Correcting Current Moisture Calculations for Purchasing High Moisture Farmers Stock Peanuts[1]

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ABSTRACT

The U.S. peanut industry may eliminate the 10% moisture content threshold for purchasing peanuts to facilitate implementing continuous flow drying systems and to increase the efficiency of the postharvest processing system. Equations based on the theoretical definition of wet basis moisture content were proposed to determine the weight of various components in a load of farmers stock peanuts. These equations more accurately describe and account for the distribution of moisture within a load of peanuts. Accurate descriptions of the amount of loose shelled kernels, foreign material, and in-shell peanuts would enable improved tracking of losses during storage. Compared to the current price structure, the proposed equations predict reduced payments to growers no more than \$30 per 5-mt load of peanuts. The maximum reduction of \$30 occurred if peanuts were delivered and marketed at 30% w.b. moisture content. A reduction of approximately \$8.50 would occur for a 5-mt load delivered at 15% moisture content. The cumulative economic impact warrants adjustment of the peanut support price schedule if accurate accounting of moisture is implemented.

Key Words: *Arachis hypogaea*, drying, marketing, storage.

Prior to 1989, commercial peanut combines were capable of harvesting a single windrow (two rows). Four-row combines were introduced in 1990 and by 1991 at least one major manufacturer ceased two-row combine production. Six-row machines were introduced in 1991 followed by the introduction of eight-row combines in 1996. Harvest capacity of two-row peanut combines currently in use is approximately 8 ha/d compared to 12 and 16 ha/d for four- and six-row combines, respectively (M. Mathis, pers. commun., 1997).

Increased harvest capacity has dramatically increased the need for higher capacity curing systems. Most U.S. peanuts are mechanically cured in bulk curing systems using wagons or trailers equipped with a perforated metal floor and plenum to force heated air through the peanuts until they reach a marketable moisture content of 10.5% wet basis or less (USDA, 1997). Most peanuts arrive at the buying point in the southeastern U.S. at an average moisture content of 15-17% w.b. The capacity of a typical peanut drying wagon is 4000-6000 kg. A typical peanut buying point in the southeastern U.S. owns 100-200 peanut drying wagons to handle the peanut crop as it is harvested. The identity of these batches of peanuts must be maintained throughout the curing process because the buying point does not own the peanuts until they have been cured, graded, and sold.

The recent increases in harvest capacity have prompted the industry to investigate alternative high capacity peanut curing systems including continuous flow systems (Ertas *et al.* 1966; Butts and Omary, 1997; Noyes *et al.* 1997; Wright *et al.*, 1997; Ertas *et al.*, 1998). Butts and Omary (1997) stated that the two-stage bin dryer could not be utilized as designed because the current requirement of maintaining batch identity did not allow the buyer to mix peanuts from several farms to fill the two-stage dryer. Noyes *et al.* (1997) tested a recirculating batch dryer in which peanuts made multiple passes through alternating heating and tempering zones until the peanuts reached the desired moisture content. Both of these systems could easily adapt to continuous flow if the current marketing system allowed.

Other commodities such as corn are marketed at higher moisture contents with adjustments made to account for changes in total grain weight of the grain (kg) and the weight per unit volume (kg/m^3). Changing ownership of the farmers stock peanuts at higher moisture contents would allow the buyer to mix peanuts according to various quality parameters prior

[1]Mention of firm names or trade products in this manuscript does not constitute a recommendation by the USDA.

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to curing and thus improve the efficiency of the entire curing and post-harvest handling process. The weight change due to moisture loss must be accurately determined, and the quality of the peanuts must be established at the higher moisture levels. Siemens and Mullinix (1998) investigated the possibility of grading peanuts at higher moisture levels, then adjusting to account for changes in kernel size distribution so that the unit value ($/mt) based on the "green" grade was the same as conventional grade. They recommended further analysis. Siemens and Mullinix did not determine the difference in weight due to moisture loss.

