REVIEWING MINIMUM HARVEST MATURITY LEVELS FOR 'MALUMA HASS' AND 'LAMB HASS'

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ABSTRACT

Hass and Hass-type cultivars dominate new avocado plantings in South Africa. The need to improve production and to extend the harvest season (both early and late) has led the industry to search for alternatives to Hass resulting in the commercialisation of cultivars such as Lamb Hass and Maluma Hass. Exporters face major challenges in the form of uneven ripening and variable quality. Physiological maturity is a major determinant of postharvest quality, and unfortunately, there is no 'one-size-fits-all' approach when it comes to maturity indices for different avocado cultivars. In turn, maturity is influenced by genotype and climatic conditions, and therefore the purpose of this study was to determine the minimum harvest maturity level of 'Maluma Hass' and 'Lamb Hass' for multiple growing regions. Harvesting palatable fruit at minimum maturity will allow exporters to provide quality fruit with minimum disorders early in the season. Currently, the minimum dry matter content (DM) is 22% for 'Maluma Hass' and 27% for 'Lamb Hass'. The aim of this research was to determine whether these cultivars can be harvested at lower DM and still be of acceptable taste and quality. The relationship between %DM, days to ripen, together with fruit shrinking/shrivelling, and incidence of postharvest defects was used to determine the minimum harvest maturity levels in the different growing regions. Selected 'Maluma Hass' orchard blocks from the Letaba and Kiepersol regions showed promising postharvest results during the second season. The high %DM of 'Lamb Hass' fruit harvested across all regions during the initial harvest period, together with the continued incidence of shrivelling and other postharvest defects through to later harvest periods, indicate that 'Lamb Hass' is not suitable for picking at lower than the current minimum required DM content of 27%.

INTRODUCTION

The 2023 SAAGA Industry Tree Census estimates total avocado plantings in South Africa at 19 500 ha, of which 'Maluma Hass' makes up 8%. 'Maluma Hass' is the second most planted Hass-type variety after 'Hass' at 51%, with 'Lamb Hass' accounting for 2% of total plantings (SAAGA, 2023). The popular Hass cultivar is not without its production challenges and there has been a focus on finding high yielding, good quality Hass-like cultivars (Bruwer & Van Rooyen, 2007). The South-African bred Maluma Hass cultivar is a precocious and prolific early bearer (Ernst, 2012) and in the earlier ripening production regions with higher daily mean temperatures, 'Maluma Hass' can be harvested for export up to 4 weeks before 'Hass' and is available from March through to July. The current recommended minimum dry matter (DM) content for 'Maluma Hass' is 22% (Ernst *et al.*, 2015). An industry-wide dispensation for the export of 'Maluma Hass' with DM content of 20% was granted by the South African Department of Agriculture, Land Reform and Rural Development, while the Plant Breeders Rights (PBR) owner, Allesbeste Nursery, still recommends harvesting fruit between 23 and 26% DM content for optimal eating quality, especially trees experiencing adverse conditions (SAAGA protocol, 2022). 'Maluma Hass' is prone to postharvest disorders, especially pink vascular staining and soft arrivals in Europe. These disorders are a result of high respiration rates of 'Maluma Hass' postharvest and can efficiently be controlled by storing fruit at ≤ 6 °C and in a controlled atmosphere (CA) environment (Ernst, 2012). The risk of pink vascular staining can be reduced by picking fruit at a higher DM percentage and reducing the exposure to endogenous ethylene (Mhlophe & Kruger, 2013). Kruger *et al*. (2017) recommended that 'Maluma Hass' fruit from orchards with normal nitrogen

levels be placed into cold storage within 8 hours of harvest, while 'Maluma Hass' fruit from young orchards with high nitrogen levels should be placed into cold storage within 4 hours post-harvest.

Lamb Hass is an ultra-late season cultivar available from August through to November (i.e. later than 'Hass') and is precocious and high yielding, with fruit larger than 'Hass' (Bijzet & Sippel, 2011). Kremer-Köhne and Köhne (2001) found that 'Lamb Hass' is prone to alternate bearing and that there is variation in fruit maturity on the same tree. This necessitates either selective picking for export or colour sorting of fruit in the packhouse to avoid postharvest problems related to storage temperatures e.g. chilling injury. The current recommended minimum DM content for picking 'Lamb Hass' is approximately 27% (Magwaza *et al*., 2020).

