

Evaluation of Small Sized Watermelon Varieties for the Bhutanese Market

Pema Yangdon^h, Sonam Tashiⁱ, Thinley Wangdiⁱ, Tshering Yangchenⁱ, Lungkiⁱ, Thinley Gyeltshenⁱ, Dechen Zangmoⁱ, Tshering Tobgay^j

Abstract

Watermelon is one of the important emerging cash crops in Bhutan contributing to the generation of farmer's income. However, a major challenge in watermelon farming in Bhutan is the lack of varieties with fruit sizes preferable to the consumers. Therefore, this research aimed to evaluate new hybrid watermelon varieties with smaller sized fruits for commercial cultivation in Bhutan. This study was conducted in four different locations in three research centres (ARDC Wengkhari, ARDC Bajo and ARDC Samteling). Six hybrid varieties namely, PPS 142, PPS 304, PPS 313, PPS 315, PPS 317 and Sugar Baby (check) were evaluated with two replications following completely randomized design. Fruit weight, diameter, height, Total Soluble Solids (TSS), fruit colour, flesh colour and yield per plot were recorded from the sample fruits. In addition, market and consumer preference surveys were conducted involving 11 vendors and 20 consumers in Mongar to evaluate the acceptability of varieties by vendors and consumers. The results showed that there was no significant difference in fruit weight, TSS, crop duration and yield among the six varieties. However, significant location-based variation was observed in the fruit weight and yield. All the varieties fell within the medium-sized category, commonly referred to as the "icebox" type in Lingmethang, Bajo and Panbang while it fell under "personal" type in Samteling. The consumer and market preference survey indicated a preference for medium-sized, round fruits with a dark green colour, which aligns with the characteristics observed in the evaluated varieties. This result of this study provides varietal choices to farmers to produce and market suitable varieties and for consumers to obtain optimum fruit size varieties for consumption.

Keywords: Watermelon; Weight; TSS; Yield; Consumer preference

Corresponding author: pyangdon@moal.gov.bt

^h Agriculture Research and Development Centre, Wengkhari, Department of Agriculture, Ministry of Agriculture and Livestock

ⁱ Agriculture Research and Development Centre, Bajo, Department of Agriculture, Ministry of Agriculture and Livestock

^j Agriculture Research and Development Centre, Samteling, Department of Agriculture, Ministry of Agriculture and Livestock

1 Introduction

The global watermelon production has witnessed a remarkable growth, surging from 21.1 million tonnes in 1972 to 101 million tonnes in 2021, reflecting an average annual growth rate of 3.42% (FAO, 1972; FAO, 2021). Scientifically classified as *Citrullus lanatus*, and a member of the Cucurbitaceae family, watermelon is mostly consumed fresh and chilled, often served as a refreshing dessert. Additionally, its rind is occasionally processed into preserves and jam (Maynard, 2008). Distinguished by its high water content, which stands at 92%, watermelon is renowned for its juicy, sweet, and refreshing qualities, especially during hot weather (Leskovar et al., 2007; Romdhane et al., 2017). Consequently, it ranks as the second most widely grown fruits after banana in 2021 (FAO, 2021). Notably, watermelon boasts as a high lycopene containing fruit, with certain types containing more lycopene than tomatoes (Guner & Wehner, 2004). Furthermore, watermelon is rich in vitamins B, C, and E, as well as essential minerals like phosphorus, magnesium, calcium, and iron (Romdhane et al., 2017). It also provides valuable antioxidant compounds such as polyphenols, anthocyanins and flavonoids to the consumers (Jaskani et al., 2005; Kaur & Kapoor, 2008).

In Bhutan, watermelon is one of the important emerging cash crops which play a pivotal role in supplementing the income of numerous rural farmers' households (Kuensel, 2023). The country has witnessed swift increase in watermelon production, recording a total production of 156.02 metric tons in 2021 which is nearly a threefold increase compared to the preceding year as reported in Agriculture statistics (NSB, 2021; NSB, 2022). This fruit shows great promise due to its quick growth cycle and thus, there is an increasing popularity for large-scale cultivation in the country.

