Brix was not a good indicator of pasture quality

Beverley C. THOMSON*, Noel SMITH, Kay WARD, Guy HAMILTON and Paul D. MUIR

On-Farm Research, Poukawa, Hawke's Bay, New Zealand

*Corresponding author: bev@on-farm.co.nz

Abstract

Measuring pasture quality by drying, grinding and laboratory analysis is expensive and time consuming. Some commentators have suggested using Brix (a measurement of soluble sugars used in wine and fruit industries) to estimate the feed value of fresh forages. However, there is little data on how useful Brix measurements are in determining pasture quality. This study compared Brix measurements to standard laboratory measurements of pasture quality for five pasture treatments: ryegrass/clover and a multi-species mixture, each harvested to 8 and 20 cm, and plantain/clover harvested to 20 cm, across three sampling dates between October 2021 and January 2022. Plant species and their physiological state varied across pasture treatment and date and resulted in variation in Brix and laboratory measures of quality. Metabolisable energy (ME) declined but Brix values increased between October and January as pasture changed from a vegetative to a reproductive state with seedheads. There was a positive relationship between Brix and dry matter percentage (Brix = 1.49 + 0.40 × DM%, R^2 = 72.1%). There was no consistent relationship between Brix and ME, neutral detergent fibre, acid detergent fibre and water-soluble carbohydrate contents. This severely limited the use of Brix in determining pasture quality.

Keywords: Brix, dry matter, metabolisable energy, plant maturity

Introduction

Whilst pasture quality is an important consideration for farmers and researchers, obtaining accurate pasture quality data requires sampling, drying, grinding together with laboratory analysis of samples, which is expensive and time consuming (Billman et al. 2024). Brix measurements of soluble sugars have been used in the wine, sugar and fruit industries to determine optimum harvest time (Zoecklein et al. 2010; Lemus, 2014; Jaywant et al. 2022). Pastures contain a range of water-soluble compounds such as sugars, oils, minerals, pectins, acids, proteins, lipids, amino acids, tannins, etc. (Billman et al. 2024). Brix measures can be taken in the field using a handheld refractometer and are being used by some farmers to obtain rapid estimates of the energy value of feeds (Balsom and Lynch, 2008; Anon 2018; Bleier et al. 2020; Billman et al. 2024). There is, however, little data around on how effective Brix measures are in comparing fresh forages or how they relate to current laboratory measures of quality. The objective of this study was therefore to assess the Brix method for determining pasture quality by comparing Brix and laboratory measures of pasture quality across contrasting pasture treatments and spring-summer sampling dates.

Materials and Methods

A dataset was collected from a small-plot experiment at Poukawa Research Farm, Hawke's Bay, on a Roseberry silt loam (Typic Orthic Melanic, USDA soil taxonomy). The experiment was designed to examine the effects of pasture type and cutting height on pasture production, quality and soil characteristics. The dataset used a subset of five pasture treatment: ryegrass/clover and a multi-species pasture, each harvested to 8 and 20 cm, and plantain/clover harvested to 20 cm. The ryegrass/clover and plantain/clover pastures were from seed mixtures normally sown at Poukawa Research Farm: 32 kg/ha of four species for ryegrass/clover and 22 kg/ha of six species for plantain/clover (Table 1). The multi-species pasture resulted from a seed mixture used at a local regenerative farm, Glenlands Farm: 180 kg/ha of 31 varieties from five plant groups (Martin and Martin 2021). The pasture treatments were laid out in a randomised block design with four replicates and a plot size of 3 m by 5 m. The plots were sown in May 2021. More experimental details are covered in Thomson et al. (2025).

From sowing, all 20 plots were mown to their allocated heights (8 or 20 cm) when the average sward height of the multi-species-20 cm treatment reached 30 cm.

Feed samples were taken at three time point harvests: October, November and January in the first year after sowing. The three time points were designed to cover a range of maturity stages, i.e. vegetative, actively growing spring forage through to reproductive summer forage. The species present in the pastures at any time point were a subset of those sown. The identity, relative abundance and physiological state of the species present in the pastures varied considerably across the different time points. This created the variation in pasture quality necessary to provide a good comparison of Brix and laboratory measurements. Samples were collected between 1000 and 1130 h at each time point.