USDA prescribes the method by which the value of a load of peanuts is determined based on the official farmers stock grade and the weight of material delivered by the farmer. Under the current grading system, a 2-kg sample is extracted from the load of peanuts. The percent foreign material (FM), loose shelled kernels (LSK), and pods are determined from an official grade sample. A 500-g portion of the peanut pods are shelled and sorted into sound mature kernels (SMK), split kernels (SS), and other kernels (OK). These percentages are calculated based on the weight of clean pods. The peanut kernels (SMK, SS, and OK) are then combined and moisture content determined using an electronic moisture tester. The moisture content is recorded in tenths or hundredths then rounded to the nearest whole percent for calculations. Moisture meters display the wet basis moisture content and is defined by ASAE (1996):

$$MC = \frac{WT_{wet} - WT_{dry}}{WT_{wet}} \times 100\% \qquad \text{[Eq. 1]}$$

where:

MC = moisture content (%, wet basis)
WT_{wet} = wet weight
WT_{dry} = oven dry weight.

The weights of the individual grade components of each load of farmers stock peanuts are determined according to formulae prescribed by USDA on the official FSA-1007 (USDA, 1995) and shown in Table 1. The value of an individual load of peanuts is based on the weight of peanuts at 7% wet basis moisture content and the official grade. The total weight of the farmers stock peanuts including the vehicle or wagon (GWV) and the empty wagon weight are recorded (WT_V). The weight of the foreign material in the wagon is calculated using the FM percent determined from the grade. The weight of moisture in the peanuts above 7% (WT_{EM}) is calculated by multiplying the gross weight (WT_G) less foreign material ($WT_{LFM} = WT_G\text{-}WT_{FM}$) by the difference in the grade moisture content and 7%. The net weight of the load of peanuts (peanut pods and LSK at 7% w.b.) is then calculated by subtracting WT_{EM} from WTL_{FM}. Mathematically, subtracting one wet basis moisture content from another is incorrect because the denominators, WT_{wet} at the purchase moisture content and at 7%, are numerically different. Substituting the known weight, WT_{LFM}, and moisture content, MC, at the time of purchase into Eq. 1 results in Eq. 2.

$$MC = \frac{WT_{LFM} - WT_{dry}}{WT_{LFM}} \times 100\% \qquad \text{[Eq. 2]}$$

The net weight of the load of peanuts is the weight of the peanuts and LSK at 7% w.b. moisture content. Substituting the desired moisture content, MC = 7, and the net weight in Eq. 1 results in:

$$7 = \frac{WT_{NET} - WT_{dry}}{WT_{NET}} \times 100\% \qquad \text{[Eq. 3]}$$

In Eq. 2 the MC and WT_{LFM} are known. The net weight of the load (WT_{NET}) in Eq. 3 is unknown. Solving Eq. 2 for WT_{dry} then substituting into Eq. 3 and solving the resultant equation for WT_{NET} results in

$$WT_{NET} = WT_{LFM} \times \frac{100 - MC}{100 - 7} \qquad \text{[Eq. 4]}$$

Table 1. Calculations used to determine value of a load of farmers stock peanuts as described by USDA when purchased at moisture contents below 10.5% and the proposed method for high moisture purchases.

	Grade factor	Mass (kg) Current	Mass (kg) Proposed
Gross weight including vehicle		WV	GWV
Vehicle weight		WT_V	WT_V
Gross weight		$WT_G = GWV\text{-}WT_V$	$WT_G = GWV\text{-}WT_V$
Foreign material[a]	FM	$WT_{FM} = WT_G{*}FT/100$	$WT_{FM} = WT_G{*}FM/100$
Gross less foreign material		$WT_{LFM} = WT_G\text{-}WT_{FM}$	$WT_{LFM} = WT_G\text{-}WT_{FM}$
Moisture content[b]	MC		
Excess moisture[c]		$WT_{EM} = WT_{LFM}{*}(MC\text{-}7)/100$	$WT_{EM} = WT_{LFM} \left[1-\left(\frac{100-MC}{(100-7)}\right)\right]$
Net weight		$WT_{NET} = WT_{LFM}\text{-}WT_{EM}$	$WT_{NET} = WT_{LFM}{*}\frac{(100-MC)}{(100-7)}$
Loose shelled kernels[a]	LSK	$WT_{LSK} = WT_G{*}LSK/100$	$WT_{LSK} = WT_G{*}LSK/100{*}\frac{(100-MC)}{(100-7)}$
Net less LSK (pod weight)		$WT_P = WT_{NET}\text{-}WT_{LSK}$	$WT_P = WT_{NET}\text{-}WT_{LSK}$