According to the existing literature, watermelon is categorized into three different types based on size: “personal” for the small size, weighing less than 2.6 kg; “icebox” for medium sized watermelons, ranging from 2.6 to 6.8 kg; and “picnic” for the large sized watermelons exceeding 6.8 kg (Miles et al., 2004). Large sized watermelons are often referred to as “picnic” type as they are commonly used to feed large gatherings during picnics, while the “personal” and “icebox” types are typically consumed within households (Klein, 2023).

In many countries, large sized watermelons are primarily sold as fresh cut fruit due to their challenging single serving consumption size (Mendoza-Enano et al., 2019). However, once

sliced, these watermelons are highly perishable owing to their high pH level (ranging from 5.2 to 6.7) and a water content ranging between 97 to 99%, which limits their shelf-life at the retail level (Cartaxo & Sargent, 1998; Lemos et al., 2017). Furthermore, fresh-cut watermelon is susceptible to off-odour development, discoloration, juice leakage, texture loss and microbial growth (Zhuang et al., 2011). Sliced watermelons also pose concerns related to heavy metal contamination and fungal and yeast growth, raising hygiene and consumer health issues (Aladesanmi, 2021). In contrast, small and medium sized watermelons are typically sold as whole fruits, ensuring freshness and hygiene. They are convenient for small households and easily fit into the refrigerator (Maynard, 2008). Moreover, they mature faster than the large sized varieties (Miles et al., 2004) allowing for immediate consumption without the need for refrigeration, which can otherwise compromise their sweetness, flavour and overall freshness (Gil et al., 2006). As a result, small and medium sized watermelons are convenient for self-consumption and contain more pulp due to thin rind when compared to larger sized watermelons (Maynard, 2008).

A notable challenge in watermelon farming in Bhutan is the lack of variety choices and manageable sizes of the fruit. The only existing small sized variety in the country is Sugar Baby while most of the varieties in the country are large in size with excessive weight which is inconvenient for household consumption. Therefore, this research aimed to evaluate new hybrid watermelon varieties with small sized fruits to provide choices for compact watermelon varieties for commercial cultivation in Bhutan. The primary objectives of this study were to assess the feasibility of the production of the compact watermelon varieties in Bhutan and to determine the yield of these varieties.

2 Materials and method

2.1 Study area

The research was carried out in 2023 in four different locations in three research centres across the country: Agriculture Research and Development Subcentre (ARDSC) Lingmethang (Altitude: 600 m, 27°15'38"N, 91°10'46"E) in the eastern region, Agriculture Research and Development Centre (ARDC) Bajo (Altitude:1200m, 27°29'25"N, 89°53'56"E) in the central region, ARDC Samteling (Altitude:375m, 26°91'01"N, 90°43'10"E) and ARDSC Panbang (Altitude:94m, 26°51'17.4"N, 90°57'50.2"E) in the southern region.

2.2 Research design

In this experimental trial, a Completely Randomized Design (CRD) was used, involving six different treatments, each replicated twice. These treatments consisted of six hybrid varieties, specifically PPS315, PPS313, PPS142, PPS304, PPS317, along with a check variety Sugar Baby. The hybrid seeds were procured from Pariposa Seeds, India in collaboration with National Seed Centre, Paro.

2.3 Methodology

The research was carried out in 2023 in all the four study sites. The nursery was raised in the end of January at ARDSC Lingmethang and in February in three other centres. Subsequently, in the second week of March, the seedlings were transplanted, and the harvesting period extended from late May to the final week of June in all the areas. The field was partitioned into 12 plots, each measuring 15 square meters, with a minimum of five plants in each plot, spaced 1 m by 3 m apart.

