Research Article

Recovery Percentage of Different Coffee Varieties (*Coffee arabica*) from Fresh Cherry in The Gulmi District of Nepal

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Article Information	Abstract
  	The recovery percentages and out-turns of diverse coffee cultivars are contingent upon distinct processing methods and fruit characteristics. Despite the availability of numerous coffee varieties, their recovery percentages and out-turns remain untested in the Gulmi District of Nepal. This study aimed to assess the recovery percentage of different coffee varieties in the Gulmi District to provide insights into the most productive varieties for local farmers, investigate the influence of processing techniques on the recovery percentage, and evaluate the potential for improving the recovery percentage through optimized agricultural practices, harvesting methods, and post-harvest processing. A field experiment was conducted in a Randomized Complete Block Design (RCBD) with three replications, encompassing ten coffee varieties (Catisic, Bourbon Amarillo, Mundo Novo, Catimor, Yellow Catura, Catuai Amarillo, Firfire,Sanroman, Gulmi Local, and Tekisic) as treatments. The research findings unveiled that Mundo Novo exhibited the highest recovery percentage at 18.13%, with Catuai Amarillo demonstrating the highest recovery percentage of wet parchment from fresh cherry at 63.13%. Moreover, Mundo Novo showcased the highest recovery percentage of dry parchment from fresh cherry at 24.85%, attributed to the removal of a higher proportion of floated parchment during the washing of fermented wet parchment. Furthermore, Mundo Novo exhibited the highest recovery percentage of green beans (21.13%) and roasted beans (18.13%) from fresh cherries, owing to factors such as a lower incidence of floated parchment, larger fruit size, and uniformly ripened cherries. Consequently, based on their superior recovery percentages and out-turns, Mundo Novo and Catuai Amarillo are recommended for cultivation in Nepal.

Introduction

Coffee is a widely enjoyed and globally consumed beverage (Lim *et al*., 2019), reaching a global production of 171.9 million 60 kg bags in 2020 and 2021 (Shahbandeh, 2024). Coffee (Coffee arabica, Coffee robusta, and Coffee spp) is classified under the Rubiaceous family (Mutua, 2000). It is referred to as grey gold and ranks as the second most traded commodity globally, surpassing 38 billion in trade, following petroleum products. It is believed that coffee was first introduced to Nepal from Myanmar in 1938 AD. Nepal has proven soil and climate characteristics that allow it to grow high-quality coffee, or "specialty coffee," at an elevation of 800 to 1400 meters (Dhakal, 2005). In the hilly region of Nepal, Coffee is considered a major cash crop (Khanal, 2003).

In Nepal, coffee cultivation spans across 45 districts, with Gulmi, Arghakhanchi, Pyuthan, Palpa, and Syangja being the leading producers. Notably, Gulmi's coffee production

for the fiscal year 2021/2022 amounted to 27 metric tons (NTCDB, 2023). The various activities involved in coffee processing include harvesting fresh cherries, Pre-sorting, cleaning, floating, pulping, fermentation, drying, hulling, and roasting. In most countries where coffee is grown, the coffee plants are harvested once a year. As the coffee cherries ripen, they develop chemical compositions that contribute to the best quality coffee (Pimenta *et al.*, 2008). These cherries also contain volatile compounds that give coffee its distinctive aroma and flavor. These compounds are initially present in small amounts in early-stage cherries but increase as the cherries mature (Pimenta *et al.*, 2008). Enzymes naturally found in coffee fruit aid in breaking down mucilage, but this alone is insufficient for a complete process (Agate and Bhat, 1966). The choice of processing method, whether wet or dry, influences the flavor characteristics and creates distinct quality variations in the resulting green coffee beans (Wintgens, 2009; Sivetz and Desrosier, 1979). Wet-processing typically produces higher-quality coffee, commanding a premium price compared to dry-processed (natural) coffee (Rothfos, 1985). Studies have demonstrated various metabolic activities in green coffee beans during processing, primarily attributed to germination processes (Bytof *et al.,* 2007) and stress metabolism contributes significantly to differences in chemical composition among green coffee beans, thus impacting their quality (Bytof *et al.,* 2005).

Haile and Kang (2019) stated that the wet method of pulping maintained the inherent quality of coffee beans and produced uniform green beans with minimum defects. After pulping coffee cherries sorting of wet parchment takes place which is followed by fermentation. The obtained parchment undergoes a 24–48-hour fermentation process, followed by a 10-15 day drying procedure. A variety of microorganisms are present during the fermentation process in wet coffee processing (Haile and Kang, 2019). Differences in the diversity of microorganisms and environmental conditions can result in variations in the types and amounts of organic acids and metabolites produced, thus giving rise to distinct qualities in coffee (Massawe and Lifa, 2010; Silva *et al.*, 2013). Subsequently, de-hulling of the dry parchment yields green beans, which are then roasted using a roaster machine. The key component in the coffee value chain is the roasting process, during which significant physicochemical alterations occur, resulting in the attainment of specific roasted coffee traits (Afonso, 2001). Roasting is regarded as a pivotal stage in shaping the aroma and flavor attributes of coffee (Arya and Rao, 2007). Temperatures exceeding 200°C during roasting cause the precursors present in green coffee to convert into constituent's characteristic of roasted coffee, thereby contributing to the creation of a variety of aroma profiles and colors (Dalla *et al.*, 1980).

Beghin and Teshome (2017) stated that the best result was obtained with roasting time ranging from 14 to 27 minutes and a roasting temperature of 188∘c to 282∘c. During roasting, the beans experience a weight loss of 15-22%, primarily comprising water, resulting in a final product with 1-2.5% moisture and a considerable volume increase ranging from 50% to almost 100% (Munchow *et al.*, 2020).

The genus Coffea potentially includes around ninety species, although the exact number remains uncertain (Soliman, 2005). The Coffee Research Program's annual report (CRP, 2020) indicates the cultivation of nearly 28 coffee varieties in Nepal. The recovery percentage, denoting the output from a specific quantity of fresh cherries, includes wet and dry parchment, green beans, and roasted beans. According to the Coffee Development Center (CDC, 2020) in Aapchaur, Gulmi, one kilogram of fresh cherry yields 0.65 grams of parchment, 0.3 grams of green beans, and 0.25 grams of roasted beans. Despite coffee's prominence in agriculture, limited research has been conducted, particularly in varietal identification within randomly planted orchards. Arabica coffee, while present in Nepal, lacks specific varieties associated with higher recovery percentages. The Nepalese coffee sector faces notable post-harvest losses at both the farmer's and processor's levels, mainly attributed to sorting and grading inefficiencies. Additionally, the absence of studies on optimal varieties, based on recovery percentage, poses a challenge in providing recommendations to Nepalese farmers. Identifying superior varieties could significantly benefit farmers and serve as a foundation for future studies. This research endeavors to explore and assess varieties with enhanced output, motivating farmers to engage in coffee cultivation, and ultimately improving the quality and productivity of coffee at the grassroots level.

Materials and Methodology

Site Selection
The study was conducted in the Gulmi district of Nepal, positioned at latitude 28°04′08.76″ North and longitude 83°18′24.84″ East, featuring a climate suitable for coffee production. Gulmi district was purposefully chosen due to its status as one of the primary coffee-producing regions in the country. Specifically, the experiment took place in Musikot Municipality Ward No.5- Aapchaur, within the Gulmi district, as it encompasses a significant coffee-producing area.

Experimental Design
The experiment adopted a Randomized Complete Block Design (RCBD) with three replications for each of the ten coffee varieties. A total of ten treatments were established, each with three replications. Among these, six coffee varieties (Catisic, Bourbon Amarillo, Mondo Novo, Catimor, Yellow Catura, and Catuai Amarillo) were sourced from the Coffee Research Program farm in Bhandaridada and Baletaksar, while the remaining four varieties (firfire, Sansoman, Gulmi Local, and Tekisic)

were obtained from the Coffee Development Centre (CDC) farm in Aapchaur, Gulmi. The experimental detail of the research and treatment details are shown in Table 1 and 2 respectively.