[a]Foreign material and loose shelled kernels determined as percentage of gross weight.
[b]Moisture content of peanuts removed from shells during grading, excluding LSK, percentage wet basis.
[c]Excess moisture is the difference in weight of peanuts at the marketed moisture and at 7% wet basis.

where:
MC = moisture content at the time of purchase (% w.b.)
WT_{LFM}= gross weight less foreign material at MC
WT_{NET}= gross weight less foreign material at 7% w.b.

Equation 4 may used to directly determine the net weight of the load of peanuts without the intermediate step of actually calculating the excess moisture. However, by substitution and algebraic manipulation, the excess moisture (WT_{EM}) can be derived and calculated using Eq. 5.

$$WT_{EM} = WT_{LFM}\left(1 - \frac{100 - MC}{100 - 7}\right) \quad \text{[Eq. 5]}$$

While not accounted for in the proposed equations, another source of error is the assumption that the peanut hulls and kernels are at the same moisture content. However, the equilibrium moisture content of hulls and kernels are considerably different (Young *et al.*, 1982).

The weight of loose shelled kernels in a load of farmers stock peanuts is calculated using the wet, gross weight of peanut material, and is not adjusted to account for the excess moisture of the LSK (Table 1). This results in a slightly higher calculated weight of LSK in each load. The LSK weight at 7% w.b. may be calculated by substituting the wet weight of LSK (WT_C × LSK/100) for WT_{LFM} in Eq. 4 (Table 1). The weight of peanut pods is calculated by subtracting the LSK weight from the net weight.

The objective of this manuscript is to demonstrate the effect of properly accounting for moisture distribution on the weight of individual components within a load of farmers stock peanuts and its subsequent effect on the value of that load of peanuts. The cumulative effect for a buying facility over a range of moisture contents at the time of purchase is also discussed.

Materials and Methods

Official grade data were obtained over three separate harvest seasons, 1989-1991, from four different buying points during a study by Butts and Smith (1995) to determine the change in value of peanuts during storage. Data from three warehouses used to store runner and virginia-type peanuts were used in this study. The average moisture content of the runner peanuts at the time of marketing was approximately 9% w.b. The average moisture of the virginia peanuts was 8% w.b. Using the official weight and grade data recorded at load-in, the weight of each of the grade components was calculated according to the official formulae (col. 3, Table 1). The dollar value of each load was determined using the 1996 peanut loan schedule for runner and virginia-type peanut. The component weights were recalculated using the proposed relationships described in Eqs. 4 and 5 (col. 4, Table 1). The dollar value of each load was then calculated using the recalculated component weights.

To simulate the effect of peanuts being purchased at higher moisture content, the moisture content of each load was increased 20% w.b. in 1% w.b increments. The component weights and load value were calculated using both methods. The gross weight of peanut material (WT_C) delivered for sale and all grade factors, except moisture content, remained constant as moisture content increased. The excess moisture (WT_{EM}), net weight (WT_{NET}), and dollar value using the two methods of weight calculation was examined for the average load and for the buying point.

Results and Discussion

The percentage foreign material was approximately the same for the virginia and runner peanuts over the 3-yr period and averaged 5% of gross weight (Table 2). Loose shelled kernels averaged 4.7% in the runner peanuts and 4.4% in the virginia peanuts. The differences in the calculations are best seen in an illustration (Table 3) using farmers stock runner peanuts with grade factors equivalent to the 3-yr average for runner peanuts in the Butts and Smith (1995) data (Table 2). If peanuts were graded and purchased at a moisture content typically harvested by the farmer (15% w.b.), the approximate amount of moisture to be removed to reach 7% w.b. would be 409 kg. The USDA calculations estimate the excess moisture as 380 kg. This directly affects the subsequent calculations of net weight and pod weight (Table 3).