Identifying the maturity standard that ensures palatable fruit together with minimal fruit disorders, allows for early harvesting to take advantage of higher early season prices (Hofman *et al*., 2013). This earlier harvesting resulting in higher early season prices would be applicable to Maluma Hass, an early cultivar, but not to Lamb Hass, an ultra-late season cultivar. Earlier harvesting of 'Lamb Hass' would result in a more favourable harvesting window period.

MATERIALS AND METHODS

Sampling sites

Representative orchards (≥ 8 years old) were used in the following regions: for 'Maluma Hass', 3 blocks each in both the Letaba and Levubu regions of Limpopo, and 3 blocks in the Kiepersol region of Mpumalanga. For 'Lamb Hass' fruit three blocks in each of the Letaba and Levubu regions of Limpopo were identified, as well as 3 blocks in KwaZulu-Natal.

Sixty 'Maluma Hass' and 30 'Lamb Hass' fruit were sampled from each block on a weekly basis and sampling took place over a period of 5 weeks, with sampling times correlating to DM content of ≥ 18% and ≤ 24%. Of the fruit harvested weekly from each of the nine orchards, half of the fruit were used for maturity determinations and the other half for storage trials (28 days at 5.5 °C to simulate export conditions) and post-storage evaluation for internal and external defects. Fruit collection and determination of fruit mass and mesocarp DM content were performed by the Levubu Centre for Excellence for all fruit collected in Limpopo and Mpumalanga, and Agri Crop and Technical Solutions for fruit collected in KwaZulu-Natal.

DM content was determined in the following way: fruit and pip peel was removed from the mesocarp prior to grating. Samples were taken using a small grater (10 mm), grating equatorially on two opposite sides of each fruit. The extracted mesocarp of at least 15 grams (≈1 mm pieces) was thoroughly mixed. Ten to fifteen (10-15) grams of mesocarp gratings were placed in a petri dish/foil container and the fresh/wet mass reading recorded. Samples were spread evenly in the container and placed in an oven, at a power setting equivalent to 50 °C, and dried overnight. The final dry mass was recorded the following morning. In instances where a microwave was used, the samples were dried until they reached constant weight. The DM content was then calculated [(dry weight)/(fresh weight) x 100 = % dry matter].

Storage and post-storage assessments

Fruit from both cultivars were weighed before entering controlled atmosphere (CA) storage at 5.5 °C and 6% CO_2: 4% O_2 for a period of 4 weeks to simulate export conditions. After 4 weeks in storage, fruit were removed and allowed to ripen at ± 22 °C (room temperature). Post-harvest internal and external quality of fruit harvested at different %DM was assessed for defects such as shrivelling, stem-end rot, and vascular staining. The relationship between %DM and days to ripen, together with fruit shrinking/shrivelling as indicator of fruit immaturity, and incidence of postharvest defects, were used to review minimum maturity levels for the different growing regions.

Statistical analysis

Data were subjected to analyses of variance (ANOVA) using XLSTAT 2019 from Microsoft Excel. Means separation was performed using Fischer's Least Significant Differences test (LSD) with a significance level of ≤ 0.05.

RESULTS AND DISCUSSION

As expected, the %DM of 'Maluma Hass' for all three regions increased as the harvest dates progressed (Fig. 1). The decline seen in %DM in Levubu (Fig. 1) between the earlier harvest weeks could possibly be ascribed to rainfall during the week preceding sampling on 22 February 2022. Sufficient rainfall can lead to an increase in fruit turgor (Pak *et al*. 2003), and, in turn, this increased turgidity can have an effect on dry matter content. On average, the %DM for the first week of harvest in the Levubu region was already over 25% and remained above the minimum prescribed DM of 22% for the harvest dates during March 2022.

Unfortunately, only a limited number of 'Maluma Hass' fruit harvested from the earlier dates were stored in CA due to knock-on effects of challenges experienced in the harbours, and we report here on post-storage evaluation for fruit harvested in Letaba and Kiepersol on 15 February 2022 for the 2022 season. The three Kiepersol orchards sampled all showed low incidence of shrivelling (Table 1) with a corresponding average DM of 16% (Fig. 1), while two of the Letaba orchards showed either no or low incidence of shrivelling (Table 1) at a corresponding average DM of 18% (Fig. 1) for fruit collected on 15 February 2022. During the 2021 season, fruit harvested from the Kiepersol region also had low incidence of shrivelling during the earlier harvest periods, which corresponded to 18% DM (Kleinert *et al.,* 2022). The mean number of days required to ripen (DTR) the 'Maluma Hass' fruit were lower compared to the results of Kruger and Lemmer (2012), where fruit were harvested at 30% DM. The average DTR for

