Predicting Ripening and Postharvest Quality of ‘Bartlett’ Pears

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ABSTRACT

The F-750 showed good potential to provide a method for the industry to more accurately assess ‘Bartlett’ pear maturity, predict post-storage quality and predict fruit ripening capacity. Following the first year of this study, preliminary results showed that near infrared spectroscopy (NIR) models developed in the spectral region between 700-1000 nm appeared accurate and robust for the rapid and non-destructive evaluation of firmness, SSC, DMC and ripening capacity (measured as lbs./day) with measurements collected at 32 and 75 °F. Models were capable of predicting at harvest and with good accuracy, quality traits in fruit at harvest and when fully ripe, including ripening with no conditioning treatment, after an ethylene treatment, and after a SmartFresh treatment. The regression models presented by the DA-Meter were much weaker, and no good predictive models could be built from its data. As we are early in our data analysis, all models will be further refined and then validated in 2016 before a complete assessment of the full capacities of the F-750 and DA-Meter can be made. However, considering the potential shown in our preliminary analysis, we consider that these techniques should be further studied in ‘Bartlett’ pear.

OBJECTIVES

1. To determine the potential of the F-750 (Produce Quality Meter, Felix Instruments, Camas, WA, USA) and DA-Meter (T.R. Turoni, Forli, Italy) to build accurate models developed at harvest-time to predict pear quality traits at harvest and after storage, as well as pear ripening capacity and fruit response to SmartFresh.

2. To evaluate the accuracy of the models for determining fruit quality, capacity to ripen and response to ethylene and SmartFresh with ‘Bartlett’ pears from different harvest seasons and orchards.

3. To evaluate the influence of model building conditions on the predictive accuracy of the models built, such as side of the fruit, environmental temperature, number of samples included in the model and growing location of the fruit. .

PROCEDURES

Fruit Material

Mature green 'Bartlett' pear fruit, sizes 6 to 11, were harvested from two orchards near Sacramento (Courtland, CA) and two orchards near Lakeport (Kelseyville, CA). Fruit were obtained near the day of the first commercial harvest and then every 7 days during the season to capture three (early, mid, late) stages of maturity (15-20 lbs firmness). Sacramento fruit from the first orchard were obtained on July 6, 13, and 23, and from the second orchard on July 8, 15 and 22. Lakeport fruit from the first orchard were collected on July 27, August 3 and 10, and from the second orchard on July 29, August 5 and 12. Fruit were packed into cardboard boxes and transported by car with air conditioning to the University of California, Davis laboratory within 1-5 hours on the day of harvest. Upon arrival in the laboratory, fruit were sorted for uniform appearance quality and lack of any defect, such as splits, sunburn, bruises or cuts. All fruit selected for the model building was previously weighed (LE62025 Sartorius scale, 0.01g accuracy; Bohemia, NY, USA) and the diameter measured with the Standard Pear Sizer (California Department of Food and Agriculture, Sacramento, CA, USA).

Model 1

The main goal of this model was to be able to measure the fruit at harvest with the F-750 or DA-Meter and obtain instant and accurate values (predictions) of quality traits such as SSC and DMC, closely linked to consumer acceptance.

Eighty fruit per orchard, harvest season and location (total of 480 fruit per model, one model per location) were selected and numbered (from 1 to 80) for model 1 building. Spectra from the fruit selected were taken on opposite cheeks on the same fruit at 75 °F with the F-750 and DA-Meter. Measurements were made on the widest part of the fruit at its equator. Immediately after the spectral measurements, color, firmness, starch content, DMC, SSC and TA were analyzed. Skin color was evaluated on opposite sides of the equatorial region of each fruit using a Minolta colorimeter (Model CR-400, Ramsey, New York). The color data were captured using the CIE L*a*b* scale and expressed as the hue angle (h°), where 120° denotes green and 60° represents yellow. The hº was calculated using the formula arctangent b*/a*. Firmness was measured on opposite sides of the equatorial region of each fruit after removing a thin slice of skin. The force required for an 8-mm diameter probe to penetrate the flesh to a depth of 5 mm was determined using a Fruit Texture Analyzer (GS-14, Güss, Strand, Western Cape, South Africa). Fruit were manually cut in half and starch content was immediately measured with the starch iodine test. Fruits were cut in half across the core and the surface was immersed in the iodine solution. After one minute fruits were removed from the solution and the treated surface was rinsed with distilled water. The reaction of iodine with the starch on the cut surface of the fruit gives dark bluish black color and is used as an indication of starch content. Starch iodine patterns were scored immediately (scale from 0 to 5; 0: 100% starch, 5: 0% starch). For DMC, the internal part of the fruit, avoiding the skin, was cut into four pieces and weighed on a pre-weighed foil tray. Samples were oven dried at 150 °F until constant weight (~48 h). DMC was expressed as a percentage of the dry weight of the initial fresh sample. The rest of the fruit, avoiding core and skin, was individually juiced with a press through two layers of cheesecloth to measure SSC by temperature compensated digital refractometry (Reichert AR6 Series; Reichert Inc., Depew, NY) and TA (expressed as % malic acid equivalents) using an automatic titrator (Radiometer TitraLab; Tim850 titration manager and SAC80 sample changer; Radiometer Analytical SAS, Villeurbanne, France).