Calculating the amount of LSK in the load using the USDA formula multiplies the percentage LSK by the gross weight of the load. This amount has not been corrected for excess moisture. The excess moisture in the LSK, in this illustration, is approximately 22 kg. The pod weight, using the USDA formula, was 4120 kg compared to 4113 kg using the proposed formula. Using the average runner grade factors, and the 1996 loan schedule, the pod value was \$730/mt and the LSK value was \$154/mt. The total value of the load of peanuts using the proposed calculations was \$3037 as compared to \$3045 using the USDA calculations. The difference is approximately 0.3% of the value using the proposed calculations. Using the proposed calculations consistently reduced the total paid to the grower for each load of peanuts depending on the peanut market type and initial moisture content (Fig. 1). The decrease in value for runner type peanuts was slightly more than for virginia type peanuts at any marketed moisture content. This is due to the slightly higher grades for runner peanuts. The value difference changed linearly from 0 to -1% as the

Table 2. Three-year average grade factors used in determining the effect of using mathematically correct calculations for adjusting weight of farmers stock peanuts to 7% moisture content (data obtained from Butts and Smith, 1995).

Grade factor	Runner-type	Virginia-type
	%	%
Foreign material	4.7	4.7
Loose shelled kernels	4.6	4.4
Extra large kernels (virginia type only)	—	43.3
Sound mature kernels	70.8	66.9
Sound splits	2.7	3.1
Other kernels	4.5	2.1
Damaged kernels	0.4	0.5
Hulls	21.5	27.4

marketed moisture increased. The higher the moisture content, the greater the difference between the value paid based on the USDA calculations and the proposed calculations. For the individual load of peanuts at 30% moisture content, the difference would be approximately $30. The proposed equations more accurately describe the load of farmers stock peanuts. Using the proposed equations would have minimal impact on the individual grower. However, the grower delivering large quantities of quota peanuts at high moisture would realize a significant difference in the total monies received.

Table 3. Example calculations for a single farmer stock purchase of peanuts using the the current method of calculating load component weights as described by USDA and the proposed method for high moisture purchases.

	Grade factor	Current	Proposed	Difference[a]
	%	--------- kg	---------	%
Gross wt including vehicle		7000	7000	
Vehicle weight		2000	2000	
Gross weight		5000	5000	
Foreign material[b]	5	250	250	
Gross less foreign material		4750	4750	
Moisture content[c]	15			
Excess moisture[d]		380	409	+7.1
Net weight		4370	4341	-0.7
Loose shelled kernels[b]	5	250	228	-9.6
Net less KSK (pod weight)		4120	4113	-0.4
Pod value @ $729.80/mt[e]		$3006.78	$3001.67	-0.2
LSK value @ $154/mt		$38.50	$35.11	-9.6
Total value		$3045.28	$3036.78	-0.3

[a]Percent difference = (proposed - current)/proposed × 100%.

[b]Foreign material and loose shelled kernels determined as percentage of gross weight.

[c]Moisture content of peanuts removed from shells during grading, excluding LSK, percentage wet basis.

[d]Excess moisture is the difference in weight of peanuts at the marketed moisture and at 7% wet basis.

[e]Pod value determined from 1996 Loan Schedule for runner peanuts using the 3-yr average grade factors for runner peanuts in Table 2.

Based on the assumption that the delivered weight of the individual load of peanuts does not change with increasing moisture and the number of loads delivered remains constant, the predominant impact would be on the sheller. Although the effect on the weight of various components and ultimately on value for a single load of peanuts is minimal, the bias of the correction is consistent and accumulates. The accumulated difference paid for the peanuts depends on the average moisture content at the time of marketing and the total amount of peanut purchased (Fig. 2). For instance, a buying point that handles a total gross weight of 14,000 mt during harvest at an average 10% moisture content would pay approximately $11,000 less for their farmers stock purchases if the proposed calculations were used. If that same buying point purchased peanuts at an average 20% moisture content, they would pay approximately $44,000 less using the proposed method of calculation. A buying point purchasing 6000 mt would spend approximately $4000 and $19,000 less at 10 and 20% moisture contents, respectively.

