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Unveiling Physical and Sensory Quality of Arabica Coffee Produced in the Kingdom of Saudi Arabia, Jazan Region

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ABSTRACT

Globally, coffee quality is a determining factor in the prices of coffee; hence the production of high quality coffee is the primary goal of every coffee growing country. This study unveils the raw and sensory quality of coffee produced in Jazan, which is the leading coffee growing region in the Kingdom of Saudi Arabia. 43 naturally processed coffee samples were collected from randomly sampled coffee farmers and subjected to green bean size evaluation using standard coffee grading sieves followed by sensory assessment using the Specialty Coffee Association protocol. The sampled coffee produced green bean sizes fitting within the spectrum of Arabica with the most prevalent being sieve number 16 (6.35 mm) with an average retention of 21 percent. On average 88 percent of the coffee was retained on sieves 14 to 20 representing the exportable sizes for many countries. The sensory evaluation revealed that 77 percent of the coffee samples attained specialty grade (80 points and above), with the highest scoring 86 points (excellent score) and the lowest 75 points. Two percent of the coffees were of excellent quality (≥85 points), 75 percent fell within the "very good" sensory class (80 – 85 points), and 23 percent did not meet the specialty class. These results indicate that with improved agronomic and processing practices, Jazan region of the Kingdom of Saudi Arabia has the potential to produce outstanding coffees (90 to 100 points).

Keywords: Arabica coffee, Raw bean size, cup quality; natural processing

1. INTRODUCTION

Coffee beans are the seeds of a perennial evergreen tropical plant belonging to the family Rubiaceae and genus *Coffea* (Davis *et al*., 2011). Following the recent discovery of six more coffee species in the Northern part of Madagascar, there are currently 130 species of the genus *Coffea* in the world (Davis and Rakotonasolo, 2021). However, out of this rich diversity, only two species, *Coffea arabica* L. and *C. canephora* Pierre are of global economic importance (Mishra, 2019). Coffee is one of the most widely consumed beverages globally. According to International Coffee Organization (ICO), around 166.63 million 60-kilogram bags of coffee were consumed worldwide in 2020/2021 which was a slight increase from 164 million bags that were consumed in the previous year (ICO, 2021). On the other hand, global coffee production reached 175.35 million 60-kilogram bags in 2020/2021, increasing from about 163.7 million 60-kilogram bags in 2019/2020 (Shahbandeh, 2022). *Coffea arabica* L. is grown in 85 percent of the coffee-producing countries (Bicho *et al*., 2013) and it predominates the world coffee trade contributing about 67 percent of the total trade volumes. *Coffea arabica* is the species currently under production in the Kingdom of Saudi Arabia.

Written historical literature indicates that Arabica coffee (*Coffea arabica*) plants were introduced to Yemen before the 15th century when they were first cultivated and used by Yemen's Sufi monasteries (Tuchscherer, 2003). Coffee cultivation in the Kingdom of Saudi Arabia dates more than 200 years ago and has continued to be a very popular traditional drink in the country (Proctor and Al Kinani, 2020). Coffee consumption spread quickly through the Arabian Peninsula reaching Makah in the late 15th century. Despite being a net coffee importer, the Kingdom of Saudi Arabia is also a coffee producer in the mountainous regions of Jazan, Asir and Al Baha, in the South Western region of the Kingdom (Sayed *et al*., 2019). In the last twenty decades, families in this region have farmed coffee with knowledge in its cultivation and processing being passed on from one generation to another. Coffee yields in the range of three to five and a half tonnes per hectare have been reported in the region among farmers in the Faifa Mountains who grow coffee at a high density and under high-frequency irrigation, with or without the application of inorganic fertilizers (Sayed *et al., 2019*). In fact, many farmers in the region have mainly achieved commendable coffee yields from the use of goat manure and stone mulching without the application of inorganic fertilisers, pesticides or herbicides (Al-Turki, 2002). This corroborates the great potential of the Kingdom of Saudi Arabia to expand coffee cultivation to meet the growing local demand as revealed by Al-Abdulkader *et al*., (2018).

Coffee consumption in the Kingdom of Saudi Arabia serves as a symbol of the country's deep-rooted culture (Khalid *et al.,* 2020). The coffee is traditionally brewed from finely ground light-golden roasted coffee beans and served hot with saffron, cinnamon, cardamom, ginger or cloves (Al-Aali and Ayoub, 2015), depending on consumer preference. The hot coffee is served as a welcome gesture in homes and other social gatherings before the tea is served, and is usually accompanied by dates and sweets (Al-Othman *et al*., 2012). According to the International Coffee Organization (ICO), coffee consumption in Saudi Arabia has had an upward trend of 85 802, 87 540, and 91 620 metric tons in 2017, 2018 and 2019, respectively (ICO, 2020).