Model 2

The main objective of this model was to measure the fruit at harvest with the F-750 or DA-Meter and obtain instant accurate predictions of the ripening capacity and the quality traits that the fruit will show when it is fully ripe. In this case, the fruit ripened with no conditioning treatment.

Eighty fruit per orchard, harvest season and location (total of 480 fruit per model, one model per location) were selected and numbered for model 2 building. Spectra from the fruit selected were taken as in model 1 and immediately after fruit were ripened at 68 °F with no conditioning treatment and in isolated tanks with constant air flow to avoid ethylene accumulation. To make sure that the selected fruit were fully ripe before proceeding to the next step, a set of additional pears were included in the tanks and checked every 2-3 days for firmness as described above. Rates of ethylene production and respiration by the samples were regularly measured during the ripening process. Eighteen fruit per treatment were selected and assigned as groups of six fruit to each of three replicate 3.8 L glass jars. The jars were sealed for 30-60 min. A headspace gas sample was collected with a 10 mL syringe and analyzed for ethylene concentration using a gas chromatograph (AGC Series 400; Hach-Carle CO., USA) with a flame ionization detector (FID) and alumina column (Villalobos-Acuña et al., 2010). Headspace samples were also analyzed with a Horiba VIA-510 infra-red gas analyzer (Horiba Instruments Co., USA) for CO2 concentration. Both the gas chromatograph and gas analyzer were calibrated with authentic ethylene and CO2 gas standards (Praxair, Inc., Sacramento, California). When fruit were fully ripe (~ 3 lbs. firmness), spectra were taken again with both F-750 and the DA-Meter. Immediately after, color, firmness, DMC, SSC and TA were analyzed as previously described. Ripening capacity was calculated as the average initial firmness at harvest minus the firmness presented by the individual fruit when fully ripe divided by the number of days to ripen.

Model 3

The main objective of this model was to measure the fruit at harvest with the F-750 or DA-Meter and obtain instant accurate predictions of the ripening capacity when the fruit is treated with SmartFresh.

Eighty fruit per orchard, harvest season and location (total of 480 fruit per model, one model per location) were selected and numbered for model 3 building. Spectra from the fruit selected were taken as for the other models at 75 °F and again 12 hours later, after the fruit were cooled to 32 °F overnight, with the objective of creating two models, one with fruits at room temperature and one with fruits at cold temperatures. To make sure that the model set was at the correct temperature before measuring, a set of additional pears were monitored with a thermometer Fruits were then treated with 300 ppb SmartFresh at 32 °F for 24h, then ripened immediately at 68 °F in isolated tanks with constant air flow to avoid ethylene accumulation. To make sure that the selected fruit were fully ripe before proceeding to the next step, a set of additional pears were checked every 2-3 days for firmness. Rates of ethylene production and respiration by the samples were regularly measured during the ripening process as described above. When fruit were fully ripe (~ 3 lbs firmness), spectra were taken with both F-750 and the DA-Meter. Immediately after, color, firmness, DMC, SSC and TA were analyzed as previously described. Ripening capacity was calculated as the average initial firmness at harvest minus the firmness presented by the individual fruit when fully ripe divided by the number of days to ripen.

Model 4

The main objective of this model was to measure the fruit at harvest with the F-750 or DA-Meter, and obtain instant accurate predictions of the post-storage quality after four months of storage at 32 °F.

Eighty fruit per orchard, harvest season and location (total of 480 fruit per model, one model per location) were selected and numbered for model 4 building. Spectra from the fruit selected were taken on opposite cheeks on the same fruit at 75 and 32 °F as described above. After four months, fruit spectra will be taken again with the F-750 and DA-Meter at 32 °F and then again at 68 °F. After the fruit are ripe (5 days), spectra are being measured again with both instruments and at both temperatures. Immediately after, storage scald, decay and internal breakdown are being assessed, as well as skin color, firmness, DMC, SSC and TA, as previously described.

Study of DMC-SSC-TA relationships

The objective of this study was to explore the relationships between DMC, SSC and TA during ripening of Bartlett pears, and the possibility of creating models with the F-750 and DA-Meter to accurately predict firmness and other quality traits during ripening.

Three hundred fruit per location were harvested at early-season, selected and numbered. At harvest, all fruit were measured with the F-750 and DA-Meter and immediately after 50 fruit were analyzed for starch, firmness, DMC, SSC and TA as described before. The rest of the fruit were exposed to 100 $\mu l\ l^{-1}$ ethylene at 68 °F for 24 h. Every 2 days a set of 50 fruit were analyzed with the F-750 and the DA-Meter, followed by quality analyses of starch, firmness, DMC, SSC and TA, as described above.