From each replication, three plants were selected at random and assigned labels. Various parameters including weight, diameter, height, Total Soluble Solids (TSS), fruit colour, flesh colour, yield per plot and number of fruits per plant, were recorded from two fruits each from the three selected plants. Fruit TSS was measured using the refractometer while the fruit height and diameter was measured using Vernier calliper.

Furthermore, a survey was conducted to understand the preference of consumers and vendors on small sized watermelons by randomly selecting 31 participants (11 vendors and 20 consumers) from Mongar. Semi structured questionnaires were used for collecting data from the participants.

The collected data was analysed using R software. Analysis of Variance (ANOVA) was used to compare the weight, height, diameter, TSS, and yield among the six different varieties while descriptive statistics was used for analysing survey data. Tukey's post hoc test was performed to compare multiple interactions among six different varieties. The decision was made at 95% confidence interval for statistical test.

3 Result and Discussion

3.1 Findings from the field experiment

3.1.1 Fruit quality parameters among different watermelon varieties at Lingmethang

The results indicated that there was no statistically significant difference in fruit weight, fruit diameter, total soluble solids (TSS), crop maturity, and yield among six different watermelon varieties. However, a notable distinction existed in fruit height within the Lingmethang region (Table 1). All the six varieties exhibited a mean weight between 3 kg and 7.7 kg, indicating that all these varieties belonged to “icebox” type watermelon. Sugar Baby demonstrated the largest fruit size at 7.7 kg, followed by PPS 142 at 6.0 kg and PPS 313 at 5.5 kg. Significantly, Sugar Baby and PPS 142 exhibited higher yields, suggesting a positive correlation between increased fruit weight and overall crop yield.

On the contrary, PPS 315 and PPS 317 displayed smaller fruits at 3.0 kg and 4.9 kg, respectively. Surprisingly, these varieties yielded higher production than PPS 313 and PPS 304 due to a greater number of bearing fruits compared to other varieties. Coming to the sweetness of the fruit, the TSS of all the varieties ranged between 10.5% and 12.5%. Notably, PPS 313 exhibited a higher TSS content at 13%, followed by PPS 317 at 12.5%, and PPS 315 at 12%, while PPS 304 exhibited the lowest TSS of 10.5%. All six varieties were harvested 80 days after transplanting (DAT). In the Lingmethang, PPS 315 and PPS 317 produced medium-sized fruits (< 5 kg) with higher yields. Thus, these two varieties can be recommended for commercial production of smaller sized watermelon.

Table 7. Fruit quality parameters among different watermelon varieties at Lingmethang

Treatments	Fruit weight (kg)	Fruit height (cm)	Fruit diameter (cm)	TSS (%)	Crop duration (DAT)	Yield (kg/plant)
PPS 142	6.0 (1.3)	28.5 (4.2) ^{ab}	20.3 (0.4)	11.0 (0.0)	80.0 (0.0)	48.7 (0.5)
PPS304	5.0 (1.6)	21.5 (3.5) ^a	20.5 (3.5)	10.5 (0.7)	80.0 (0.0)	32.4 (2.6)
PPS 313	5.5 (0.9)	31.8 (1.8) ^b	19.0 (1.4)	13.0 (1.4)	80.0 (0.0)	37.9 (1.8)
PPS 315	3.0 (0.9)	20.3 (1.1) ^a	17.5 (2.1)	12.0 (0.0)	80.0 (0.0)	45.0 (22.9)
PPS 317	4.9 (1.6)	29.0 (4.2) ^{ab}	18.3 (2.4)	12.5 (0.7)	80.0 (0.0)	49.2 (6.8)
Sugar Baby	7.7 (1.3)	21.0 (0.0) ^a	25.5 (2.1)	11.0 (1.4)	80.0 (0.0)	51.4 (24.6)
<i>P-value</i>	0.12	0.03	0.09	0.17	0.49	0.73