Table 1: Experimental detail of the research

S. N.	Design	RCBD Design
1	Replication	3
2	Treatments	10
3	Fermentation time	48 hours
4	Drying time/days	30 days
5	Roasted temperature	240∘c
6	Roasted time	15 min
7	Cooling time	15min

Table 2: Treatments Detail of the research

S. N.	Treatments	Variety
1	V1	Catistic
2	V2	Bourbon Amarillo
3	V3	Mundo Novo
4	V4	Catimor
5	V5	Yellow Catura
6	V6	Catuai Amarillo
7	V7	Firfire
8	V8	Sanroman
9	V9	Gulmi Local
10	V10	Tekisic

Evaluation Procedure

The pulper machine was placed in a safe place and following test procedures were applied in evaluating the recovery percentage.

- 1 kg of coffee cherry of each variety (V=10) was prepared, followed by pulping them separately on the pulping machine.

- After pulping, coffee beans of each variety were weighed.

- The recovery percentage of wet parchments from fresh coffee of each variety was calculated.

- After pulping, fermentation of different coffee varieties individually in plastic cans for 48 hours was conducted, followed by washing wet parchments to remove the mucilage. It floated parchment and placed the wet

parchments into the plastic shade house for the drying process for 30 days.

- After thoroughly drying, different varieties' parchments were weighted individually, and the recovery percentage of dry parchment was calculated.

- The dried parchments were hulled using metal mortar and pestle separately.

- Coffee green beans were weighted after hulling.

- The recovery percentage of coffee green beans from fresh coffee beans and dry parchment was calculated.

- Green beans were roasted using a roaster at a temperature of 240∘c for 15 min and cooled for 15 min which was similar to Beghin and Teshome, (2017). The recovery percentage of roasted beans from green beans, dry parchment, and fresh cherry was calculated.

Research Practices

The following research activities were conducted to accomplish the research.

Harvesting

Fully ripened red coffee cherries were harvested by picking the berries one by one by hand. Harvesting of the fresh cherry was conducted in the Coffee Development Centre Aapchaur, Gulmi, and the farm of the Coffee Research Program, Bhandaridada, and Baletaksar. Four coffee varieties, namely, Tekisic, Gulmi Local Sanroman, and Firfire, were harvested from the coffee farm of CDC, and the remaining six coffee varieties, namely, Catisic; Bourbon Amarillo, Mundo Novo; Catimor, Yellow Catura and Catuai Amarillo, were harvested from the farm of CRP. Mutua (2000) stated that the best quality was obtained by picking ripe berries one by one by hand, so ripened cherries were harvested one by one.

Pulping

Wet pulping method was applied and weight was taken within 24 hours of harvesting at the pulping center of CRP.

Sorting and Fermentation

Immediately after pulping coffee cherries, wet parchment was sorted and cleaned by hand.Sorted wet parchment was subjected to fermentation. Fermentation was conducted in plastic cans tagged with the number of replications and names of treatments (varieties). We had thirty fermentation cans. Fermentation was done for 48 hours to remove the mucilage.

Washing of Wet Parchment

Fermented wet parchments were thoroughly washed with clean water 3-4 times until the mucilage was removed entirely.

Tagging and Drying of Wet Parchment

For drying wet parchment, a thin net was cut into thirty pieces, tagged individually with the name of treatment and

replication numbers, and placed in the shade. The wet parchment was dried in the shade for 25 days, and the dry parchments were further dried in a solar house for five days. Completely dried parchments were weighed, and the data was recorded.

Hulling of Dry Parchment

The hull of parchment left over after the cherries had been pulped, washed, and dried was removed with the help of a metal mortar and pestle. Hulling was conducted for five days.

Roasting of Green Beans

Green beans were roasted at a temperature of 240∘c for 15 minutes and cooled for 15 minutes in a roaster machine. Roasting was conducted for five days. The roasted beans were stored in plastic cans tagged with treatment names and replication numbers.

Observations Taken

The following observations were taken to analyze the recovery percentage of parchment, green beans, and roasted beans of different coffee varieties from fresh cherry.

Observation of Fresh Cherry

Fresh cherries of 10 coffee varieties were replicated three times, so 30 samples of 1 kg of fresh cherry were taken for the research.

Observation of Wet Parchment

After pulping and sorting, the weight of wet parchments was taken with the help of a digital weighing machine.

Observation of Dry Parchment

After drying the wet parchment for 30 days, the dry parchment was weighed.

Observation of Green Beans

Hulling of dry parchments was done using metal mortar and pestle to obtain green beans, and the weight of green beans was taken.

Observation of Roasted Beans

Green beans were roasted in a roaster at a temperature of 240∘c for 15 minutes and cooled for 15 minutes to obtain roasted beans, and the weight of roasted beans was taken.

Statistical Data Analysis

The collected data were compiled and subjected to analysis of variance. R-Studio package was used for data analysis after entering data in Microsoft Excel. Ten treatments were used in the analysis. As a significant result, data were separated at a 5% significance level by Duncan's Multiple Range Test (DMRT).

$$Recovery\ \%\ of\ wet\ parchment$$
$$= \frac{weight\ of\ wet\ parchment}{weight\ of\ fresh\ cherry} \ x\ 100\%$$

$$Recovery\ \%\ of\ dry\ parchment$$
$$= \frac{weight\ of\ dry\ parchment}{weight\ of\ fresh\ cherry} \ x\ 100\%$$

$$Recovery\ \%\ of\ green\ beans$$
$$= \frac{weight\ of\ green\ beans}{weight\ of\ fresh\ cherry} \ x\ 100\%$$

$$Recovery\ \%\ of\ roasted\ beans$$
$$= \frac{weight\ of\ roasted\ beans}{weight\ of\ fresh\ cherry} \ x\ 100\%$$

Result

Results of Recovery Percentage of Parchment Green Beans and Roasted Beans

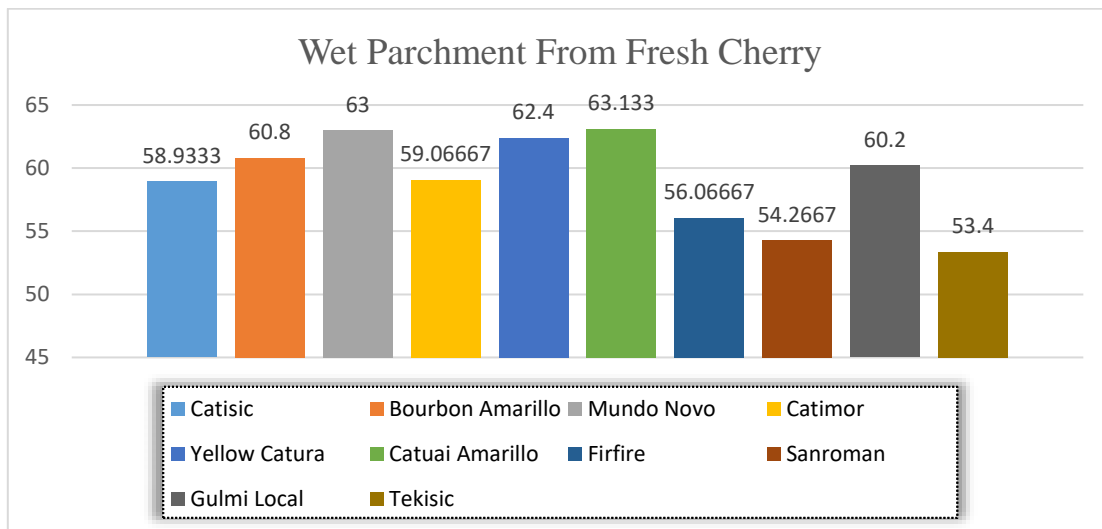*Recovery Percentage of Wet Parchment from Fresh Cherry*
The mean recovery percentage of wet parchment from fresh cherry was 59.12%. Varieties significantly influenced the recovery percentage of wet parchment. Catuai Amarillo (63.13%) had the highest recovery percentage, which was statistically similar to Mundo Novo (63.0%), Yellow Catura (62.40%), Bourbon Amarillo (60.80%), Gulmi Local (60.20%), Catimor (59.07%) and Catisic (58.93%). Tekisic had the lowest recovery percentage of wet parchment (53.40%). Likewise, varieties Firfire (56.07%) and Sanroman (54.27%) were statistically similar to Tekisic (53.40%) (Fig. 1).