RESULTS

Spectral data analysis

The ability of a model to make accurate and robust predictions can be enhanced by excluding irrelevant and noisy regions of the spectra. Spectral measurements below 500 nm were quite noisy and were removed. The absorbance spectra was converted to second derivative form, and narrowed to the 729-975 nm range, a region known to include relevant carbohydrate, sugar and water absorbance bands in the NIR. Models are currently being built using a Partial Least Square (PLS) regression approach with the ModelBuilder (Felix Instruments, Camas, WA, USA) and XL Stat (Addinsoft SARL, 2015) software. The number of PLS factors are being selected by “leave one out” internal cross validation, which involves generating a pseudo-validation data set by setting aside fruit one at a time, building the subsequent calibration, and validating that calibration on the set aside fruit. The number of principle components with the minimum root mean square error of cross validation is selected. In our preliminary results, model performance and accuracy will be assessed in terms of R^2 (calibration coefficient of determination) and RMSEC (root mean square error of calibration). The first one describes the general accuracy of the model; the closer this number is to 1, the better the predictions will be. RMSEC indicates the standard error in the predictions that the instrument operator can get; the smaller the number, the more accurate the predictions will be. In future analyses, the predictive performance of the models will be judged by number of PLS factors, root mean square error of calibration, cross validation root mean square of calibration, coefficient of determination of calibration models, cross validation coefficient of determination of calibration models and ratio of performance to deviation of calibration for the models. Our primary interest was to evaluate the performance of the F-750 and DA-Meter in different environments, so we are studying significant differences between predictions considering various factors, including harvest season, growing location and fruit temperature. Statistical analyses are being performed using XL-Stat (Addinsoft SARL, 2015). There were no differences between predictions from models developed using different sides of the fruit for any of the harvests, locations or orchards, and therefore this factor was not further analyzed.

Models 1, 2 and 3 from Sacramento and Lakeport are currently being built. Fruit from model 4 are currently being analyzed or still in cold storage. Hence, only some preliminary results from the fruit from the three harvest dates and the two Sacramento orchards will be reported.

Model 1

Harvest date had an effect on the fruit weight, size and skin color (Table 1). Internal quality parameters such as starch, firmness, SSC, TA and DMC were also influenced by the harvest time (Table 2). DA-Meter showed slight changes in value with harvest date (Table 2). F-750 showed differences in the spectra related to harvest date (Fig. 1).

Table 1. Mean and standard deviations of the main characterization parameters of the 480 fruit selected from the two Sacramento orchards for the NIR-Model 1

Orchard	Harvest	Weight (g)	Diameter (inches)	Skin Color (h °)
#1	Early	134.0 ± 17.9	2.2 ± 0.3	115.4 ± 0.9
	Mid	183.1 ± 34.7	3.2 ± 0.4	113.8 ± 1.5
	Late	194.9 ± 37.8	3.3 ± 0.4	113.8 ± 1.2
#2	Early	134.1 ± 17.9	2.2 ± 0.3	114.9 ± 1.1
	Mid	231.5 ± 38.7	3.7 ± 0.4	114.4 ± 0.8
	Late	227.1 ± 40.9	3.6 ± 0.3	113.8 ± 1.3

Table 2. Mean and standard deviations of the main internal quality traits of the 480 fruit selected from the two Sacramento orchards for the NIR-Model 1

Orchard	Harvest	DA-Meter	Starch Score	Firmness (lbs.)	SSC (%)	TA (%)	DMC (%)
#1	Early	2.2 ± 0.1	0.9 ± 0.8	19.1 ± 1.9	12.6 ± 0.9	0.27 ± 0.1	15.9 ± 1.1
	Mid	2.0 ± 0.1	0.5 ± 0.5	16.5 ± 1.3	13.1 ± 0.9	0.30 ± 0.3	15.3 ± 1.6
	Late	1.9 ± 0.1	0.9 ± 0.4	15.7 ± 1.1	13.2 ± 0.9	0.26 ± 0.1	15.5 ± 1.5
#2	Early	2.1 ± 0.1	0.6 ± 0.7	17.8 ± 1.3	10.6 ± 0.6	0.29 ± 0.1	13.7 ± 0.8
	Mid	2.3 ± 2.5	0.7 ± 0.5	17.3 ± 1.2	11.1 ± 0.6	0.27 ± 0.1	13.8 ± 1.2
	Late	1.8 ± 0.3	1.1 ± 0.9	15.9 ± 1.1	11.1 ± 0.7	0.25 ± 0.1	13.7 ± 0.8

Starch score scale from 0 to 5: 0 represents 100% starch and 5 represents 0% starch; SSC: soluble solids content; TA: titratable acidity; DMC: dry matter content

Fig. 1. Average spectra of the early, mid and late-harvests measured by the F-750 NIR handheld device.