*Different lower-case letters in the superscript indicate statistically significant differences following the Tukey's HSD post hoc analysis at $P < 0.05$; Values in parentheses indicate standard deviation of the mean

3.1.2 Fruit quality parameters among different watermelon varieties at Bajo

The result showed that there was a significant difference in fruit weight, fruit height, fruit diameter and crop yield of six different varieties while there were no significant differences in TSS and crop duration (Table 2). The mean weight of the watermelon ranged from 1.7 kg to 6.2 kg, falling under “icebox” type. Out of six varieties, the highest fruit weight was observed in PPS 142 and PPS 315 with a mean weight of 6.2 kg and 4.5 kg while the lowest mean weight was recorded in PPS 304 and PPS 317 with 1.7 kg and 2.1 kg respectively. Likewise, PPS 142 and PPS 317 demonstrated the highest mean plant yields at 52.9 kg and 37 kg, suggesting a positive correlation between fruit weight and yield, particularly in the case of PPS 142 (Table 2). While the increased yield in PPS 317 is attributed to a greater number of bearing fruits, akin to the trend observed in Lingmethang.

Table 8. Fruit quality parameters among different watermelon varieties at Bajo

Treatments	Fruit weight (kg)	Fruit height (cm)	Fruit diameter (cm)	TSS (%)	Crop duration (DAT)	Yield (kg/plant)
PPS 142	6.2 (1.2) ^b	27.9 (3.7) ^b	14.2 (0.6) ^a	10.5 (0.7)	82.0 (0.0)	52.9 (0.4) ^b
PPS304	1.7 (0.6) ^a	14.9 (2.0) ^a	13.4 (1.8) ^a	10.0 (1.4)	82.0 (0.0)	20.4 (1.8) ^a
PPS 313	2.6 (0.4) ^a	23.5 (1.1) ^{ab}	17.2 (0.4) ^a	12.5 (0.7)	82.0 (0.0)	23.0 (3.0) ^a
PPS 315	4.5 (0.7) ^{ab}	23.7 (2.0) ^{ab}	14.8 (0.5) ^a	12.0 (0.0)	82.0 (0.0)	21.9 (0.4) ^a
PPS 317	2.1 (0.1) ^a	22.5 (1.5) ^{ab}	17.9 (1.1) ^a	11.0 (1.4)	82.0 (0.0)	37.0 (2.3) ^{ab}
Sugar Baby	3.3 (1.3) ^{ab}	20.1 (3.7) ^{ab}	19.4 (2.2) ^a	11.5 (0.7)	82.0 (0.0)	25.5 (0.4) ^a
<i>P</i> -value	0.01	0.03	0.01	0.22	0.49	0

*Different lower-case letters in the superscript indicate statistically significant differences following the Tukey's HSD post hoc analysis at $P < 0.05$; Values in parentheses indicate standard deviation of the mean

The TSS content of the fruits ranged from 10% to 12.5%, with PPS 313 and PPS 315 exhibiting the highest TSS levels at 12.5% and 12% respectively. Harvesting for all the varieties completed within 82 DAT. In Bajo, PPS 304, PPS 313 and PPS 317 displayed fruit weights below 3 kg, with PPS 317 achieving higher yield despite its smaller size (Table 2). Consequently, PPS 317 can be recommended for commercial cultivation, emphasizing its suitability for smaller sized watermelons with a concurrently higher yield.

3.1.3 Fruit quality parameters among different watermelon varieties at Samtenling and Panbang

The result showed that there was no significant difference in fruit weight, fruit height, fruit diameter, TSS, crop duration and yield among the six varieties in both Panbang and Samtenling region (Table 3). The mean weight of watermelon varieties ranged from 2.9 kg to 4.9 kg, falling under the “icebox” type watermelon. In contrast to the Lingmethang and Bajo regions, PPS

304 displayed the highest weight at 4.9 kg in Panbang and 1.3 kg in Samtenling, while the lowest weights were observed at 2.9 kg and 3.1 kg in Sugar Baby and PPS 317 in Panbang. In Samtenling, all varieties exhibited a mean weight less than 1.5 kg, falling under the “personal” type.