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fruit from the Letaba region was 7.3 days, and 7.2 days for fruit from the Kiepersol region (Table 1). During the 2021 season, fruit from Letaba required an average of 6.5 days to ripen and fruit from the Kiepersol region 6.7 days (Kleinert *et al.,* 2022). These averages were calculated across all the weeks of harvest and not only for a single week as during the 2022 season above, and rainfall over this period could also have had an effect. The fruit from Block 2 in the Letaba region had no incidence of vascular staining for the harvest date but had high incidence of stem-end rot, while Block 3 showed low incidence of vascular staining with relatively low incidence of stem-end rot (Table 1). All three blocks in the Kiepersol region had incidence of vascular staining and stem-end rot (Table 1). It is important to note that the three blocks representing each of the regions were situated on different farms and therefore might experience different microclimatic conditions which could influence fruit maturity and postharvest disorders. The occurrences of these postharvest disorders could be managed by limiting the time between harvest and cooling of the fruit. Current protocols for 'Maluma Hass' dictate that fruit should be cooled within 4 hours after harvest when picked from younger trees with a high nitrogen status, and within 8 hours from harvest for fruit from normally fertilised older trees (Kruger *et al.,* 2017).

The average %DM measured for 'Lamb Hass' fruit collected during the first week of the 2022 period for both Letaba and KwaZulu-Natal was above the minimum requirement, and in Levubu the %DM of fruit harvested during the first week was just below the required minimum of 27% (Fig. 2).