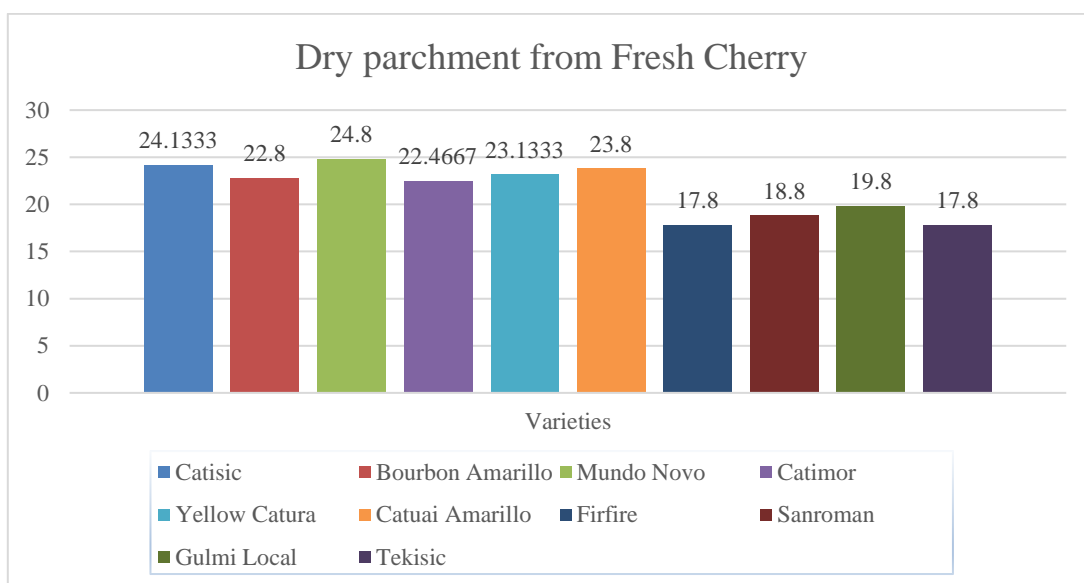*Recovery Percentage of Dry Parchment from Fresh Cherry*
The mean recovery percentage of dry parchment from fresh cherry was 21.43%. Varieties significantly influenced the recovery percentage of dry parchment. Mundo Novo (24.80%) had the highest recovery percentage, which was statistically similar to Catuai Amarillo (23.80%), Catisic (23.13%) and Yellow Catura (23.13%) and it was followed by Bourbon Amarillo (22.80%), Catimor (22.47%), and Gulmi Local (19.80%). Variety Tekisic(17.80%) had the lowest recovery percentage, to which Sanroman (18.80%) and Firfire (17.80%) were statistically similar (Fig. 2).

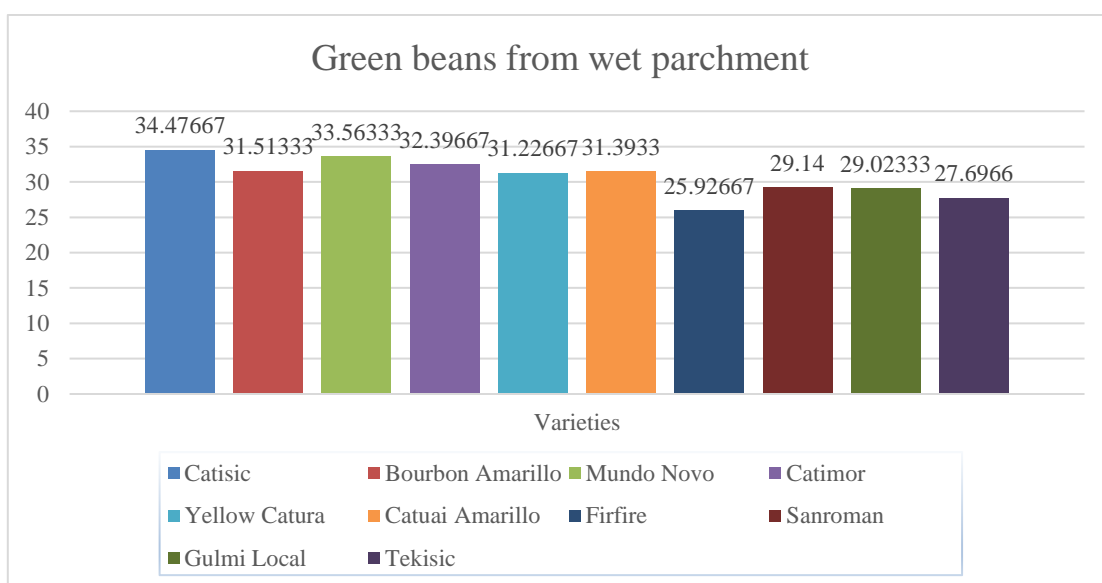*Recovery Percentage of Green Beans from Wet Parchment*
The mean recovery percentage of green beans from wet parchment was 30.45. Varieties significantly influenced the recovery percentage of green beans. Mundo Novo (33.56%) had the highest recovery percentage, which was statistically similar to Catisic (32.46%), Catimor (32.39%), Bourbon Amarillo (31.51%), Catuai Amarillo (31.39%) and Yellow catura (31.22%). Variety Firfire (25.96%) had the lowest recovery percentage, while varieties Sanroman (29.14%), Gulmi Local (29.02%), and Tekisic (27.96%) were statistically similar (Fig. 3).

Fig. 1: Recovery percentage of wet parchment from fresh cherry

Fig. 2: Recovery percentage of dry parchment from fresh cherry

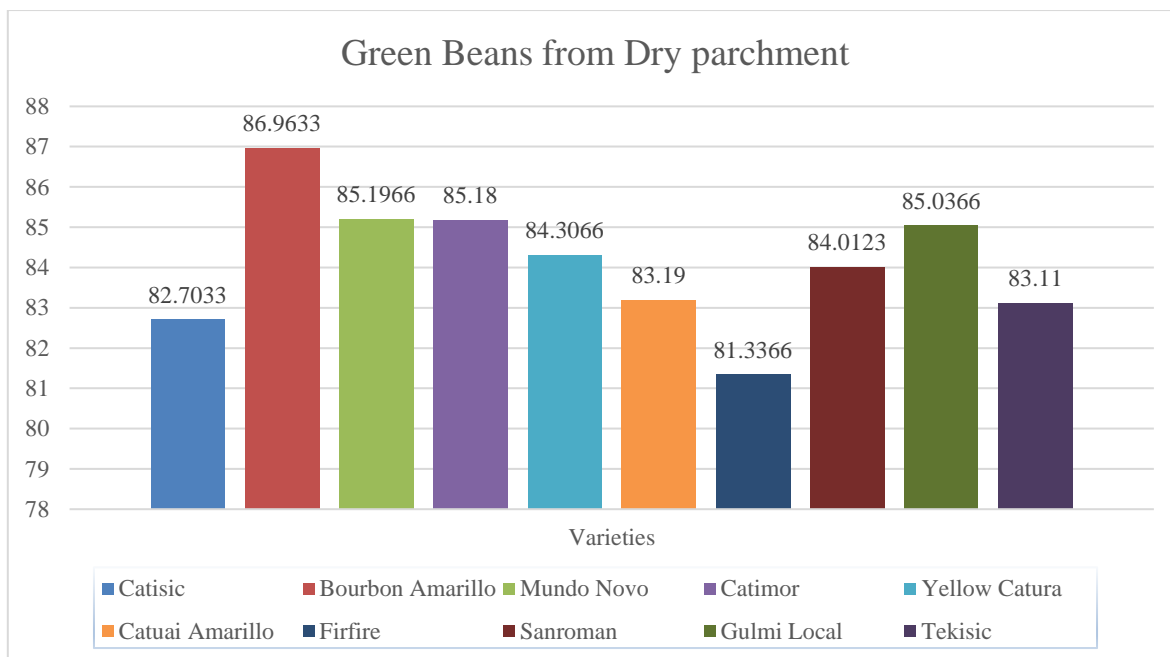**Fig. 3**: Recovery percentage of green beans from wet parchment