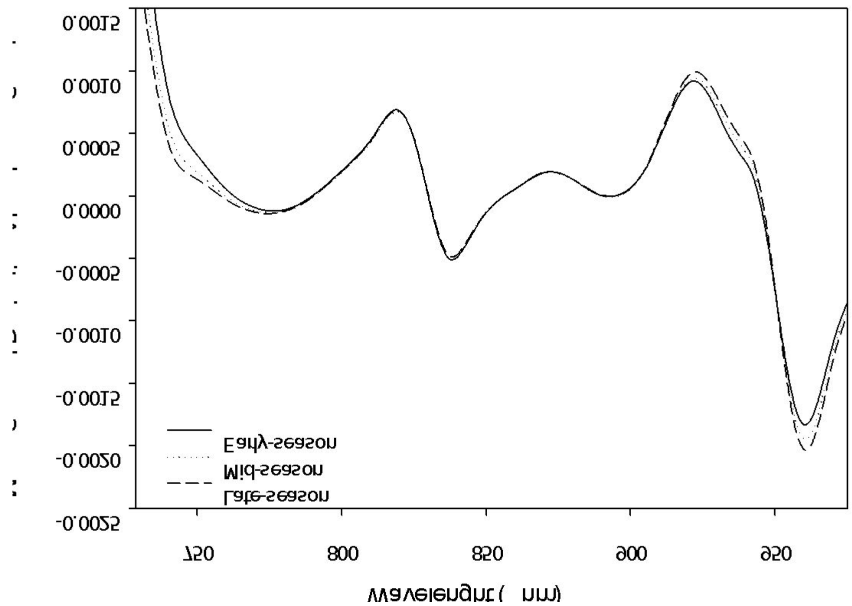
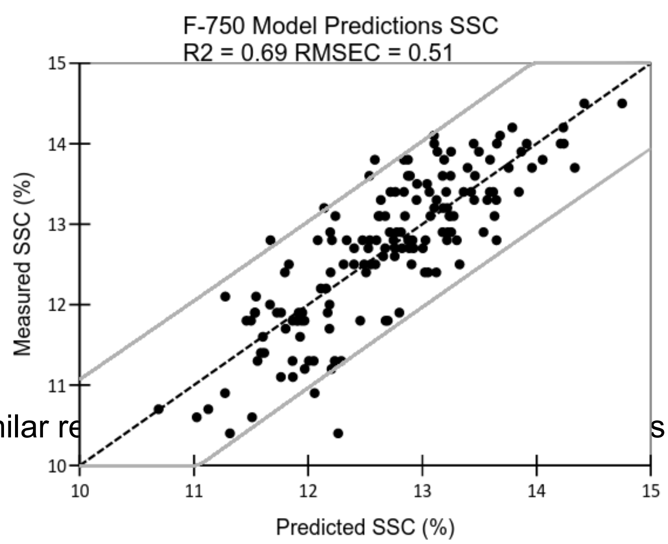


Fig.. 2. Prediction model of % SSC developed with the F-750 from early-season Sacramento fruit.



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for % DMC; the F-750 created a very good predictive model (R^2 = 0.77, RMSEC = 0.53) (Fig. 3), while the DA-Meter could not create a useful one.

Fig. 3. Prediction model of % DMC developed with the F-750 from early-season Sacramento fruit.

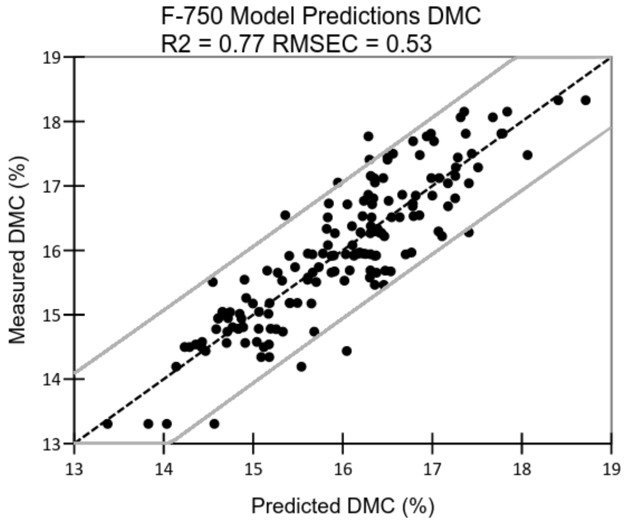


Fig. 4. Prediction models of % SSC using the F-750, data from early-, mid- and late-season fruit from the same orchard in Sacramento.