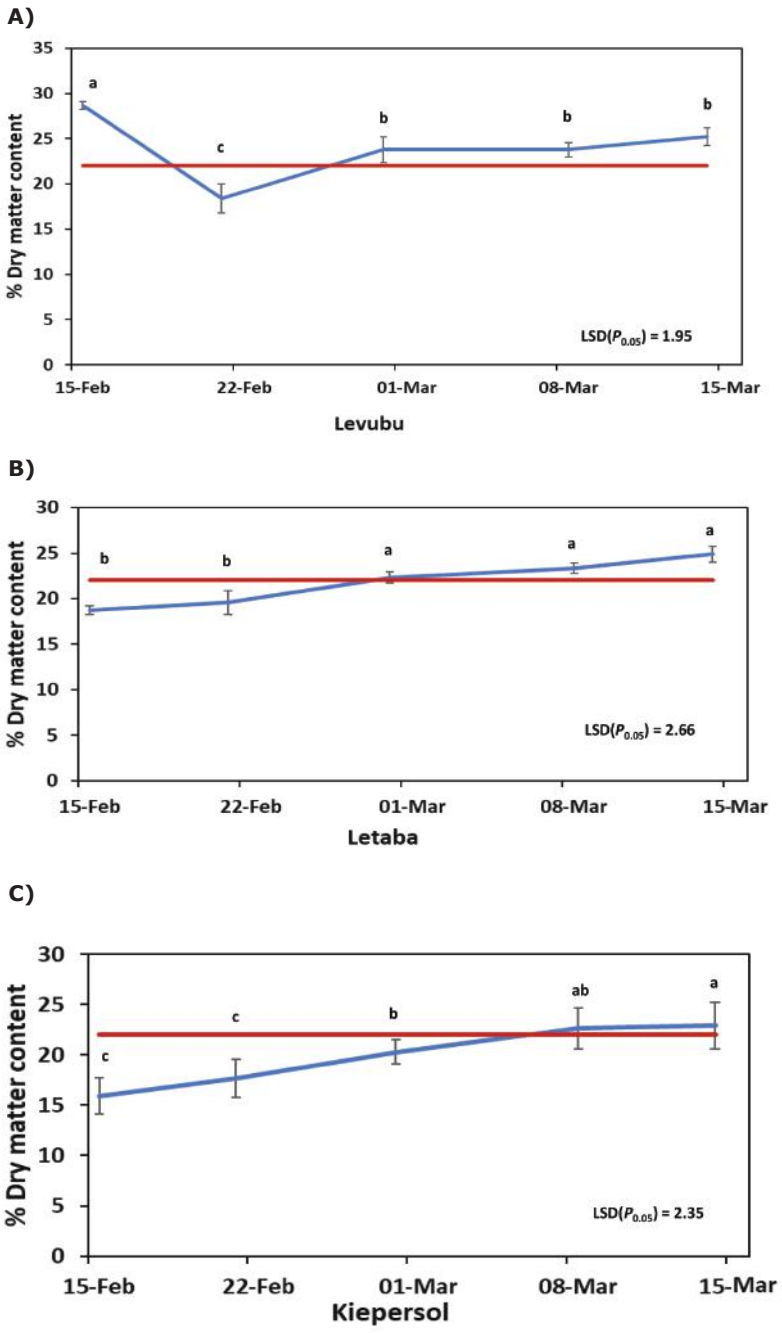

Figure 1: Change in % dry matter content of 'Maluma Hass' fruit in 2022 for the Levubu and Letaba regions in Limpopo, and the Kiepersol region in Mpumalanga. Error bars denote standard error. The red line indicates the current prescribed minimum % dry matter content for this cultivar.

Table 1: Post-storage fruit quality of 'Maluma Hass' harvested on 15 February 2022 from orchards in the Letaba, Limpopo, and Kiepersol, Mpumalanga, regions

Area and Block/ orchard	Dry matter content (%)	Incidence of shrivelling (%)	Incidence of stem-end rot (%)	Incidence of vascular staining (%)	Days to ripen
Letaba Block 1	18,7	50	50	50	7,7
Letaba Block 2	18,0	0	67	0	7,5
Letaba Block 3	19,5	23	37	20	6,7
Kiepersol Block 1	17,1	23	3,3	37	6,9
Kiepersol Block 2	18,3	27	67	50	7,3
Kiepersol Block 3	12,3	23	60	20	7,5

The drop in %DM observed for the Letaba region during the harvest week of 6 September may either be due to a climatic event such as rainfall which would affect fruit turgidity and dry matter content, or due to variation in fruit maturity on the same tree which necessitates selective picking. In this study fruit of a similar size were sampled from various positions in the canopy, but not evaluated based on canopy position. Magwaza *et al.* (2020) reported that early season 'Lamb Hass' fruit stored for 28 days at 5.5 °C ripened after 8 days and this concurs with results from this study (Table 2). While the % incidence of shrivelling decreased in all regions after the initial week of harvest, stem-end rot and vascular browning were still observed across the harvest period, despite meeting the minimum required %DM (except for Letaba during the week of 6 September 2022) (Table 2). 'Lamb Hass' fruit harvested from the Levubu and Letaba regions during the 2021 season had %DM below that of the current minimum required level of harvest maturity, but displayed shrivelling and vascular browning, indicative of immature fruit (Table 3). During the 2021 season, fruit from the Baynesfield and Howick regions measured an average %DM higher than the required minimum dry matter content while still displaying vascular browning (Table 4). Fruit from the first harvest point in the Wartburg region during the 2021 season measured an average %DM lower than the minimum requirement, but this coincided with a high incidence of shrivelling and vascular browning, indicative of fruit immaturity (Table 4).

CONCLUSIONS

Selected 'Maluma Hass' orchard blocks from the Letaba and Kiepersol regions showed promising postharvest results during the second season. There was variation in %DM between the respective blocks across the two seasons measured. However, not all data sets were complete for all weeks in all regions, which complicated statistical analyses and made it difficult to make scientifically and statistically sound recommendations. Another point to consider is that canopy position of fruit was not measured in the present study, and this could also have an influence in the variability of results obtained. While the fruit in this study were picked from different positions in the tree, the fruit from these different positions were not separately evaluated based on their canopy positions. Hofman and Jobin-Décor (1997) reported a significant variation in %DM of fruit harvested from individual trees in the same orchard, which indicates the need for larger samples for studies on a harvest level and post-storage quality studies. An option for future studies would be to significantly increase the number of fruit harvested at every time point to account for as much early-season variability as possible, and to evaluate fruit in terms of %DM and postharvest quality based