Internationally, coffee is marketed based on its quality, described as green bean characteristics and beverage quality. Coffee producing countries have developed country-specific classification systems and vocabulary for describing coffee quality (ICO, 2013). The Speciality Coffee Association (SCA) developed the Q-Coffee system for grading coffee that is recognised internationally. The intrinsic quality of coffee is determined mainly by the growing conditions as well as the pre- and post-harvest practices (Belay *et al.*, 2016). This study sought to unveil the green bean physical characteristics and cup quality of the coffee grown and processed by farmers in Jazan region of Saudi Arabia whose quality profiles had not been analysed prior to this study.

2. MATERIALS AND METHODS

2.1 Study site and sampling

The study was carried out in Jazan coffee growing region in the South West of Saudi Arabia lying 17-23^0 N, 42-43^0 E (Figure 1). The region has six governorates which have relatively better conditions for coffee production namely Al Dayer, Al Faifa, El Edabi, Al Reith, Al Aridhah and Harub. The climate in the region is highly moderated by proximity to the Red sea and the mountainous range, thus, the weather is more sub-tropical than desert (Vincent, 2008). Jazan is characterized by maximum temperature ranges between 37.9^0 C and 19.7^0 C while the minimum temperatures are between 21.6^0 C and 29.6^0 C with a diurnal range of 8.8^0 C (FAOKSA, 2021). The region has a long rainy period from July to December receiving a total of 153.5mm. June being the driest month (1.0mm) and August being the wettest month (28.4 mm). The soils are described as sandy loams and alkaline in nature with a pH of 7.5-8.0 (Tounekti *et al*., 2017).

2.2 Sampling Procedure and Sample Collection

Al Dayer and Al Faifa governorates in the Jazan coffee growing region were purposively selected for this study based on the fact that they are the main coffee growing areas in the region. The sampling was done in December 2021 which coincides with the main coffee picking season in the area. The samples were collected from 43 randomly selected coffee farms representing the other coffee farmers in the two areas. All the samples were of Arabica coffee and had been processed by the dry method, commonly known as natural processing. Approximately one kilogram of dry coffee cherry was obtained from each of the sampled coffee farms. The samples were packed in impermeable odour-free bags to ensure the original condition of the sample was maintained as much as possible and transported to the laboratory for hulling and subsequent grading.

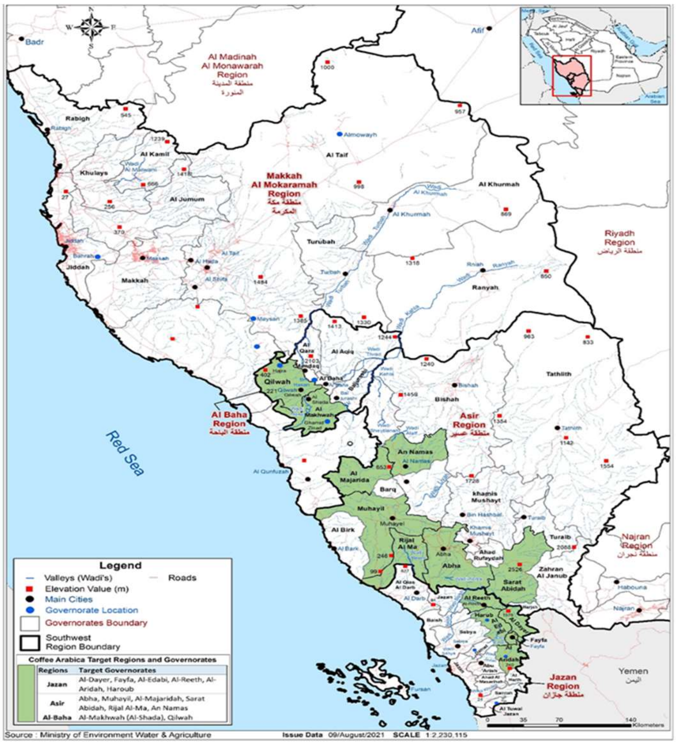

Figure 1: Map of Saudi Arabia showing coffee-producing regions

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2.3 Determination of the raw bean quality