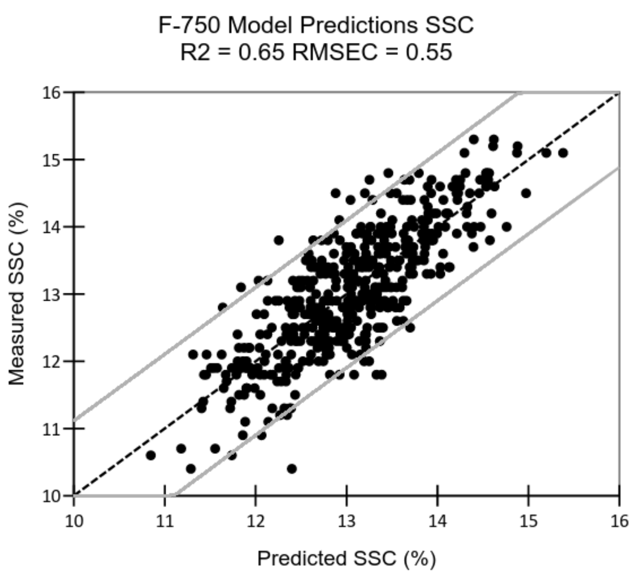


Fig. 5. Prediction models of firmness (lbs.) using the F-750 and the DA-Meter. Data from early-, mid- and late-season fruit from the same orchard in Sacramento.

Some preliminary models are being built from the spectra belonging to the first orchard, early-season Sacramento fruit. The F-750 is capable of developing a robust and accurate model to non-destructively analyze SSC in ‘Bartlett’ pear, with a standard error in the SSC value of 0.51 (Fig. 2). The DA-Meter was not adequate for performing SSC predictions; no model was usable.

To evaluate the importance of using the three harvest dates in the model building, some models are being developed from data from the same orchard and early-, mid- and late-harvested fruit. Surprisingly, the predictions were not more accurate in most of the traits tested (Fig. 4).

However, using the spectra from three harvests from the same orchard permitted the development of successful predictive models for firmness with the F-750 and the DA-Meter (Fig. 5). Still, the F-750 offered better accuracy than the DA-Meter (R^2 = 0.56 *versus* R^2 = 0.49).

Model 2

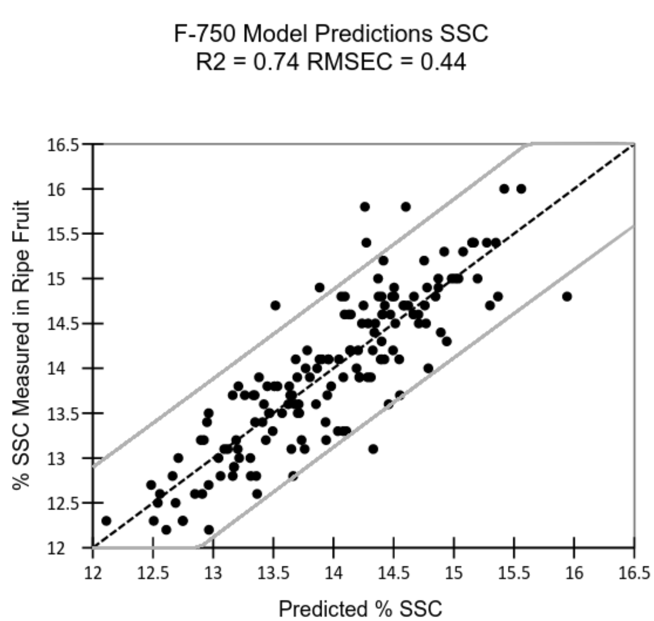
As expected, external and internal quality traits changed greatly during fruit ripening (Table 3). The F-750 was capable of developing models to predict SSC with an standard error of 0.44 (Fig. 6). No reliable model could be obtained from the DA-Meter.

Table 3. Mean and standard deviations of the main quality traits and DA-Meter values of the 480 fruit selected from the two Sacramento orchards for the NIR-Model 2.

		At harvest		Fully ripe				
Orchard	Harvest Date	DA-Meter	Skin Color h °	DA-Meter	Skin Color h °	SSC (%)	DMC (%)	Ripening rate (lbs./ day)
#1	Early	2.2 ± 0.1	115.1 ± 1.1	0.3 ± 0.1	95.8 ± 2.1	13.9 ± 0.8	15.9 ± 1.4	1.1 ± 0.1
	Mid	2.0 ± 0.2	114.3 ± 1.4	0.2 ± 0.1	97.2 ± 2.1	14.3 ± 0.7	15.6 ± 0.9	1.2 ± 0.1
	Late	1.9 ± 0.1	113.7 ± 1.1	0.6 ± 0.2	101.5 ± 2.3	14.2 ± 0.8	15.7 ± 1.0	1.5 ± 0.1
#2	Early	2.1 ± 0.1	114.8 ± 1.5	0.4 ± 0.2	98.8 ± 3.3	12.2 ± 0.6	13.9 ± 2.2	1.3 ± 0.1
	Mid	1.9 ± 0.1	114.8 ± 1.5	0.6 ± 0.9	101.6 ± 5.9	12.4 ± 0.6	13.6 ± 0.7	1.6 ± 0.0
	Late	1.8 ± 0.1	113.9 ± 1.1	0.3 ± 0.2	99.0 ± 2.3	12.7 ± 0.7	14.2 ± 1.6	1.7 ± 0.0