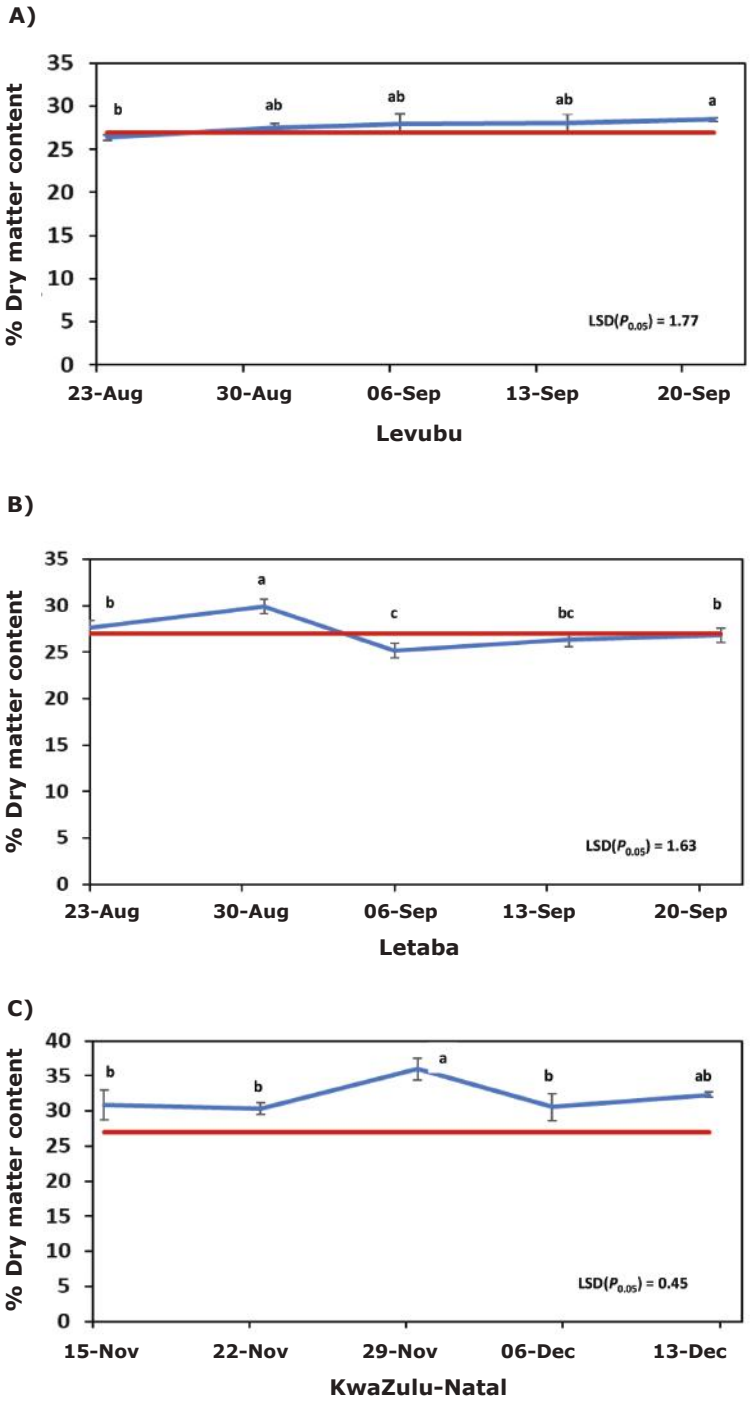

Figure 2: Change in % dry matter content of 'Lamb Hass' fruit in 2022 in the Levubu and Letaba regions in Limpopo, and the Baynesfield, Howick, and Wartburg regions in KwaZulu-Natal. Error bars denote standard error. The red line indicates the current prescribed minimum % dry matter content for this cultivar.

on their canopy position (inside *vs* outside fruit, as well as tree aspect).

The high %DM of 'Lamb Hass' across all regions at the start of the harvest period, together with the continued incidence of shrivelling and other postharvest defects at later harvest periods, indicate that 'Lamb Hass', known as an ultra-late season cultivar, appears unsuitable for picking at lower than the current minimum required dry matter content.