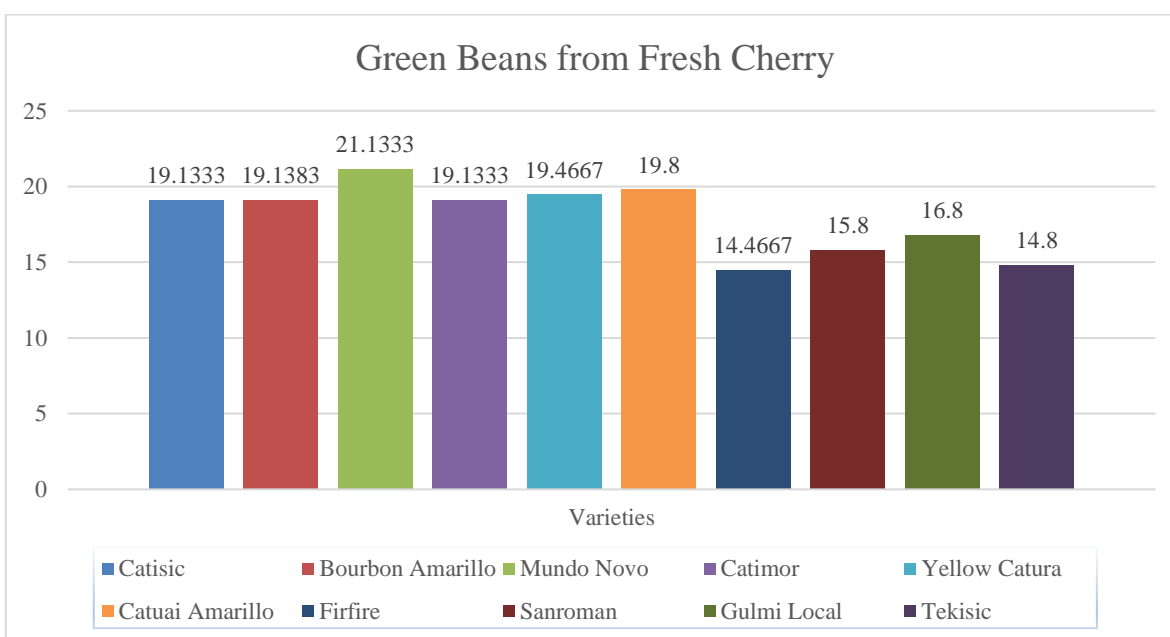*Recovery Percentage of Green Beans from Dry Parchment*
The mean recovery percentage of green beans from dry parchment was 83.87%. Mundo Novo (85.19%) had the highest recovery percentage, followed by Catimor (85.18%), Gulmi Local(85.03%), Yellow Catura (84.30%), Sanroman (84.01%), Bourbon Amarillo (83.96%), Catuai Amarillo (83.19%), Tekisic (83.11%), Catisic (82.70%) and Firfire (81.33%) (Fig. 4).

Recovery Percentage of Green Beans from Fresh Cherry
The mean recovery percentage of green beans from fresh cherry was 17.9%. Varieties significantly influenced the recovery percentage of green beans. Mundo Novo(21.13%) had the highest recovery percentage, statistically similar to Catuai Amarillo (19.80%). Similarly, Catuai Amarillo (19.80%), Yellow Catura (19.47%), Catisic (19.13%), Bourbon Amarillo (19.13%), and Catimor (19.13) were statistically similar. Firfire (14.47%) had the lowest recovery percentage, to which Sanroman (15.80%) and Tekisic (14.80%) were statistically similar (Fig. 5).

Fig. 4: Recovery percentage of green beans from dry parchment
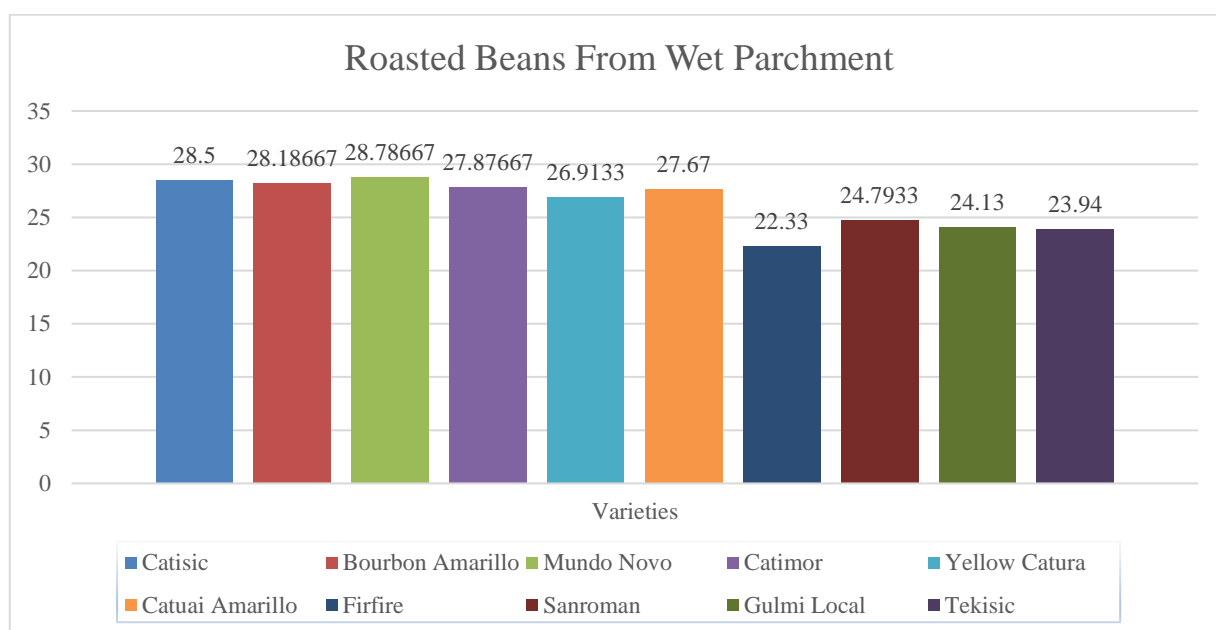

Fig. 5: Recovery percentage of green beans from Fresh Cherry

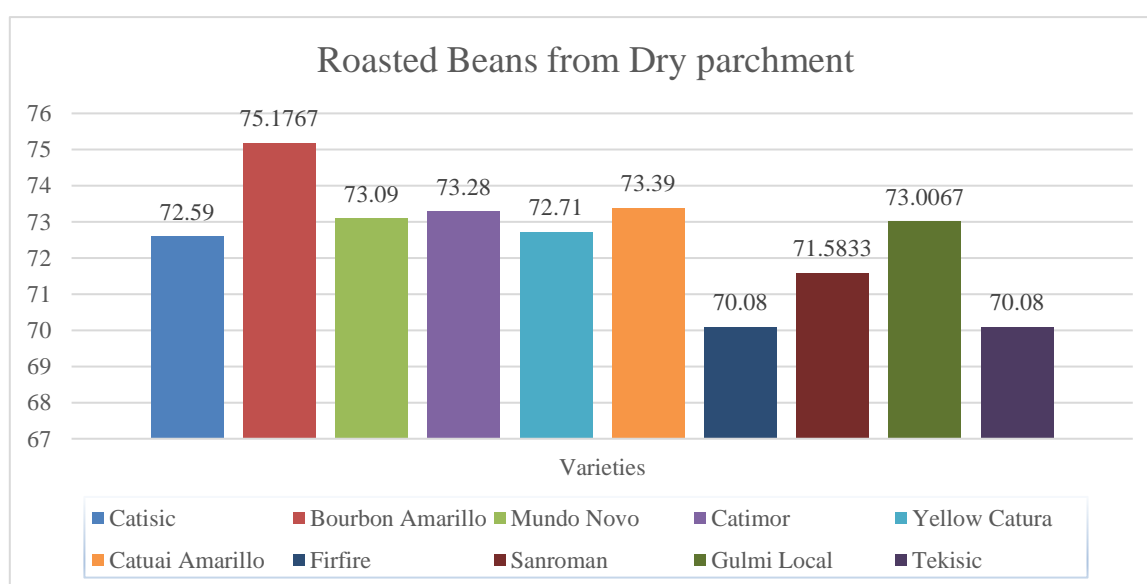*Recovery Percentage of Roasted Beans from Wet Parchment*

The mean recovery percentage of roasted beans from wet parchment was 2.24%. Varieties significantly influenced the recovery percentage of roasted beans. Mundo Novo (28.78%) had the highest recovery percentage, to which Catisic (28.50%), Bourbon Amarillo (28.18%), Catimor (27.87%), Catuai Amarillo (27.67%) and Yellow Catura (26.91%) were statistically similar. At the same time, Firfire (22.33%) had the lowest recovery percentage. Gulmi Local (24.13%) and Tekisic (23.34%) were statistically similar to Firfire (22.33%) (Fig. 6).