The variety PPS 142 produced the highest mean plant yield of 24 kg in Panbang while PPS 304 recorded the highest mean plant yield of 24.5 kg in Samtenling. The highest yield of PPS 142 obtained at Panbang corresponded to the yield recorded at Lingmethang and Bajo. In comparison to other regions, Samtenling displayed relatively smaller sized fruits across all varieties, potentially influenced by soil and microclimate.

The TSS level of the fruits ranged from 9.0% to 11.7% in Panbang and 8.3% to 10.9% in Samtenling. The highest TSS was observed in PPS 304 in Panbang and PPS 315 in Samtenling. Additionally, the crop duration was 82 days in Samtenling and varied from 92 days to 113 days in Panbang. Considering the small size and higher yield, PPS 317 is recommended for Panbang and PPS 304 for Samtenling.

Table 9. Fruit quality parameters among different watermelon varieties at Panbang and Samteling

Location	Treatments	Fruit weight (kg)	Fruit height (cm)	Fruit diameter (cm)	TSS (%)	Crop duration (DAT)	Yield (kg/plant)
Panbang	PPS 142	4.5 (0.5)	22.8 (2.1)	20.4 (1.7)	10.0 (2.1)	92.0 (7.8)	24.0 (2.8)
	PPS304	4.9 (1.5)	21.7 (2.9)	18.6 (3.5)	11.7 (1.4)	103.0 (0.0)	19.0 (7.4)
	PPS 313	3.4 (0.6)	23.1 (2.1)	15.9 (0.1)	10.8 (0.5)	103.0 (0.0)	15.0 (2.8)
	PPS 315	2.9 (0.2)	20.8 (0.4)	15.2 (0.7)	10.1 (0.7)	103.0 (7.8)	13.5 (3.1)
	PPS 317	3.1 (0.2)	23.0 (0.1)	16.4 (0.8)	11.3 (2.5)	92.0 (14.9)	16.0 (1.1)
	Sugar baby	2.9 (0.1)	18.5 (1.3)	17.9 (0.4)	9.0 (0.2)	113.0 (7.1)	14.0 (0.7)
	<i>P -value</i>	0.1	0.16	0.08	0.65	0.78	0.08
Samteling	PPS 142	1.0 (0.2)	15.8 (1.1)	65.4 (0.6)	8.3 (1.1)	82.0 (0.0)	21.5 (2.1)
	PPS304	1.3 (0.3)	12.8 (1.2)	13.0 (1.2)	8.8 (1.7)	82.0 (0.7)	24.5 (2.1)
	PPS 313	1.0 (0.1)	15.1 (1.1)	53.9 (1.8)	8.2 (2.8)	82.0 (0.0)	20.5 (0.7)
	PPS 315	1.0 (0.2)	14.4 (1.9)	10.8 (1.1)	10.4 (0.5)	82.0 (0.0)	20.5 (3.5)
	PPS 317	1.0 (0.2)	14.9 (0.5)	10.9 (0.4)	9.5 (0.0)	82.0 (0.0)	21.5 (3.5)
	Sugar baby	1.0 (0.0)	13.4 (1.3)	12.05 (0.2)	8.9 (0.5)	82.0 (0.0)	21.5 (0.7)
	<i>P-value</i>	0.46	0.29	0.69	0.67	0.49	0.62

* Values in parentheses indicate standard deviation of the mean

3.1.4 Comparison of fruit quality parameters among different watermelon varieties in four study sites

The combined analysis of variance indicated that there was a significant difference in fruit yield among the four locations and treatments while there was no significant difference in yield by the interaction between location and treatments (L*T) as shown in the Table 4. This shows that the fruit yield is affected by locations and treatments alone and not by the interactions between them at predetermined level of significance (5%).