The dry coffee cherry samples were hulled using a sample huller (Coffee Direct PRO) to obtain the coffee outturn (OT), which is the quantity of clean coffee obtained from a known quantity of dry coffee after removal of the husk, and it is usually expressed as a percentage. The moisture content (MC) of the green coffee beans was then determined using a calibrated SINAR AP 6060 coffee moisture analyser. The weight of 100 green coffee beans was obtained from random sub-samples of each sample and weighed to the nearest 0.1 g. The green bean sizes were then determined using a set of sieves with round apertures in accordance with ISO 4150 standard (ISO, 2011). Nine standard sieves, 12 to 20, were assembled in descending order based on the aperture size. Sieving was done manually through uniform agitation of the nest of sieves for three minutes. The beans retained on each sieve were weighed to the nearest 0.1 g. The proportion of the bean sizes was determined by taking the weight of green coffee (WGC) retained in each sieve and expressing it as a percentage of the total weight of the green bean sample. All the variable measurements were repeated three times and the raw data was subjected to analysis of variance as well as descriptive analysis where possible.

2.4 Sensory evaluation of the coffee samples

The protocol developed by the Specialty Coffee Association (SCA) was adopted and applied for the cup quality analysis (Lingle, 2001). The green coffee was roasted to attain a medium roast using a laboratory coffee roaster (IKAWA PRO100) within 24 hours after hulling and allowed to rest for at least eight hours. The roasted samples were weighed out as whole beans to a predetermined weight of 8.25 g per 150 ml cup and ground individually directly into the cup (five cups per individual sample). First, the ground samples were sniffed dry from the cups to assess the fragrance after which they were infused with clean and odour-free hot water (93^{0}C) within less than 15 minutes after grinding. The water was poured gently into the cup and topped to the rim of the cup, making sure to wet all of the grounds. The coffee was left to steep undisturbed for three to four minutes before evaluation. The crust was broken by stirring gently while sniffing to assess the aroma. The samples were further assessed for flavour, aftertaste, acidity, body, balance, clean cup, uniformity, sweetness and the overall score. The evaluation was conducted by a panel of three sensory judges certified as Q-graders by the Coffee Quality Institute (CQI) of America.

2.5 Statistical analysis

The raw bean quality and sensory data were subjected to descriptive analysis to illustrate the performance of the sampled coffee for comparison with the known and the results were presented in graphs, charts and tables. Pearson correlation was also conducted to determine the relationship between the coffee bean's physical characteristics and the cup quality using XLSTAT version 2022.

3. Results

3.1 Coffee bean physical characteristics

The percentage coffee outturn ranged from 15 to 54 percent with an average of 39 portraying high milling losses of 85 to 46 percent. The coffee samples also revealed a high variation in the average weight of 100 beans, ranging from 7.1 to 17.7 g, with a mean of 11.4 g. The moisture content ranged from 9.0 to 15.5 percent with an average of 12.2 percent. The proportion of green bean sizes as determined by the standard set of 10 sieves of different aperture sizes was also highly variable across the sampled coffee as shown in Figure 2. The most prevalent was sieve number 16 (6.35 mm) with an average retention of 21 percent. On average 88 percent of the coffee was retained on sieves 14 to 20 representing the exportable sizes for Arabica coffee in many producing countries.

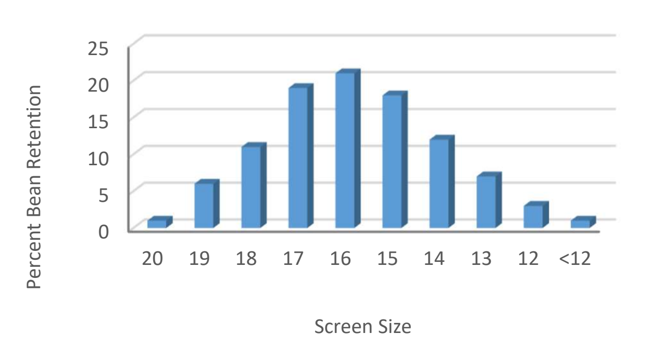

Figure 2: Distribution of green coffee bean sizes in the sampled coffee

3.2 Coffee Cup quality analysis

Results of the total sensory score are shown in Figure 3. The differences detected in the individual sensory parameters contributed to the discriminative cumulative score (total sensory score) which gave a better reflection of the broad sensory quality performance of the coffee samples. None of the samples was classified in the outstanding class of ≥90 points. Only one sample representing two percent of the sampled coffee achieved an excellent (≥85 points) score of 86 points while 75 percent of the samples were classified as very good (80.0 to 84.99). Therefore, 77 percent of the samples were in the specialty class (≥80 points) while the remaining 23 percent scored between 76 to 79 points and were therefore classified as good hence did not achieve the specialty class.