ISSN 2463-2872 (Print) ISSN 2463-2880 (Online) https://doi.org/10.33584/jnzg.2024.85.3733

Table 1 Seed mixtures (kg/ha) for the three pasture types.

Ryegrass/clover: 20 Governor perennial ryegrass, 4 Weka white clover, 4 Morrow red clover, 4 Coolamon subterranean clover (32 kg/ha)
Plantain/clover: 8 Captain plantain, 4 Weka white clover, 2 Morrow red clover, 4 Coolamon subterranean clover, 2 Laser Persian clover, 2 Vista balansa clover (22 kg/ha)
Multi-species: 8 Italian ryegrass, 1 fescue, 0.5 Matrix SE perennial ryegrass, 1 Kainui cocksfoot, 1.5 Atom prairie grass, 3.5 Bareno pasture brome, 5 Japanese millet, 2canary seed, 35 oat, 35 barley, 10 maize, 55 pea, 0.5 Weka white clover, 0.25 Laser Persian clover, 0.5 Zulu II arrowleaf clover, 1 crimson clover, 1 lucerne, 1.5 red clover, 0.25 lotus, 1 Kingsford rape, 0.5 Bouncer rape, 1 Pasja II leafy turnip, 0.25 Dynamo bulb turnip, 1 oilseed rape, 1.5 Captain plantain, 1 chicory, 6 sunflower, 0.25 squash, 2 buckwheat, 2.5 linseed, 0.5 phacelia (180 kg/ha)

Table 2 Brix and laboratory measures of pasture quality for ryegrass/clover (RGC) and a multi-species (MS) pasture, each harvested to 8 and 20 cm, and plantain/clover (PLC) pasture harvested to 20 cm, in October 2021, November 2021 and January 2022 at Poukawa Research Farm, Hawke's Bay.

Date	RGC8	MS8	RGC20	MS20	PLC20	SEM	P_{Pas}	P_{Date}	P_{Int}
	Brix (%solids in sap)								
Oct.	8.5	8.8	8.0	8.8	9.3	0.51	0.08	0.001	0.002
Nov.	12.3	10.5	11.6	10.5	12.0				
Jan. #	20	-	-	11.4	-				
	Dry matter (DM%)								
Oct.	15.2	15.0	15.4	15.2	12.5	3.14	0.001	0.001	0.001
Nov.	18.5	18.3	18.3	18.4	15.4				
Jan.	41.4	38.8	46.1	27.4	46.4				
	Neutral Detergent Fibre (% of DM)								
Oct.	47.1	43.7	48.0	43.8	37.8	1.78	0.02	0.001	0.001
Nov.	47.4	49.7	50.8	48.5	45.4				
Jan.	37.2	40.9	45.2	39.6	48.9				
	Acid Detergent Fibre (% of DM)								
Oct.	27.7	25.7	27.7	26.9	25.6	1.03	0.001	0.001	0.001
Nov.	29.8	31.7	32.2	30.5	33.5				
Jan.	27.5	30.8	32.2	29.1	35.4				
	Water-Soluble Carbohydrate (% of DM)								
Oct.	9.5	13.4	9.8	12.2	8.2	0.62	0.001	0.04	0.001
Nov.	11.9	10.7	11.2	13.5	11.4				
Jan.	11.8	10.3	10.8	12.3	10.3				
	Metabolisable Energy (MJ/kg DM)								
Oct.	12.4	12.6	12.2	12.3	12.1	0.17	0.001	0.001	0.001
Nov.	11.3	10.9	10.8	10.7	10.0				
Jan.	10.5	9.9	9.7	10.5	8.7				

#Values were only obtainable for one replicate of two treatments. SEM: Standard error of mean. P_{Pas}, P_{Date} and P_{Int}: Levels of significance for pasture treatment, date and treatment × date interaction.