The data analysis revealed no significant differences in TSS levels among the six different varieties in all the study sites suggesting that all these varieties possess an equal degree of sweetness (Table 1, 2 and 3). Watermelon fruits with TSS content ranging from 10% to 12% are classified as having "very good" eating quality based on US grading standards, making them suitable for transportation (Yara, 2018). The minor variations in TSS levels observed within the varieties could potentially be attributed to soil variability in the growing locations and the maturation stages of the melons, as discussed by Ammawath et al. (2001). Furthermore, our findings aligned with the results reported by Davis et al. (2008), which indicated the presence of higher TSS levels in pigmented watermelons compared to non-pigmented varieties. The crop duration for these six varieties ranged from 80 to 113 DAT across the four growing locations, which is similar to the crop duration of icebox varieties of watermelon ranging between 70 to 120 DAT in Washington (Miles et al., 2004).

Table 10 Combined analysis of variance of yield for six watermelon genotypes evaluated at four environments

Source	DF	Sum of squares (SS)	Mean sum of squares (MS)	Explained (%)
Total	10	879	87.9	9.15
Replication	1	0	0.2	0
Location (L)	3	4955	1651.8	51.59
Treatments (T)	5	1775	177.5	18.48
L*T	15	672	67.2	7
Error	24	1323	55.1	13.78

When it comes to the shape of the fruits, this research observed two different fruit shapes namely, broad elliptical and round shape among six different varieties. The shapes of the fruits were identified using the cucurbit species descriptor (ECPGR, 2008). Broad elliptical shapes were found in four varieties viz, PPS 315, PPS 142, PPS 313 and PPS 317, while round shape was observed in sugar baby and PPS 304 (Figure 1).

Regarding fruit colour, all the varieties, except PPS 142, displayed a dark green colour. In contrast, PPS 142 had a light green colour with dark green stripes. Similarly, with regard to flesh colour, PPS 142 had light pink flesh while the remaining varieties had dark red flesh indicating that all the varieties are pigmented type (Figure 1). Red fleshed watermelons are a rich source of phytochemical lycopene which acts as an antioxidant and protects from cancers (Perkins-Veazie et al, 2004). None of the varieties had yellow flesh.



Figure 10. Images of six different varieties (Right from top: Sugar baby, PPS 313, PPS 317; Left from top: PPS 142, PPS 304, PPS 315)

3.2 Findings from the market and consumer preference survey

3.2.1 Shape, size and colour

In order to gain valuable insights into market demand and consumer preferences regarding watermelons, we conducted interviews with a total of 11 vendors and 20 consumers. The results of our market and consumer preference survey revealed a strong inclination towards medium sized watermelons characterized by a dark green colour and moderate level of sweetness. A significant majority of respondents, comprising 64% of vendors and 85% of consumers, expressed a distinct preference for medium-sized watermelons over the smaller and larger watermelons (Table 5 and Table 6). This preference is primarily attributed to the convenience

of medium-sized fruits, which can be easily consumed in one sitting, conveniently stored in refrigerators, and are generally more affordable compared to larger varieties. Respondents also indicated that smaller-sized watermelons tend to have less pulp, making them less desirable. Correspondingly, our findings align with a similar study conducted in Nigeria, where a preference for medium-sized watermelons was attributed to their affordability and reduced postharvest loss (Adeoye & Balogun, 2012). Given that all six varieties under consideration bear fruits weighing less than 6 kg, all the six varieties can be recommended for medium-sized fruits.