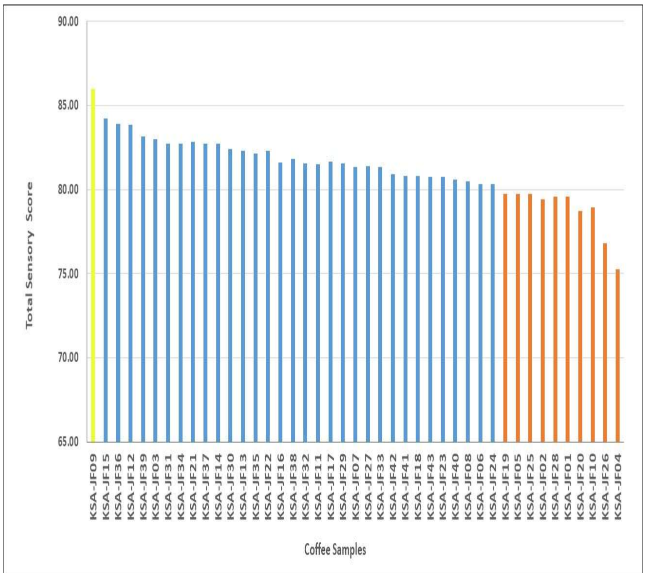

Figure 3: Total sensory score of the sampled coffee. Colours yellow, blue and orange represent the different classifications as excellent, very good and good, respectively.

All the 43 samples scored the maximum score of 10 points for sweetness but produced variable scores for the other sensory parameters namely, fragrance, flavour, aftertaste, acidity, body, balance, clean cup, uniformity and overall sensory perception. The sample with the highest sensory performance, the average and the lowest of the sampled coffee based on the SCA evaluation criteria are shown in Figure 4. While the highest scoring coffee attained the maximum possible scores in clean cup and uniformity (10) the quality of the lowest scoring coffee was partially lowered by being unclean and non-uniform.

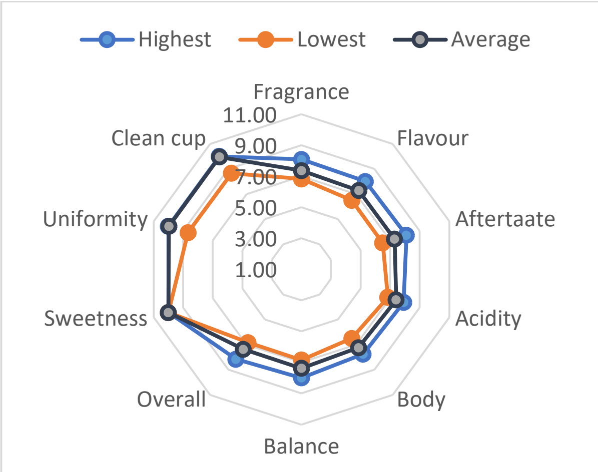

Figure 4: Radar chart illustrating the highest sensory performance, the average and the lowest of the sampled coffee based on the SCA evaluation criteria.

3.2 Correlation between the sensory and green bean physical characteristics

The cup quality characteristics of fragrance/aroma, flavour, aftertaste, acidity, body, balance and overall were positively and significantly correlated among themselves (Table 1). Positive significant correlations were observed between the coffee outturn and the weight of 100 beans, which was also positively and significantly correlated aftertaste, body and overall quality characteristics. Positive significant correlations were also observed between coffee outturn and fragrance and balance.

Table 1: Correlation between the raw bean and sensory quality of the sampled coffee

Variables	OT	Fragrance	Flavour	Aftertaste	Acidity	Body	Balance	Overall
HBW	**0.55**	0.30	0.27	**0.31**	0.20	**0.33**	0.27	**0.37**
OT		**0.32**	0.26	0.17	0.08	0.22	**0.34**	0.29
Fragrance			**0.73**	**0.63**	**0.51**	**0.56**	**0.54**	**0.68**
Flavour				**0.84**	**0.70**	**0.65**	**0.69**	**0.83**
Aftertaste					**0.65**	**0.69**	**0.74**	**0.80**
Acidity						**0.61**	**0.70**	**0.72**
Body							**0.77**	**0.73**
Balance								**0.75**

Key: Values in bold are different from 0 at P=0.05. OT – Outturn; HBW – Weight of 100 Beans.