When each plot was mown, a sample of the freshly harvested forage was taken and inserted into a garlic press. The material was squeezed, the resulting juice placed on to the prism of a handheld optical Brix refractometer and the cover placed on top of the juice to ensure no air bubbles. The meter was then pointed towards the sun and the Brix value determined through the eye piece. Between measurements, the garlic press

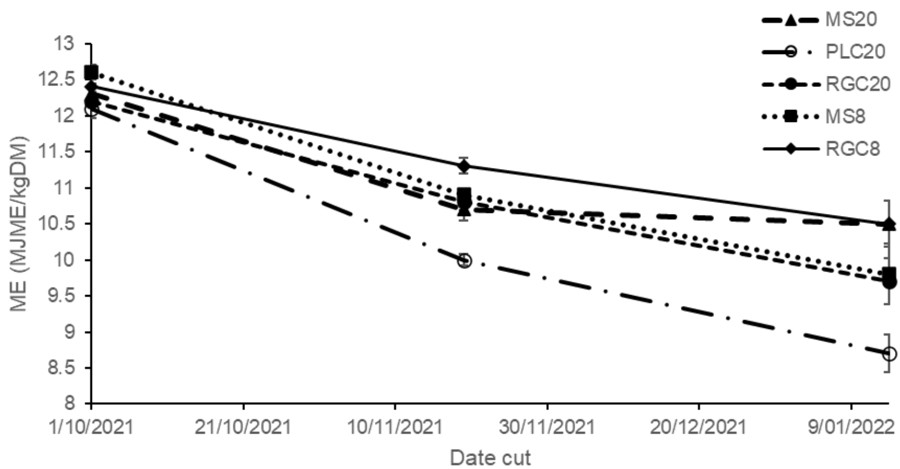

Figure 1 Metabolisable energy (ME) for a ryegrass/clover and a multi-species pasture, each harvested to 8 and 20 cm, and plantain/clover pasture harvested to 20 cm, in October 2021, November 2021 and January 2022 at Poukawa Research Farm, Hawke's Bay. Means +/– standard error of mean.

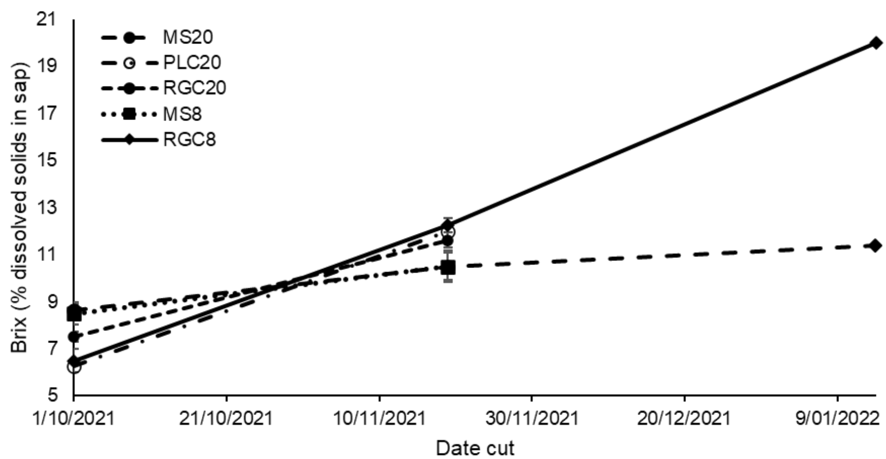

Figure 2 Brix levels for a ryegrass/clover and a multi-species pasture, each harvested to 8 and 20 cm, and a plantain/clover pasture harvested to 20 cm, in October 2021, November 2021 and January 2022 at Poukawa Research Farm, Hawke's Bay. Means +/– standard error of mean.

was emptied, washed and dried. The lens was rinsed and dried to prevent sample contamination and to ensure there was no additional water present. The refractometer was calibrated using water at the start of each measurement period.

Two subsamples of the freshly harvested forage from each plot were taken for laboratory analysis of dry matter and pasture quality. The dry matter sample was dried at 100°C for 48 h whilst the pasture quality sample was dried at 60°C for 48 h, ground and analysed for neutral detergent fibre (NDF), acid detergent fibre (ADF), water-soluble carbohydrate (WSC, i.e. soluble simple sugars) and metabolisable energy (ME) by near-infrared spectroscopy (Analytical Research Laboratory, Hastings).