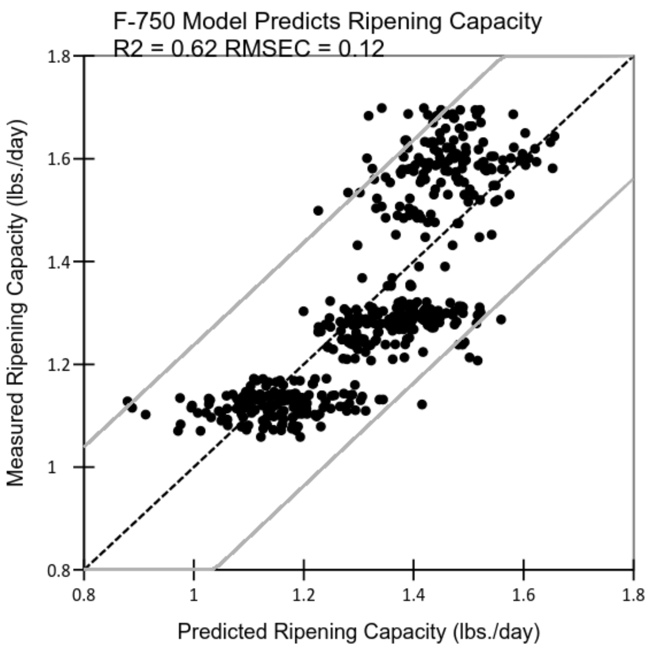
SSC: soluble solids content; DMC: dry matter content

Fig. 6 Prediction model of %SSC in ripe fruit using F-750 spectra from fruit at harvest.



Apart from other quality traits that the F-750 could potentially predict according to preliminary studies, this experiment also showed that the F-750 could be used to build prediction models for the rate of pear ripening (Fig. 7). With this model, it would be possible to predict the number of lbs. (firmness) that each individual fruit would lose per day during ripening, with an standard error of .12 lbs./day.

Fig. 7. Prediction models of ripening capacity (lbs./day) using F-750. Spectra taken at harvest predicted the rate of ripening of each individual fruit. Data from early-, mid- and late-season fruit from the same orchard in Sacramento. Harvest dates are separated in clusters.



Model 3

In this experiment, pear ripening was delayed by the application of 300 ppb SmartFresh. This treatment had a strong effect on the skin color and ripening rate of the fruit (Table

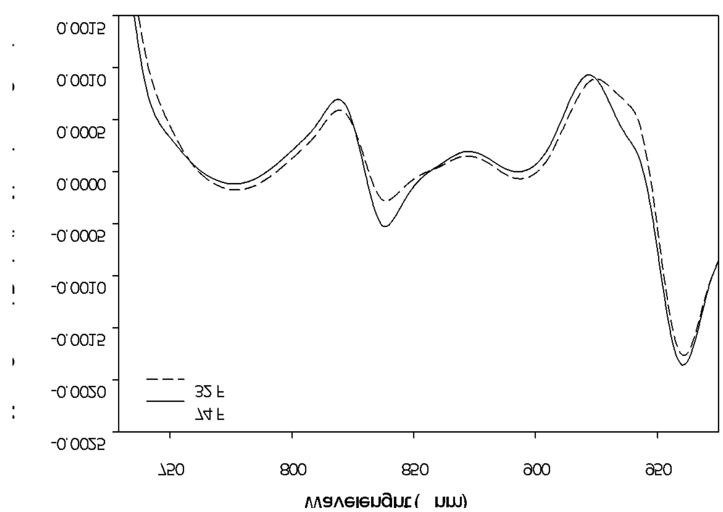
6); ripening rate significantly decreased and the fully ripe fruit was visibly more yellow (Table 4) than fully ripe fruit ripened without SmartFresh treatment (Table 3).

Table 4. Mean and standard deviations of the main quality traits and DA-Meter values of the 480 fruit selected from the two Sacramento orchards for the NIR-Model 3.

		At harvest		Fully ripe				
Orchard	Harves t Date	DA-Mete r	Skin Color h °	DA-Mete r	Skin Color h °	SSC (%)	DMC (%)	Ripening rate (lbs./ day)
#1	Early	2.1 ± 0.1	115.2 ± 1.1	0.1 ± 0.1	90.3 ± 1.5	13.9 ± 1.0	15.8 ± 2.1	0.51 ± 0.1
	Mid	2.0 ± 0.1	114.2 ± 1.3	0.1 ± 0.3	91.7 ± 1.2	13.8 ± 0.9	15.5 ± 1.0	0.53 ± 0.1
	Late	1.8 ± 0.2	113.6 ± 1.2	0.0 ± 0.1	92.5 ± 1.7	13.4 ± 0.9	16.9 ± 1.8	0.58 ± 0.0
#2	Early	2.1 ± 0.1	115.0 ± 1.3	0.1 ± 0.0	94.0 ± 2.5	12.3 ± 0.6	13.8 ± 0.8	0.63 ± 0.0
	Mid	2.0 ± 0.1	114.6 ± 0.8	0.2 ± 0.1	94.5 ± 1.6	12.2 ± 0.6	13.7 ± 0.8	0.57 ± 0.1
	Late	1.9 ± 0.1	113.9 ± 1.3	0.1 ± 0.1	94.8 ± 1.5	13.4 ± 0.5	13.3 ± 0.9	0.96 ± 0.1

SSC: soluble solids content; DMC: dry matter content

Fig. 8. Average spectra of the same pears taken with the F-750 at 32 and 75 °F.