Recovery Percentage of Roasted Beans from Dry Parchment

The mean recovery percentage of roasted beans from dry parchment was 72.49%. The varieties did not significantly influence the recovery percentage of roasted beans from dry parchment; however, Bourbon Amarillo (75.17%) had the highest recovery percentage, followed by Catuai Amarillo (73.39%), Catimor (73.28%), Mundo Novo (73.09%), Gulmi Local (73.007%), Yellow Catura (72.71%), Catisic (72.59%), Sanroman (71.58%). Firfire (70.08%) and Tekisic (70.08%). Firfire (70.08%) had the lowest recovery percentage. All varieties were statistically similar (Fig. 7).

Fig. 6: Recovery percentage of roasted beans from wet parchment
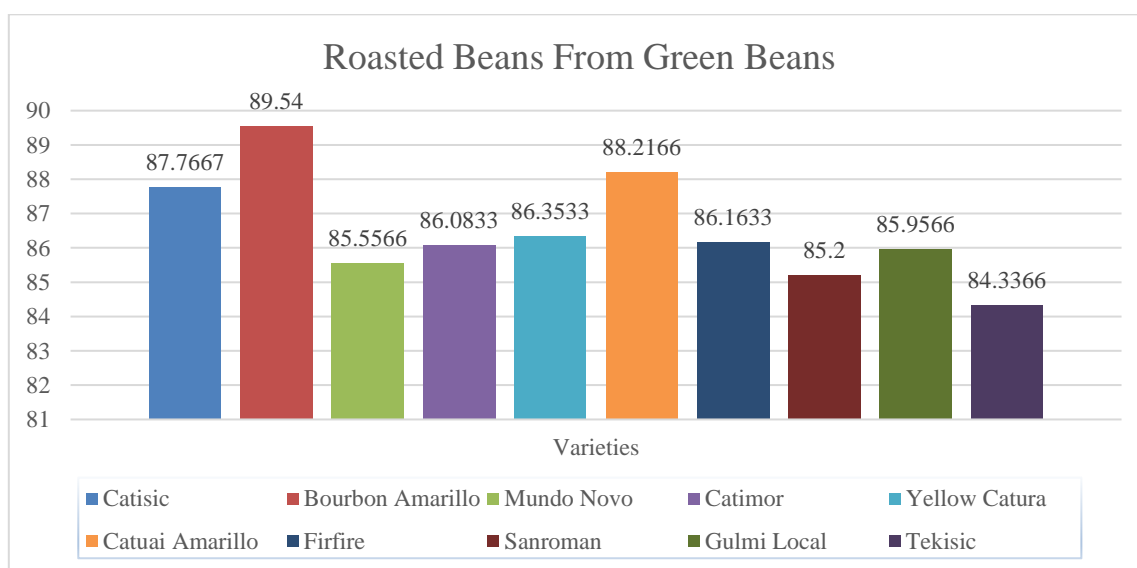

Fig. 7: Recovery Percentage of roasted beans from dry parchment

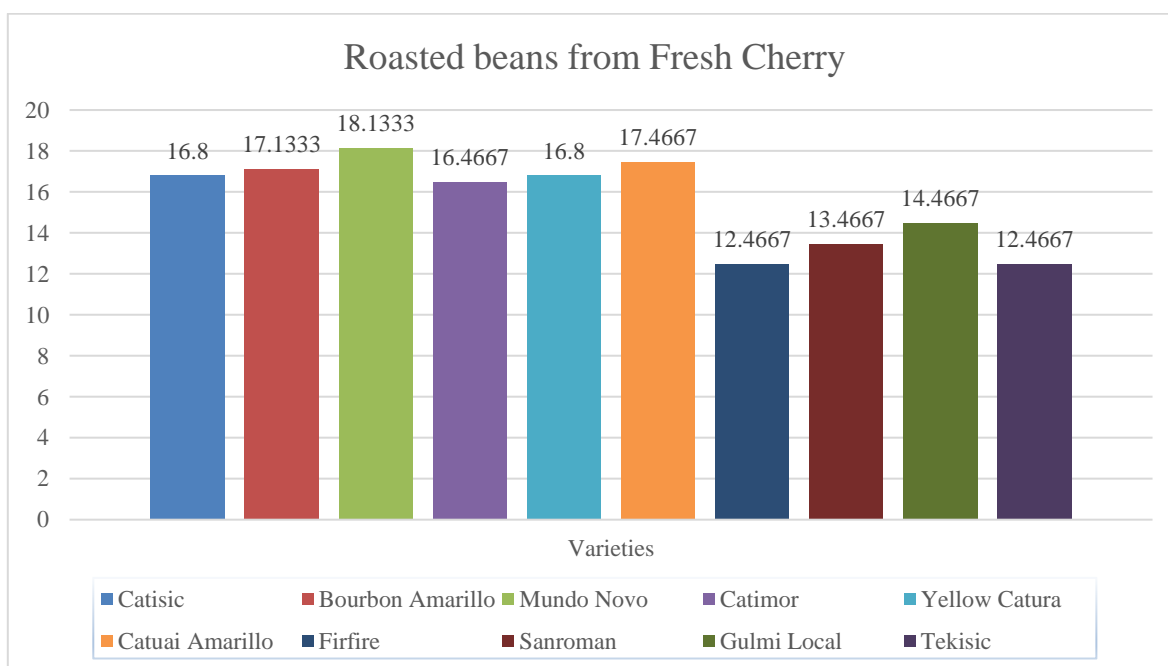*Recovery Percentage of Roasted Beans from Green Beans*
The mean recovery percentage of roasted beans from green beans was 86.54%. Varieties did not significantly influence the recovery percentage of roasted beans from green beans. However, Bourbon Amarillo (89.54%) had the highest recovery, followed by Catuai Amarillo (88.21), Catisic (87.76%), Yellow Catura (86.35%), Firfire (86.16%), Catimor (86.08%), Gulmi Local (85.95%), Mundo Novo (85.77%), Sanroman (85.20%) and Tekisic (84.33%). All varieties were statistically similar in the case of roasted beans recovery from green beans (Fig. 8).

Recovery Percentage of Roasted Beans from Fresh Cherry
The mean recovery percentage of roasted beans from fresh cherry was 15.56%. Varieties significantly influenced the recovery percentage of roasted beans. Mundo Novo (18.13%) had the highest recovery percentage, which was statistically similar to Catuai Amarillo (17.46%), Bourbon Amarillo (17.13%), Catisic (16.80%), Yellow Catura (16.80%) and Catimor (16.46%). Similarly, Gulmi local (14.46%) and Sanroman (13.46%) were statistically similar. Variety Tekisic (12.46%) had the lowest recovery percentage, to which Sanroman (13.46%) and Firfire (12.46%) were statistically identical (Fig. 9).

Fig. 8: Recovery Percentage of roasted beans from green beans

Fig. 9: Recovery percentage of roasted beans from fresh cherry

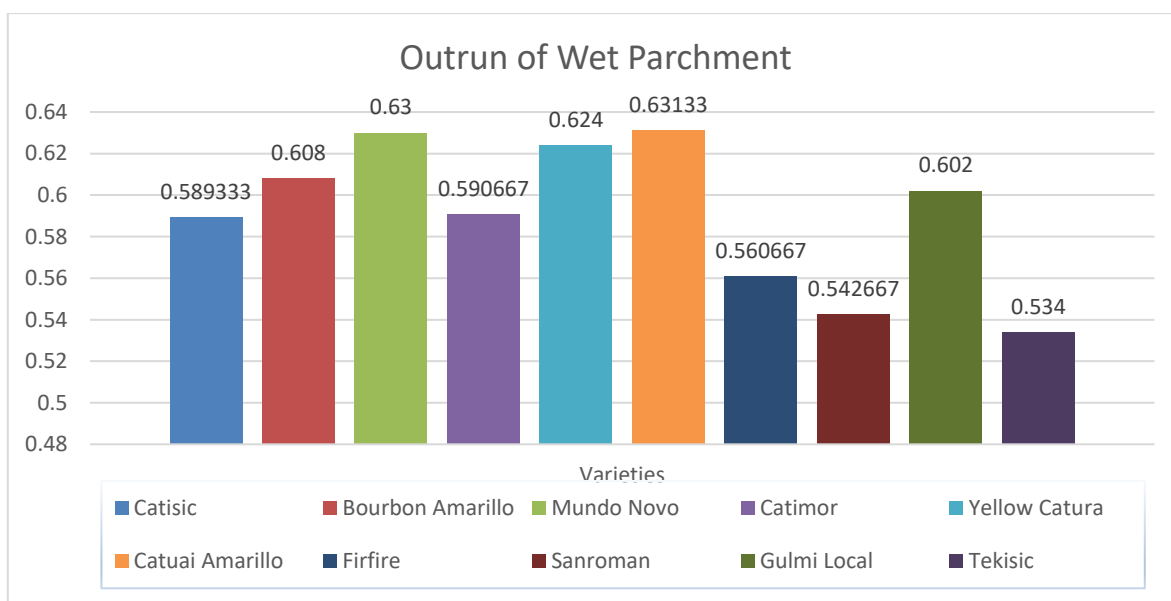### Results of Outturn of Parchment Green Beans and Roasted Beans