4. DISCUSSION

This study targeted to unveil the quality of coffee that is currently being cultivated and processed under farmer's practices, in the Kingdom of Saudi Arabia. This was a preliminary strategy to understand the necessary areas of intervention for coffee quality improvement in the Kingdom hence the tested samples were picked randomly from diverse farmers. Though there are no established standards for deciding the conversion ratio from fruit to clean coffee the International Coffee Organization agrees to a conversion of dried cherry to green bean of 0.5 percent which is equivalent to an outturn of 50 percent. (ITC, 2012). Factors such as environment, genotype, health of the tree and degree of maturity have been reported to affect the outturn (Fialho *et al.* 2020, Gichimu *et al.* 2012). The wide range observed in the percentage of coffee outturns (15 - 54) of the sampled coffee could be an indication of the diversity of the farm management practices by the farmers hence practices promoting higher outturns should be promoted as this has economic importance.

Managing the moisture content of a coffee bean is of paramount importance in ensuring the ultimate cup quality of the coffee. 40 percent of the analysed samples were found to have a moisture content above 12.5 percent which was higher than the recommended range of 8.0 - 12.5 percent in marketable green coffee beans (ICO, 2004). High moisture content may enhance the growth of moulds which not only affects the flavour of coffee but may also introduce mycotoxin contamination (Velmourougane and Bhat, 2009). On the other hand, over-drying would translate to loss of income since moisture content in green coffee contributes to the ultimate weight at the time of sale. In addition, over-dried coffee also breaks up more easily during hulling which increases the percentage of broken beans, which further reduces both the quality and the value of the coffee (Wintgens, 2004). Though there is no exact standard for ideal moisture content, 11 percent is proposed as a good target for most coffee (ITC, 2012).

Although the analysed coffee samples revealed a high variation in the average weight of 100 beans, the data obtained showed that the coffee currently being produced in the sampled area compares well with Arabica coffee from other countries (Bertrand *et al.*, 2005; Tran *et al.*, 2017; Cheserek *et al.*, 2020; Malau 2018). This is an important observation considering that the weight of green coffee is a key factor in determining the coffee income majorly in the international market alongside other determinants like the bean size and the cup quality (Wintgens, 2004; Belete, 2014). In addition, the coffee bean size distribution compared well with the green bean sizes typical of Arabica coffee as reported from other origins (Wintgens, 2004). Coffee bean size is partly determined genetically (Cheserek *et al.*, 2020) and also influenced by environmental conditions and agronomic conditions including plant nutrition, pest and disease control, pruning and weed management (Wintgens, 2004 Sakai *et a*l., 2013). Considering that these bean sizes were achieved under farmers' practices with minimal advisory services, it is evident that the coffee trees in the sampled area have even greater potential to produce higher premium coffee grades. Therefore, there is need to upscale farmer advisory services in the area and avail easier access of the key production resources, mainly irrigation water and inputs.

The sensory evaluation placed the sampled coffee on the specialty coffee map which further unveiled the unexploited potential of the coffee sector in the Kingdom of Saudi Arabia. The specialty coffee niche offers an opportunity for producers to differentiate and accrue higher income in the liberalised coffee sector. Poltronieri and Rossi (2016) presented a possible increase of income for producers by assuring high standards of coffee quality. The significant positive correlation that was observed between the raw bean quality (mainly coffee bean outturn and bean weight) and most of the cup quality characteristics was a clear indication that production of coffee of high raw bean quality would directly result in high cup quality. Similar observation was made by researchers Cheserek et al. (2020) and Gichimu *et al*. (2012). This intervention would guarantee the farmer better returns from both increased yields and premium prices attracted by high quality coffee and hence underscores the need for the adoption of appropriate agronomic practices among the coffee farmers. The significant positive correlation that was observed between different cup quality parameters indicates that the cup quality characteristics are interrelated and confirms the possibility of improving the cup quality through a holistic approach.

5. CONCLUSION

This study established that the coffee produced in Jazan region in the Kingdom of Saudi Arabia fits in the spectrum of Arabica coffee in terms of bean sizes. On the other hand, the sensory evaluation placed the sampled coffee in the specialty coffee map. This is a clear indication that Jazan region, and by extension, the Kingdom of Saudi Arabia has a great untapped potential to produce outstanding quality coffee for both local and international markets. This can be achieved through the adoption of good agronomic and processing practices by the farmers, hence there is a need for upscaling the extension services for coffee farming in the Kingdom of Saudi Arabia.

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