The building of these models included the study of the spectra at two different temperatures, 32 and 75 °F. The DA-Meter did not register any difference in its values related to temperature. However, the F-750 spectra were very different depending on the temperature of the fruit (Fig. 8).

These changes in the spectra had a marked effect on the model building. Models developed with the F-750 for the prediction of ripening capacity showed that temperature could play an important role in model building. Predictive models could be built from the fruit at 32 and 75 °F, but models were stronger when the temperature of the fruit when the spectra were collected was at 32 °F (Fig. 11. This model was capable of predicting at harvest, with a standard error of 0.10 lbs./day, how many lbs. per day each individual pear would lose in the ripening process, when the fruit was treated with 300 ppb SmartFresh (Fig. 9). No reliable model could be obtained from the DA-Meter.

Fig. 9. Prediction models of ripening capacity (lbs./day) using the F-750 at different fruit temperatures. Spectra taken at harvest predicted the ripening capacity of pears treated with SmartFresh. Data from early-, mid- and late-season fruit from the same orchard in Sacramento.

<u>Study of DMC-SSC-TA relationships</u>

Changes in the fruit during ripening were recorded in this study (Table 5). Averages of firmness, starch, skin color (h°) and DMC decreased, while average SSC and TA increased during ripening. The F-750 showed differences in the spectra averages every two days of ripening (Fig. 10). With small differences in the whole spectra, the maximum spectra divergences were found between 729-775, 915-945 and 955-975 nm.

Table 5. Means and standard deviations of the quality traits and DA-Meter values of the 300 fruit selected for the study of the ripening process.

Day	DA-Meter	Starch	Skin Color h °	Firmness (lbs.)	SSC (%)	TA (%)	DMC (%)
0	2.1 ± 0.1	0.9 ± 0.7	114.9 ± 1.6	19.4 ± 1.9	12.5 ± 0.9	0.27 ± 0.1	16.1 ± 1.0
2	2.1 ± 0.1	1.3 ± 0.7	114.5 ± 1.2	19.1 ± 1.5	12.8 ± 0.9	0.27 ± 0.1	15.9 ± 1.6
4	2.2 ± 1.8	2.6 ± 1.1	113.4 ± 2.1	15.7 ± 3.1	13.1 ± 1.1	0.28 ± 0.1	15.6 ± 1.1
6	1.6 ± 0.2	3.6 ± 0.6	110.0 ± 2.4	8.2 ± 3.3	13.7 ± 0.7	0.27 ± 0.1	15.5 ± 1.0
8	1.2 ± 0.3	4.2 ± 0.9	105.5 ± 4.2	4.9 ± 2.8	13.8 ± 1.1	0.30 ± 0.0	15.8 ± 1.2
10	0.6 ± 0.4	4.9 ± 0.3	100.3 ± 4.9	3.1 ± 1.8	13.9 ± 1.1	0.29 ± 0.0	15.2 ± 1.5

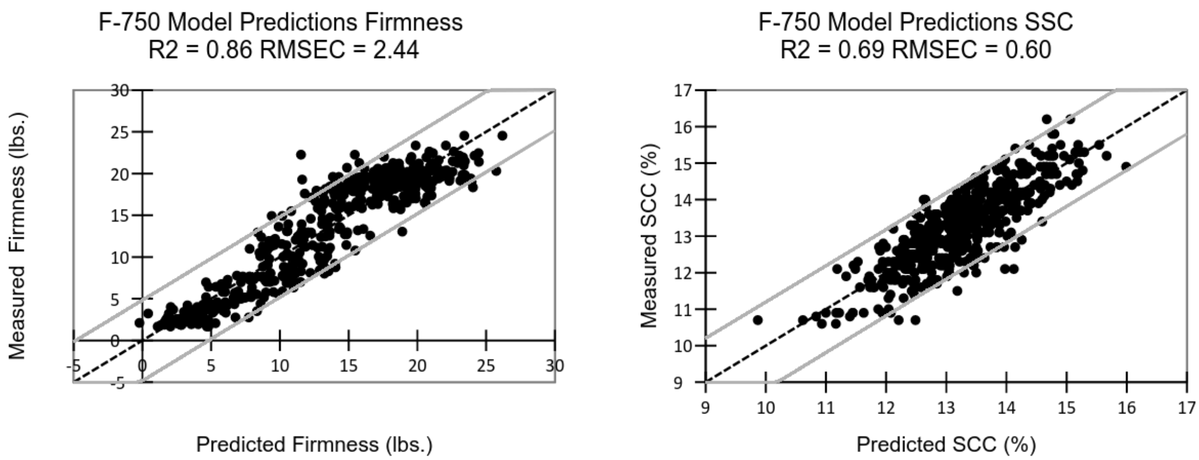
Starch score scale from 0 to 5: 0 represents 100% starch and 5 represents 0% starch; SSC: soluble solids content; TA: titratable acidity; DMC: dry matter content

Fig. 10 Average of spectra obtained from the Sacramento fruit every two days of ripening after exposing the fruit to 100 μl l^{-1} ethylene at 68 °F for 24 h.