Outturn of Wet Parchment

The mean outturn of wet parchment was found to be 0.59 kg. Varieties significantly influenced the outturn of wet parchment. Catuai Amarillo (0.63 kg) has the highest outturn, whichwas statistically similar to Mundo Novo (0.63 kg), Yellow Catura (0.62 kg), Bourbon Amarillo (0.60 kg), Gulmi Local (0.60 kg), Catimor (0.59 kg) and Catisic (0.58 kg). Similarly, Firfire (0.56 kg), Sanroman (0.54 kg) and
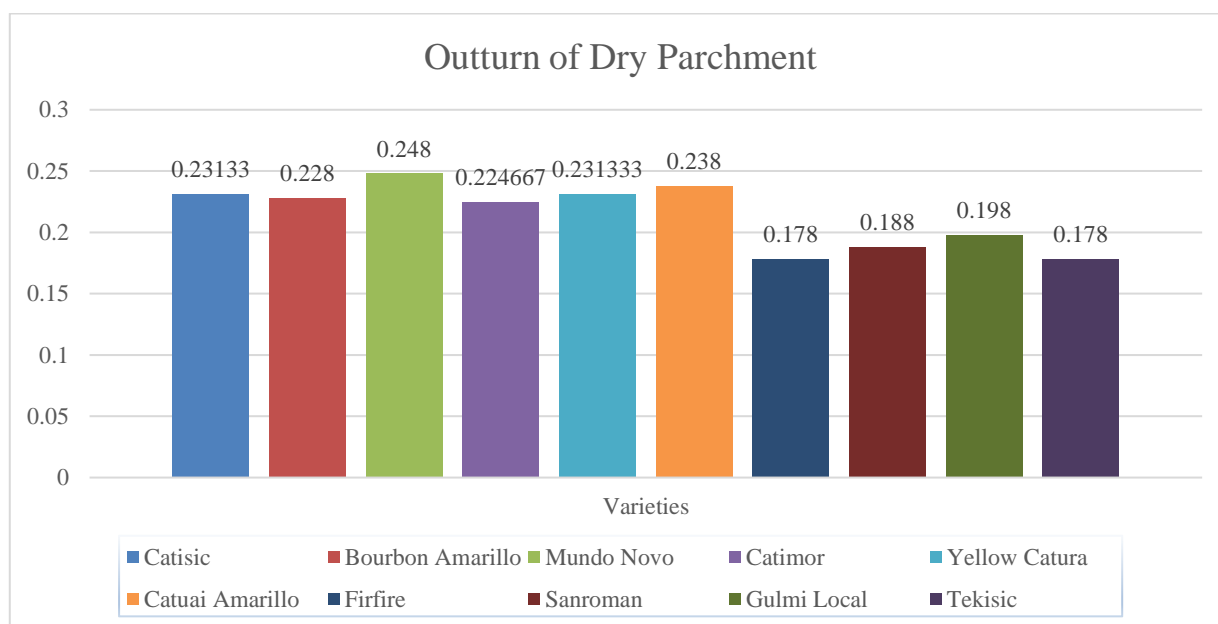
Tekisic (0.53 kg) were statistically similar, and Tekisic (0.53 kg) had the lowest outturn (Fig. 10).

Outturn of Dry Parchment

The mean outturn of dry parchment was found to be 0.21 kg. Varieties significantly influenced the outturn of dry parchment. Mundo Novo (0.24 kg) had the highest outturn, which was statistically similar to Catuai Amarillo (0.23 kg), Catisic (0.23 kg) and Yellow Catura (0.23 kg).Similarly, Sanroman (0.18 kg), Firfire (0.17 kg) and Tekisic (0.17 kg) were statistically similar.Firfire (0.17 kg) and Tekisic (0.17 kg) had the lowest outturn (Fig. 11).

Fig. 10: Outturn of wet parchment

Fig. 11: Outturn of dry parchment

Outturn of Green Beans

The mean outturn of green beans was found to be 0.17 kg. Varieties significantly influenced the outturn of green beans. Mundo Novo (0.21 kg) had the highest recovery percentage, which was statistically similar to Catuai Amarillo (0.19 kg). Yellow Catura (0.19 kg), Catisic (0.19 kg), Bourbon Amarillo (0.19 kg) and Catimor (0.19 kg) were statistically similar and followed by Mundo Novo (0.21 kg). Firfire (0.14 kg) had the lowest outturn, to which Sanroman (0.15 kg) and Tekisic (0.14 kg) were statistically similar (Fig. 12).

Outturn of Roasted Beans

The mean outturn of roasted beans was found to be 0.15 kg. Varieties significantly influenced the outturn of roasted beans. Mundo Novo (0.18 kg) had the highest outturn, which was statistically similar to Catuai Amarillo (0.17 kg), Bourbon Amarillo (0.17 kg), Catisic (0.16 kg), Yellow Catura (0.16 kg) and Catimor (0.16 kg). Likewise, Sanroman (0.13 kg), Firfire (0.12 kg) and Tekisic (0.12 kg) were statistically similar. Firfire (0.12 kg) and Tekisic (0.12 kg) had the lowest outturn (Fig. 13).
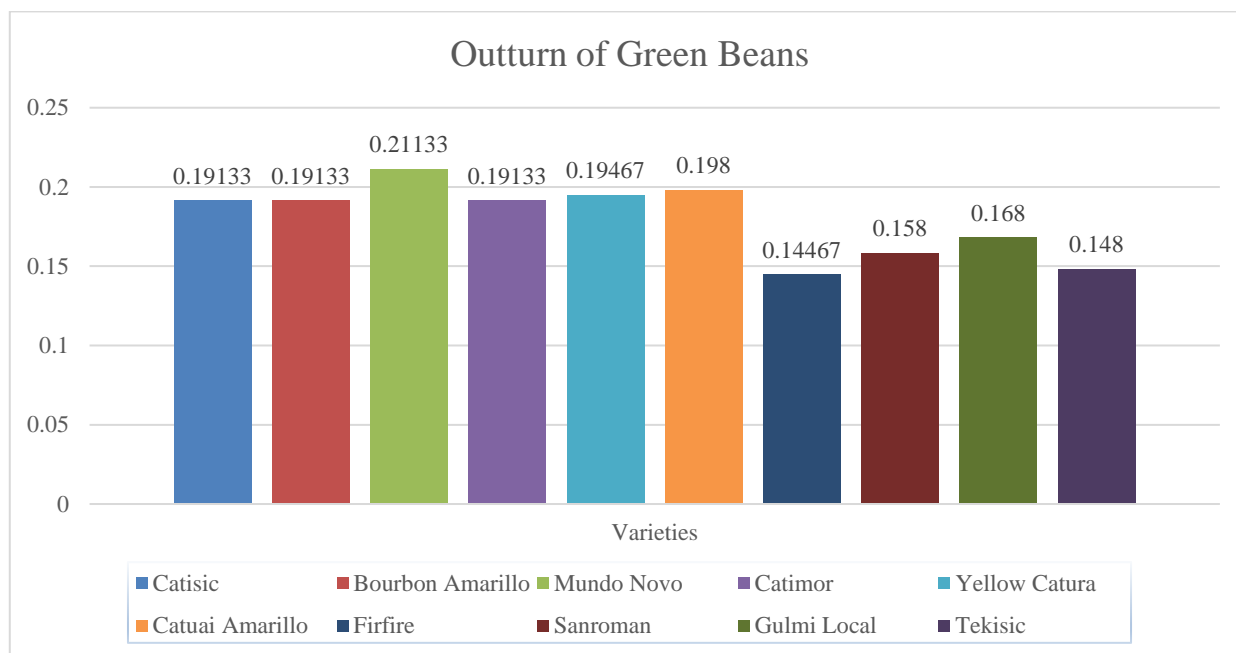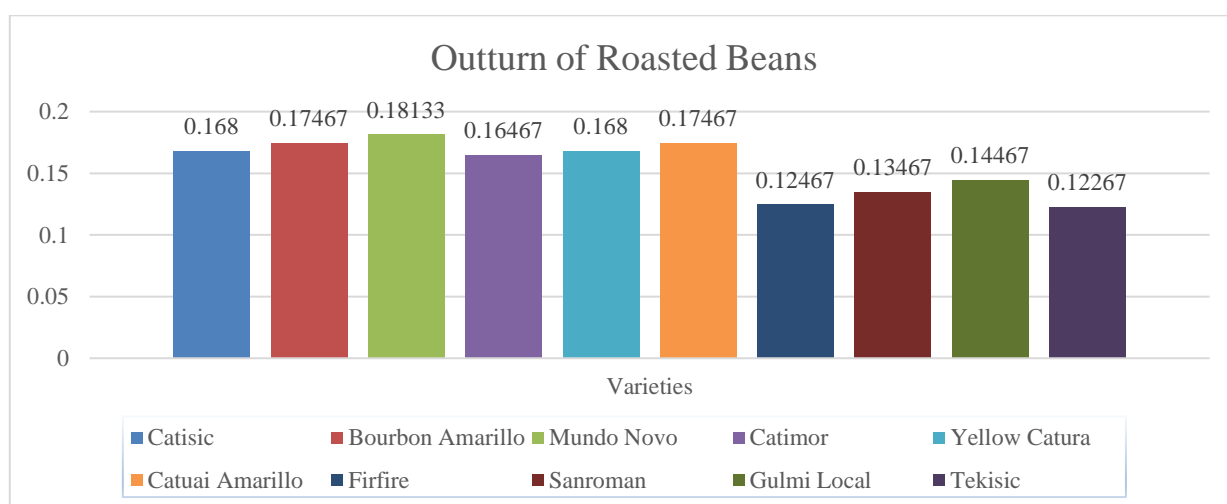