Statistical analysis was carried out using a multivariate analysis of variance (MANOVA) with pasture treatment and date fitted as variables. The January data points for Brix measurements were left out of the MANOVA analysis due to several missing values. Relationships between the Brix and laboratory measurements of pasture quality were carried out using a linear regression analysis with the individual data points included in the analysis. All statistics were undertaken using Minitab for Windows (version 14).

Results

There were significant effects of pasture treatment and date for all pasture quality characteristics measured (Table 2). As expected, pasture quality varied across the pasture treatments and over time.

Metabolisable energy decreased over time for all pasture treatments (Figure 1), whilst the Brix measures increased over the same period (Figure 2). By January, it was difficult to squeeze the juice out of the fibrous herbage, so it was only possible to obtain Brix readings on two of the 20 plots at that time. These values have been included in the regression analysis only. The Brix measures increased with the dry matter percentage of the forage (Brix = 1.49 + 0.40 × DM%, R^2 = 72.1%, s = –1.24, P<0.001). There was no relationship between Brix measurements and NDF, ADF and WSC. There was a weak tendency for the Brix to increase as the ME decreased (Brix = 20.6 – 1.05 × ME, R^2 = 14.6%, s = 2.18, P<0.006).

Discussion

Pasture quality is measured by its nutritive value (crude protein, ME and digestibility), dry matter content and the presence of less desirable components such as dead matter, weeds, or toxins. Plant species composition, forage production, stage of plant maturity, pasture management e.g. grazing intensity and environmental factors such as soil type, moisture and fertility and climatic conditions all affect pasture nutritional quality (Waghorn and Barry 1987; Lambert and Litherland 2000; Moore and Lenssen 2020). Pasture quality combined with pasture availability determine animal performance in a grazing situation. As a plant progresses towards maturity, its relative protein content tends to decrease while its structural fibre content, as indicated by fractions such as ADF and NDF, tends to increase (Moore and Lenssen 2020).

While measuring the amount of pasture available or grown is relatively straight forward, measuring pasture quality is more challenging. Current measurements of quality involve cutting representative pasture samples and drying them to a consistent weight to determine DM prior to laboratory analysis. Widely used indicators for assessing the nutritional value of forage are digestibility measures – cell-wall components (mostly cellulose), ADF, NDF and DM digestibility, as well as ME concentration and nitrogen (Waghorn and Barry 1987; Lambert and Litherland 2000; Jeranyama and Garcia 2004). For farmers, the ability to collect real time information on pasture quality would allow them to better manage grazing systems and achieve higher animal performance.

Brix is a measurement of the dissolved solids (mainly sugars, but also minerals, proteins and other nutrients) in plant sap and is based on specific gravity. The handheld optical Brix refractometer uses the associated optical changes in the refractive properties to provide an index of dissolved solids. Brix has been used in a range of food industries including fruit and vegetable juices, wine and soft drink industries to indicate the level of sucrose/soluble sugars. It has been suggested that Brix could provide a quick, real time on-farm tool to indicate pasture quality and thus allow animal performance to be optimised by maximising pasture feed quality (Balsom and Lynch 2008; Lemus 2014). A higher Brix measure indicates more solids in the sap suggesting a higher nutrient density and more water-soluble sugars and therefore a greater energy availability.

In this study, there were differences in Brix measures between the sampling time points. Within a sampling time, there was no difference in Brix values between the pasture treatments although there was an interaction between sampling time and pasture. Other measures of pasture quality varied with both pasture treatment and sampling time. Not unexpectedly, ME decreased and dry matter increased from spring to summer as plants changed from a vegetative to a reproductive state (Ulyatt et al. 1980; Machado et al. 2005). Brix is a measure of sap concentration and as the dry matter increases, the sugar concentration is likely to increase. Billman et al. (2024) and Soder et al. (2020) found that different sampling dates and different forages had both positive and negative correlations between sugar and Brix values and suggested that other methods need to be examined. Our study also found no consistent relationship between ME, WSC, or NDF and the Brix reading across the treatments. As Brix measures the concentration of dissolved solids in plant sap, care must be taken when using it as indication of pasture quality as other factors affect Brix independently of pasture quality.