Mean Second Derivative Absorbance Spectra

Robust and accurate models for the non-destructive evaluation of firmness and SSC were built in this experiment (Fig. 11. By using these models with the F-750, firmness could be accurately predicted in any ‘Bartlett’ pear from harvest to fully ripe stages, withan standard error of 2.44 lbs. in the predictions (in a range from 24 to 1 lbs.), and SSC could be predicted with an standard error of 0.60% (range of 16 to 10.5%). A model for the prediction of DMC was also accurate enough to be used, but appeared to be weaker than the others, with a R^2 of 0.54 and a RMSEC of 0.57%.

Fig. 11. Prediction models of firmness and % SSC using F-750



The DA-Meter data did not provide a prediction model strong enough to be confidently used.

DISCUSSION

The F-750 showed potential to accurately predict pivotal ‘Bartlett’ pear traits, such as SSC and DMC, essential to the pear eating quality. The preliminary models developed in our study based on NIR spectra (729-975 nm) showed coefficients of determination ranging from 0.55 to 0.86 and standard errors of predictions ranging from 0.10 to 2.44. These data indicate that the handheld device F-750 could be useful for developing robust and predictive models for ‘Bartlett’ pears. The DA-Meter did not show good predictive capacities. Further studies are needed to study the reason for this lack of accuracy and to confidently evaluate its possible use in ‘Bartlett’ pear. Additional work on all of our models will be conducted over the next few months to fully assess the potential of these two devices.

Other authors have discussed the possibility that NIR spectroscopy could not easily distinguish between forms of carbohydrate, making the distinction between SSC and DMC difficult for model development. In fact, spectra values were very similar between SSC and DMC in our study, and the predictions were based on similar spectral characteristics. However, several absorbance peaks appeared to be relevant exclusively to the DMC prediction models of the pears. This outcome agrees with previous studies that found that the spectral region between 900 and 970 (composed of overlapping absorbance bands of starch and cellulose (900-930 nm), sucrose (900-920 nm) and water (940-960 nm) was particularly relevant for DMC, requiring additional wavelengths in this region for optimal prediction.

The side of the fruit selected for NIR measurement had no effect on the accuracy of any of the pear models. However, the accuracy of most of the models was different when developed at different temperatures; a change from 32 to 75 °F meant a difference in the standard error of prediction in most of the traits tested in these preliminary results. These outcomes agree with previous NIR research, indicating that environmental temperature when developing a model could have a strong influence on measurement results; nonlinear temperature effects on NIR spectra may lead to strongly biased predictions. The absorbance values were different when the same fruit was measured at 32 and at 75 °F. Therefore, using spectral measurements from a broad range of temperatures could strength the model’s prediction accuracy instead of weakening it; a model built with a range of temperatures may not perform as well as a model built for a specific temperature, but may perform better for temperatures for which no calibration data is available. It could be recommended, then, to build models covering the broadest possible range of temperatures at which the pears will be analyzed with NIR; predictions could gain accuracy and consistency.

Some of the models presented with the F-750 open the door to real-time and nondestructive assessments of pear maturity. Predictive models of firmness and ripening rate have been developed in pears ripening with no conditioning treatment (coefficient of determination of 0.62) and pears treated with SmartFresh (coefficient of determination of 0.72). These models would help to establish adequate conditioning and SmartFresh treatments in ‘Bartlett’ pears, being able to sort each fruit individually by its own firmness or ripening capacity. In additional, the sensory profile of the pears could potentially be predicted from the commercial harvest stage, considering the prediction capacities of SSC and DMC shown in some of these preliminary studies. The prediction of postharvest quality and sensory attributes by instrumental nondestructive measures would represent a much needed innovation in quality control. The information provided by this study, when fully evaluated, could provide us with robust and accurate models which could be easily applied in the near future by ‘Bartlett’ pear growers, packing houses and processors.

However, to be confidently used, NIR models need to be validated with different harvest seasons, orchards and stages of ripeness to study the accuracy of the predictions. The observed values will be correlated to the NIR-spectra. If the models demonstrate accurate predictions, the use of NIR devices could be considered for routine analysis of pear quality and for sorting activities. This technique could allow pear growers to objectively and nondestructively establish in the orchard or on the packing line the quality of the fruit, including firmness and ripening rate, and select the best fruit for more demanding marketing destinations.