Fig. 12: Outturn of green beans

Fig. 13: Outturn of roasted beans

Discussion

Recovery Percentage of Parchment, Green Beans and Roasted Beans

Recovery Percentage of Parchment:

The recovery percentage of wet parchment derived from fresh cherry exhibited statistical significance and was notably influenced by varieties, as detailed in Appendix 1. Catuai Amarillo exhibited the highest recovery percentage, followed by Mundo Novo, Yellow Catura, Bourbon Amarillo, Catimor, and Catisic. Conversely, varieties Tekisic demonstrated the lowest recovery percentage. Notably, the uniform ripeness and size of fresh cherries, along with the well-maintained condition of the pulping machine, contributed to the uniformity in the results. The average recovery percentage was determined to be 59.12%. A parallel study by Mutua (2000) reported recovery percentages within the range of 40% to 60%.

Similarly, the recovery percentage of dry parchment from fresh cherry was significantly influenced by varieties (Appendix 1). Mundo Novo exhibited the highest recovery percentage, followed by Catuai Amarillo, Catisic, and Yellow Catura varieties. Conversely, varieties Tekisic and Firfire displayed the lowest recovery percentages. The wet parchment underwent a recommended fermentation period of 48 hours, as per the guidelines of Coffee Research Program and Coffee Development Center. Adequate drying was ensured under shade and in plastic/solar houses for a duration of 30 days. Furthermore, meticulous removal of floated wet parchment during the washing process of fermented parchments was identified as a crucial factor contributing to the highest recovery percentage of dry parchment. The average recovery percentage of dry parchment was determined to be 21.43%, as reported by BeaCoN (2018).

Recovery Percentage of Green Beans:

The recovery percentage of green beans derived from fresh cherry exhibited statistical significance, with the highest recovery percentage observed in the Mundo Novo variety, followed by Catuai Amarillo, Yellow Catura, Catisic, Bourbon Amarillo, and Catimor. Conversely, Firfire and Tekisic varieties exhibited the lowest recovery percentages. It is noteworthy that varieties characterized by larger fruit widths were associated with a diminished fresh cherry-to-clean coffee conversion out-turn ratio (Sualeh and Dawid, 2014).

The recovery percentage of green beans obtained from wet parchment displayed statistical significance and was influenced by varieties, as outlined in Appendix 2. Mundo Novo exhibited the highest recovery percentage, succeeded by Catisic, Catimor, Bourbon Amarillo, Catuai Amarillo, and Yellow Catura. In contrast, Tekisic and Firfire demonstrated the lowest recovery percentages. The overall average recovery percentage from wet parchment was determined to be 30.43% (Raghuramolu and Gopinandhan, 2020).

While the recovery percentage of green beans from dry parchment did not exhibit statistically significant variations among varieties (Appendix 2), Mundo Novo showcased the highest recovery percentage, followed by Catimor, Gulmi Local, Yellow Catura, Sanroman, Bourbon Amarillo, Catuai Amarillo, Tekisic, Catisic, and Firfire. Firfire, in particular, exhibited the lowest recovery percentage among the considered varieties. The average recovery percentage of green beans from dry parchment was found to be 83.80%, aligning with similar findings reported by ICO (2021).

Recovery Percentage of Roasted Beans:

The recovery percentage of roasted beans derived from fresh cherry exhibited significant variability among varieties, as outlined in Appendix 3. Mundo Novo demonstrated the highest recovery percentage, succeeded by Catuai Amarillo, Bourbon Amarillo, Catisic, Yellow Catura, and Catimor, while Firfire and Tekisic exhibited the lowest recovery percentages. Utilizing a mechanical roaster, uniform green beans underwent roasting at the recommended temperature and time (240∘C for 15 minutes), resulting in a heightened recovery percentage of roasted beans at 15.57%.

The recovery percentage of roasted beans from wet parchment was also notably influenced by varieties (Appendix 3). Mundo Novo showcased the highest recovery percentage, followed by Catisic, Bourbon Amarillo, Catimor, Catuai Amarillo, and Yellow Catura, with Firfire displaying the lowest recovery percentage. The average recovery percentage across varieties was 26.26%.

Although the recovery percentage of roasted beans from dry parchment did not exhibit significant variations among varieties (Appendix 3), Bourbon Amarillo displayed the highest recovery percentage, trailed by Catuai Amarillo, Catimor, Mundo Novo, Gulmi Local, Yellow Catura, Catisic, Sanroman, Firfire, and Tekisic. Tekisic and Firfire had the lowest recovery percentages. The average recovery percentage was determined to be 72.47%.

Similarly, the recovery percentage of roasted beans from green beans was not significantly influenced by varieties (Appendix 3). Bourbon Amarillo led with the highest recovery percentage, followed by Catuai Amarillo, Catisic, Yellow Catura, Firfire, Catimor, Gulmi Local, Mundo Novo, Sanroman, and Tekisic, with Tekisic exhibiting the lowest recovery percentage. The average recovery percentage across varieties was 86.53%. ICO (2021) reported a recovery percentage of roasted beans from green beans at 84%, and further noted that the conversion from roasted beans to green beans involved multiplying the net weight of the roasted coffee by a factor of 1.1.

Out-Turn of Parchment Green Beans and Roasted Beans

The outturn of wet parchment was found to be significantly influenced by varieties, as outlined in Appendix 1. Catuai Amarillo demonstrated the highest outturn, followed by Mundo Novo, Yellow Catura, Bourbon Amarillo, Gulmi Local, Catimor, and Catisic. Tekisic exhibited the lowest outturn. According to CCRI (2020) the conversion of 100 kg of fresh cherry results in 36-44 kg of wet parchment. The average outturn of wet parchment was determined to be 0.59 kg from 1 kg of fresh cherry.

Varieties also played a significant role in influencing the outturn of dry parchment, as indicated in Appendix 1. Mundo Novo had a higher outturn, followed by Catuai Amarillo, Catisic, Yellow Catura, Bourbon Amarillo, Catimor, Gulmi Local, Sanroman, Firfire, and Tekisic. Tekisic and Firfire exhibited the lowest recovery percentage. The average outturn, consistent with ICO (2021) findings, was determined to be 0.21 kg.

Similarly, the outturn of green beans was notably affected by varieties (Appendix 2). Mundo Novo displayed the highest outturn, followed by Catuai Amarillo, Yellow Catura, Catisic, Bourbon Amarillo, Catimor, Gulmi Local, Sanroman, Tekisic, and Firfire. Tekisic and Firfire had the lowest outturn among the varieties considered. The average outturn of 0.17 kg was corroborated by ICO (2021), CCRI (2020), and Raghuramolu & Gopinandhan (2020).