ACKNOWLEDGEMENTS

This work was funded by MPI's SFFF (Contract S3F-21011), Hawke's Bay Regional Council, AGMARDT, Ravensdown, Barenbrug Seeds, Poukawa Research Foundation and Atkins Ranch.

REFERENCES

Anon. 2018. *Brix values and forage: practical uses and limitations*. Retrieved 10 February 2025 from: https://peaceforage.bc.ca/wp-content/uploads.

Balsom T, Lynch G. 2008. Monitoring pasture quality using Brix measurements. Retrieved 10 February 2025 from: https://www.novel.co.nz/brix/

Billman ED, Soder KJ, Horst J, Hafla A, Balk K. 2024. Validation for Brix for predicting sugar concentration of alfalfa and orchard grass. *Applied Animal Science 40*: 433-445. http://dx.doi.org/10.15232/aas.2024-02552

Bleier JS, Coblentz WK, Kalscheur KF, Panke-Buisse K, Brink GE. 2020. Evaluation of warm season annual forages for forage yield and quality in the north-central United States. *Translational Animal Science 4*: 145. 10.1093/tas/txaa145 https://doi.org/10.1093/tas/txaa145

Jaywant SA, Singh H, Arif KM. 2022. Sensors and Instruments for Brix Measurement: A Review. *Sensors (Basel) 22(6)*: 2290. https://doi.org/10.3390/s22062290

Jeranyama P, Garcia AD. 2004. Understanding Relative Feed Value (RFV) and Relative Forage Quality (RFQ). SDSU Extension Extra, Paper 352. http://openprairie.sdstate.edu/extension_extra

Lambert MG, Litherland AJ. 2000. A practitioners guide to pasture quality. *Proceedings of the New Zealand Grassland Association 62*:

111-115. https://doi.org/10.33584/jnzg.2000.62.2383

Lemus R. 2014. Brix level in your forage: what does it mean? Forage News Volume 7 Issue 2 February 2014. Mississippi State University Extension Service. https://extension.msstate.edu.

Machado CF, Morris ST, Hodgson J,Fathalla M. 2005. Seasonal changes of herbage quality within a New Zealand beef cattle finishing pasture. *New Zealand Journal of Agricultural Research 48*: 265-270. https://doi.org/10.1080/00288233.2005.9513655

Martin D, Martin A. 2021. Glenlands Farm. Retrieved 1 February 2021 from: https://glenlandsfarm.co.nz/

Moore KJ. Lenssen, A. 2020. Factors Affecting Forage Quality. In: Moore KJ, Collins M, Nelson CJ & Refearn DD. Eds. Forages: the Science of Grassland Agriculture, II, 7th edition. Iowa State University Iowa. Pp 701-717. 10.1002/9781119436669.ch39

Soder KJ, Billman ED, Horst J, Balk K, Hafla A. 2020. Brix as an Indicator of Energy Value in Alfalfa and Orchardgrass Herbage. *Journal of Animal Science 98*: 77. https://doi.org/10.1093/jas/skaa278.140

Thomson BC, Smith N, Ward K, Hamilton G, Muir PD. 2025. Effect of mowing height on productivity of three different pasture mixes. *Journal of New Zealand Grasslands 87*: XXX-XXX. https://doi.org/10.33584/jnzg.2025.87. 3734

Ulyatt MJ, Fennessy PF, Rattray PV, Jagusch KT. 1980. The nutritive value of supplements. In: Drew KR & Fennessy PF. Eds. Supplementary feeding. Occasional Publication No 7. New Zealand Society of Animal Production. Dunedin, New Zealand, pp 157-184.

Waghorn GC, Barry TN. 1987. Pasture as a nutrient source. In: Nicol AM. Ed. Livestock feeding on pasture. Occasional Publication No 10. New Zealand Society of Animal Production. Dunedin, New Zealand, pp 21-37.

Zoecklein BW, Fugelsung KC, Gump BH. 2010. 4. Practical methods of measuring grape quality. In: Reynolds AG. Ed. Managing Wine Quality Series in Food Science, Technology and Nutrition. Pub Woodhead, Cambridge, United Kingdom, pp 107-133.