Table 11. Consumer preference on watermelon characteristics

Category	Consumer (No)	Percentage (%)
a. Gender		
Male	6	30
Female	14	70
b. Size		
Medium	17	85
large	2	10
Small	1	5
c. Shape		
Oblong	1	5
Round	11	55
Elliptical	6	30
Flattened	1	5
Don't know	1	5
d. Colour		
Dark green	17	85
Stripped	2	10
Medium green	1	5
e. Rind thickness		
Thick	1	5
Thin	17	85
Don't know	1	5
Both	1	5
f. Flesh colour		
Red fleshed	20	20
Yellow fleshed	0	0
g. Sweetness		
High	8	40
medium	12	60
Low	0	0
h. Seed content		

Fewer seed	18	90
Medium seed	1	5
Don't know	1	5

When it comes to the shape of watermelons, our survey revealed that 55% of consumers favoured round fruits, while 30% preferred broad elliptical ones (Table 5). Consumers tend to favour round watermelons for their sweetness, whereas elliptical varieties are perceived to be waterier with less flavour, as indicated by Yazawa (2023). In contrast, 73% of vendors reported a higher demand for broad elliptical watermelons, with round fruits accounting for only 18% of their preference (Table 6). Consequently, for round watermelons, varieties such as "Sugar Baby" and "PPS 304" are recommended, while for broad elliptical fruits, the remaining varieties including "PPS 313," "PPS 315," "PPS 317," and "PPS 142" are suitable choices.

In terms of colour, a significant majority of both vendors (85%) and consumers (80%) preferred dark green watermelons. Moreover, all consumers unanimously favoured red-fleshed watermelons, believing them to be sweeter than the striped and light green fruits. For watermelons with dark green skin and red flesh, five varieties, namely "PPS 304," "PPS 315," "PPS 317," "PPS 313," and "Sugar Baby," are recommended. Additionally, for those seeking stripe watermelons, "PPS 142" is a suitable option.

Table 12. Market preference on watermelon characteristics

Category	Vendors (no)	Percentage
a. Gender		
Male	10	90.9
Female	1	9.1
b. Market demand		
Yes	6	54.5
No	5	45.5
c. Size		
Medium	7	63.6
Small	4	36.4
Large	0	0
d. Shape		
Broad elliptical	8	72.7
Round	2	18.2
Don't know	1	9.1
e. Colour		
Stripped	2	18.2
Dark green	8	72.7
Don't know	1	9.1

3.2.2 TSS, rind thickness and seed content

In our survey, it was found that 60% of consumers prefer fruits with a moderate level of sweetness, while the remaining 40% prefer fruits with a high level of sweetness (Table 5). Yara (2018) reported that fruits with medium sweetness typically have a Total Soluble Solids (TSS) content ranging between 10-12%, a characteristic that is exhibited by all six varieties examined in this study.

Furthermore, a significant majority of consumers, specifically 85%, expressed a preference for fruits with thin rinds (Table 5). Thin-rinded fruits are favoured because they tend to have a higher pulp content. In contrast, a small minority, constituting 5% of consumers, favoured fruits with thicker rinds, citing their convenience and suitability for transportation. Regarding seed content, a substantial 90% of the consumers indicated a preference for fruits with fewer seeds (Table 5). However, this study has failed to record the rind thickness and seed count of each variety which may be included in the future studies.

4 Conclusions

This study found that all the six watermelon varieties evaluated fall under the classification of medium sized watermelons, often referred to as "icebox" types except for Samtenling where it falls under "personal" types. Overall, there were no significant differences for various parameters, including weight, height, diameter, TSS, crop duration, and yield indicating that all six varieties demonstrated consistent performance in terms of yield and size in all the study sites. All the six varieties can be promoted for commercial production of small sized watermelon production. However, considering location effect on yield and size, this research recommends PPS 315 and PPS 317 for Lingmethang, PPS 317 for Bajo and Panbang and PPS 304 for Samtenling for commercial production. Both fruit vendors and consumers demonstrated a preference for medium-sized watermelons characterized by moderate TSS content and a dark green colour. Thus, this study shows the potential of small sized watermelon for commercial production. Since the present study's finding is based on the experiment conducted in the research centres, this study recommends future study on the comparison of fruit quality parameters in farmer's field to validate the findings.

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