيف للمنتوج طعم أو رائحة أو تلوث.

2-1-8 مواد التعبئة والتغليف يجب أن تطابق التعليمات الفنية الإلزامية الفلسطينية رقم 25 لسنة 2009 والتعليمات الفنية الإلزامية الاخرى الصادرة بموجبها وفي حال عدم وجودها يتم الرجوع الى مواصفات ادارة الاغذية والادوية الامريكية FDA.

2-8 النقل والتخزين والتسويق:

يجب أن يكون النقل والتداول والتخزين بشكل ملائم يحمي المنتوج من المطر والشمس أو أي مصادر أخرى للحرارة الزائدة والروائح غير المرغوب فيها واي مصادر أخرى للتلوث خاصة عند نقلها بالسفن.

3-8 التخزين: يجب أن تكون غرف التخزين جافة وخالية من الروائح غير المرغوب فيها ومحمية من دخول الحشرات والقوارض، وأن تكون التهوية بشكل منتظم وبشكل يضمن أن تكون جيدة في فترات الجفاف ويمكن ايقافها بشكل نهائي في فترات الرطوبة والحرارة الزائدة.

9- البيان

يكون البيان للمنتوج كما ورد في التعليمات الفنية الإلزامية رقم 21 لسنة 2008 الخاصة بوسم وعرض المنتجات الغذائية والإعلان عنها والتعليمات الفنية الإلزامية الاخرى الصادرة بموجبها، يجب أن تدون على كل عبوة البيانات الإيضاحية التالية باللغة العربية ويجوز كتابتها بأي لغة اخرى اختياريا الى جانب اللغة العربية الأساسية:

- مدة الصلاحية وفق م ف 59.

10- المحتوى

يجب ان لا يزيد الانحراف في الوزن عما هو محدد في المواصفة الفلسطينية م ف 21.

11- طرق الفحص

تجرى طرق الفحص بالرجوع إلى كتاب AOAC أو إي مرجع دولي معتمد.

12- المطابقة مع المواصفات

تعتبر عبوة واحدة مطابقة للمواصفة إذا طابقت جميع بنودها وغير مطابقة إذا لم تطابق أي بند من بنودها.

13- المراجع

13-1 المواصفة القياسية الأردنية الحبوب والبقول ومنتجاتها _ الفريكة رقم 2236\ 2019.

13-2 المواصفة القياسية لهيئة التقييس لدول مجلس التعاون لدول الخليج العربية\ الحبوب والبقول ومنتجاتها _ الفريكة رقم 233\2013.

13-3 المواصفة القياسية السورية الفريكة رقم 3056\ 2005.

14- المصطلحات

لأغراض هذه المواصفة تحمل المصطلحات العربية المذكورة أدناة المعنى للمصطلحات الانجليزية المقابلة لها:

المصطلح العربي	المقابل الانجليزي
الفريكة	Freekeh
حشرات	Insects
الشوائب	Impurities