In the case of roasted beans, varieties played a significant role in determining the outturn (Appendix 3). Mundo Novo showed the highest outturn, followed by Catuai Amarillo, Bourbon Amarillo, Catisic, Yellow Catura, Catimor, Gulmi Local, Sanroman, Firfire, and Tekisic. Firfire and Tekisic exhibited the lowest outturn among the considered varieties.

The uniform ripening, consistent size, proper pulping, fermentation, uniform and adequate drying, careful hulling, and roasting at recommended temperature and time were identified as factors contributing to the highest recovery percentage and outturn.

Conclusion

The coffee varieties were ranked based on recovery percentage, with Mundo Novo exhibiting the highest recovery, followed by Catuai Amerillo, Yellow Catura, Catisic, Catimor, Bourbon Amerillo, Gulmi Local, Sanroman, Tekisic, and Firfire. Conversely, Firfire and Tekisic demonstrated the lowest recovery percentages. Consequently, Mundo Novo and Catuai Amerillo are recommended for cultivation by farmers in Aapchaur, Gulmi. The conversion amounts from 1 kg of fresh cherry into wet parchment, dry parchment, green beans, and roasted beans were determined as follows: 0.6 kg, 0.21 kg, 0.18 kg, and 0.15 kg, respectively.

Authors' Contribution

M Sapkota, D Chand and K kafle designed the research plan; M Sapkota, D Chand and K kafle performed experimental works & collected the required data. M Sapkota, K Kafle, & PR Dhital analysed the data; M Sapkota, D Chand & K Kafle prepared the manuscript. M Sapkota, D Chand & A Poudel critically revised and finalized the manuscript. Final form of manuscript was approved by all authors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work report in this paper.

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Appendices

Appendix 1: Recovery percentage and out-turn of wet and dry parchment from fresh cherry

	Weight of wet parchment (kg)	Weight of dry parchment (Kg)	Recovery% of wet parchment	Recovery % of dry parchment
Catisic	0.58[abc]	0.23[ab]	58.93[abc]	24.13[ab]
BourbonAmarillo	0.60[ab]	0.22[b]	60.80[ab]	22.80[b]
Mundo Novo	0.63[a]	0.24[a]	63.00[a]	24.80[a]
Catimor	0.59[abc]	0.22[b]	59.06[abc]	22.46[b]
YellowCatura	0.64[a]	0.23[ab]	62.40[a]	23.13[ab]
Catuai Amarillo	0.63[a]	0.23[ab]	63.13[a]	23.80[ab]
Firfire	0.56[bcd]	0.17[d]	56.06[bcd]	17.80[d]
Sanroman	0.54[cd]	0.18[cd]	54.26[cd]	18.80[cd]
Gulmi Local	0.60[ab]	0.19[c]	60.20[ab]	19.80[c]
Tekisic	0.53[d]	0.17[d]	53.40[d]	17.80[d]
LSD	0.05	0.01	5.02	1.74
SEM(±)	0.01	0.005	1.69	0.58
F-probability(0.05)	**	***	**	***
CV%	4.95	4.75	4.95	4.75
Grant Mean	0.59	0.21	59.12	21.43

Note: NS: Non- Significance; Treatment- mean followed by a common letter(s) within t h e same column are not significantly different based on DMRT at a 5% significance level.

Appendix 2: Recovery percentage of green beans

	Weight of green beans (kg)	Recovery % of green beans from wet parchment	Recovery % of green beansfrom dry parchment	Recovery % of green beans fomfresh cherry
Catisic	0.19[b]	32.47[ab]	82.70[a]	19.13[b]
Bourbon Amarillo	0.19[b]	31.51[ab]	83.96[a]	19.13[b]
Mundo Novo	0.21[a]	33.56[a]	85.19[a]	21.13[a]
Catimor	0.19[b]	32.39[ab]	85.18[a]	19.13[b]
Yellow Catura	0.19[b]	31.22[ab]	84.30[a]	19.46[b]
Catuai Amarillo	0.19[ab]	31.39[ab]	83.19[a]	19.80[ab]
Firfire	0.14[d]	25.92[c]	81.33[a]	14.46[d]
Sanroman	0.15[cd]	29.14[bc]	84.01[a]	15.80[cd]
Gulmi Local	0.16[c]	29.02[bc]	85.03[a]	16.80[c]
Tekisic	0.14[d]	27.69[c]	83.11[a]	14.80[d]
LSD	0.013	3.08	3.64	1.37
SEM(±)	0.0046	1.03	1.22	0.46
F-probability(0.05)	***	**	NS	***
CV%	4.45	5.90	2.53	4.45
Grand Mean	0.17	30.43	83.80	17.96

Note: NS: non- significance; Treatment- mean followed by a common letter(s) within t h e same column are not significantly different based on DMRT at a 5% significance level.

Appendix 3: Recovery percentage of roasted beans from wet parchment, dry parchment, greenbeans and roasted beans and out-turn of roasted beans

	Weight of roasted beans (Kg)	Recovery % of roasted beansfrom wet parchment	Recover % of roasted beansfrom dry parchment	Recovery % of roasted beans from green beans	Recovery % of roasted beans from fresh cherry
Catisic	0.16[a]	28.50[a]	72.59[a]	87.76[a]	16.80[a]
BourbonAmarillo	0.17[a]	28.18[a]	75.17[a]	89.54[a]	17.13[a]
Mundo Novo	0.18[a]	28.78[a]	73.09[a]	85.55[a]	18.13[a]
Catimor	0.16[a]	27.87[a]	73.28[a]	86.08[a]	16.46[a]
YellowCatura	0.16[a]	26.91[ab]	72.71[a]	86.35[a]	16.80[a]
Catuai Amarillo	0.17[a]	27.67[a]	73.39[a]	88.21[a]	17.46[a]
Firfire	0.12[c]	22.33[d]	70.08[a]	86.16[a]	12.46[c]
Sanroman	0.13[bc]	24.79[bc]	71.58[a]	85.20[a]	13.46[bc]
Gulmi Local	0.14[b]	24.13[cd]	73.006[a]	85.95[a]	14.46[b]
Tekisic	0.12[c]	23.34[cd]	70.08[a]	84.33[a]	12.46[c]
LSD	0.015	2.24	4.54	5.41	1.59
SEM(±)	0.004	0.75	1.52	1.82	0.53
F-probability(0.05)	***	***	NS	NS	***
CV%	5.95	4.99	3.65	3.64	5.95
Grand Mean	0.15	26.25	72.49	86.53	15.56

Note: NS, non- significance; Treatment- mean followed by a common letter(s) within t h e same column are not significantly different based on DMRT at a 5% significance levelAppendix 4: Mean square from ANOVA for recovery percentage and out-turn of parchment(wet and dry) as influenced by a variety

Appendix 4: Mean square from ANOVA for recovery percentage and out-turn of parchment(wet and dry) as influenced by a variety

Sources	Degree of freedom	Wt. of wet parchment	Wt. of dry parchment	Recovery percentage ofwet parchment from fresh cherry	Recovery percentage ofdry parchment from fresh cherry
Treatments	9	0.003**	0.002***	37.18**	20.55***
Replication	2	0.001	0.00016	14.40	1.63
Error	18	0.0008	0.0001	8.58	1.04

Appendix 5: Mean Square from ANOVA for recovery percentage and out-turn of green beansas Influenced by variety.

Sources	Degree of freedom	Wt. of green beans	Recovery percentage of green beans from wet parchment	Recovery percentage of green beans from dry parchment	Recovery percentage of green beans from fresh cherry
Treatments	9	0.001***	17.33**	4.61.	16.01***
Replication	2	0.00002	2.65	13.30	0.23
Error	18	0.00006	3.22	4.52	0.64

Appendix 6: Mean Square from ANOVA for recovery percentage and outturn of roasted beans as influenced by a variety

Source	Degree offreedom	Wt. ofroasted beans	Recovery percentageof roasted beans from wet parchment	Recovery percentageof roasted beans fromdry parchment	Recovery percentage of roasted beans from green beans	Recovery percentage of roasted beans from fresh cherry
Treatments	9	0.001***	16.93***	7.25	7.09	13.78***
Replication	2	0.00009	3.18	2.43	11.63	0.93
Error	18	0.00008	1.71	7.00	9.97	0.85