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Table 2: Average post-storage fruit quality of 'Lamb Hass' collected across the 2022 harvest dates from orchards in the Levubu and Letaba regions in Limpopo, and Baynesfield, Howick, and Wartburg regions in KwaZulu-Natal. Different letters next to values indicate significant differences (P ≤ 0.05)

Harvest date	Area	Dry matter content (%)		Incidence of shrivelling (%)		Incidence of stem-end rot (%)		Incidence of vascular browning (%)		Days to ripen	
2022-08-23	Levubu	26.4	b	39.72	A	8.89	b	5.3	AB	6.0	bc
2022-08-31	Levubu	27.5	ab	3.67	B	19.90	ab	1.1	B	5.4	c
2022-09-06	Levubu	27.9	ab	3.45	B	15.11	ab	2.4	AB	8.4	a
2022-09-14	Levubu	28.0	ab	7.55	B	29.11	a	8.9	A	5.3	c
2022-09-21	Levubu	28.5	a	10.24	B	22.62	ab	5.6	AB	7.2	ab
2022-08-23	Letaba	27.6	b*	25.55	A*	32.22	a*	17.8	CD*	10.1	ab*
2022-08-31	Letaba	29.9	a*	5.29	B*	27.65	a*	10.5	D*	5.2	c*
2022-09-06	Letaba	25.1	c*	0	B*	64.14	a*	32.6	B*	12.1	a*
2022-09-14	Letaba	26.3	bc*	1.15	B*	80.88	a*	52.8	A*	8.5	b*
2022-09-21	Letaba	26.8	b*	0	B*	37.78	a*	26.4	BC*	9.2	b*
2022-11-15	KZN	30.8	b′	35.56	A′	48.89	a′	53.3	A′	8.6	a′
2022-11-22	KZN	30.3	b′	20	B′	35.56	a′	17.8	C′	8.6	a′
2022-11-29	KZN	35.9	a′	4.60	C′	32.5	a′	35	BC′	7.9	a′
2022-12-05	KZN	30.5	b′	0	C′	46.67	a′	44.4	AB′	7.6	a′
2022-12-12	KZN	32.3	ab′	0	C′	57.78	a′	37.8	AB′	8.5	a′

Table 3: Summary of change in % dry matter content together with post-storage fruit quality of 'Lamb Hass' fruit over the 2021 harvest period for the Levubu and Letaba regions in Limpopo. Different letters next to values indicate significant differences (P ≤ 0.05)

Harvest date	Area	Dry matter content (%)		Incidence of shrivelling (%)		Incidence of vascular browning (%)		Days to ripen	
2021-07-13	Levubu	23.5	C	52.5	a	15.9	AB	8.2	d
2021-07-20	Levubu	24.8	B	11.4	b	22.9	A	9.3	ab
2021-07-27	Levubu	25.4	B	9.7	b	6.2	B	9.8	a
2021-08-03	Levubu	23.7	C	5.6	b	11.1	B	9.1	bc
2021-08-10	Levubu	26.5	A	0	b	6.9	B	8.7	cd
2021-07-13	Letaba	26.2	B′	75.2	a′	16.8	A′	9.1	a′
2021-07-20	Letaba	28.4	A′	4.5	b′	14.5	A′	9.1	a′
2021-07-27	Letaba	27.8	A′	10.3	b′	8.9	AB′	9.3	a′
2021-08-03	Letaba	28	A′	0	b′	12.2	A′	9.0	a′
2021-08-10	Letaba	27.2	AB′	6.7	b′	1.1	B′	8.8	a′

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Table 4: Summary of change in % dry matter content together with post-storage fruit quality of 'Lamb Hass' fruit over the 2021 harvest period for the Baynesfield, Howick, and Wartburg regions in KwaZulu-Natal

Harvest date	Area	Dry matter content (%)	Incidence of shrivelling (%)	Incidence of vascular browning (%)	Days to ripen
2021-09-16	Wartburg	17,6	53,3	40,0	9,9
2021-09-21	Wartburg	26,9	40,0	33,3	11,3
2021-09-27	Wartburg	39,1	20,0	0,0	9,9
2021-10-04	Wartburg	27,9	0,0	13,3	9,5
2021-10-11	Wartburg	29,1	0,0	20,0	9,4
2021-10-11	Baynesfield	33,2	0,0	60,0	10,1
2021-10-18	Baynesfield	29,9	0,0	26,7	8,9
2021-10-25	Baynesfield	33,8	0,0	46,7	9,1
2021-11-04	Baynesfield	38,8	0,0	33,3	7,7
2021-11-08	Baynesfield	48,7	0,0	26,7	6,7
2021-10-11	Howick	34,6	0,0	73,3	12,3
2021-10-18	Howick	30,8	0,0	66,7	10,0
2021-10-25	Howick	33,0	0,0	80,0	9,3
2021-11-04	Howick	38,0	0,0	60,0	8,8
2021-11-08	Howick	49,5	0,0	60,0	6,7

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