As seen in the single trailer illustration, the difference in value comes from the differences in the calculated distribution of weight of materials. The remainder of this discussion is based on the impact on a 14,000-mt buying point. If peanuts are purchased at an average 10% w.b. during the season, the total excess moisture deducted is approximately 400 mt using the current equations and 450 mt using the proposed equations (Fig. 3). The difference between the methods increases as the average moisture content increases, with the excess moisture calculated using the proposed equations always being higher. Therefore, the total net weight determined using the proposed equations is always less than

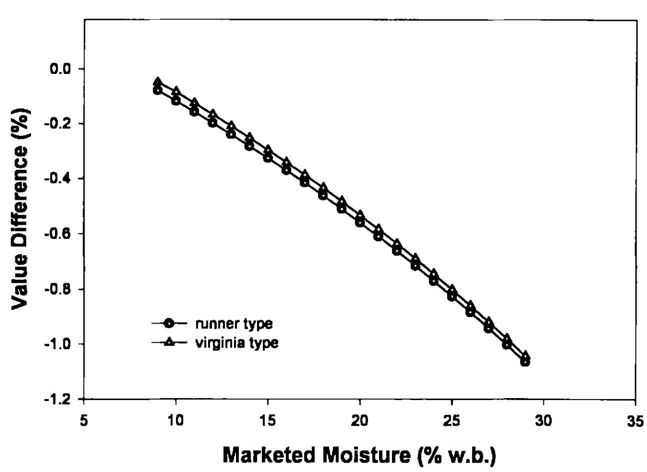

Fig. 1. Percent difference in value of a load of farmers stock peanuts using the current USDA-prescribed and proposed equations to calculate component weights for virginia and runner type peanuts [(proposed-current)/proposed × 100%].

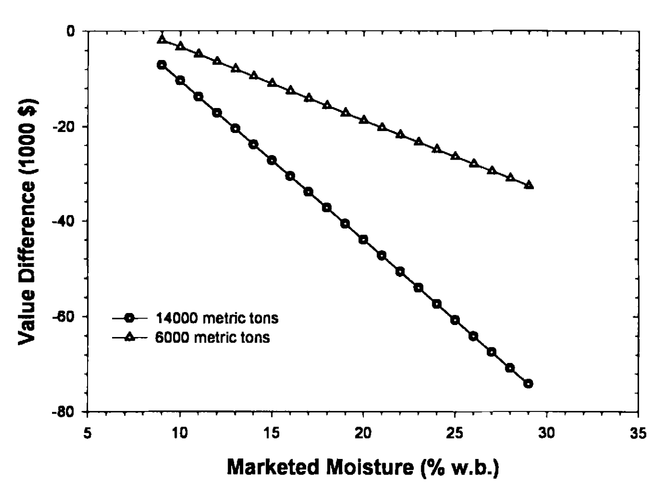

Fig. 2. Cumulative difference in value of farmers stock peanuts purchased using the current USDA-prescribed and the proposed equations to determine various weight components for peanut buying points purchasing 14,000 and 6000 mt annually.

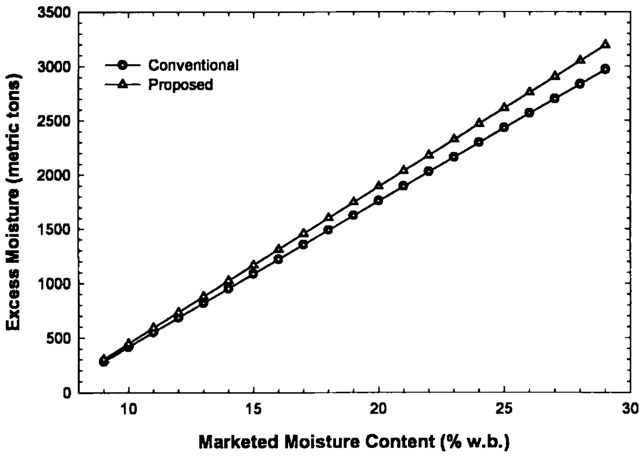

Fig. 3. Cumulative excess moisture deducted from farmers stock peanuts purchased using the current USDA-prescribed and proposed equations to calculate various weight components.

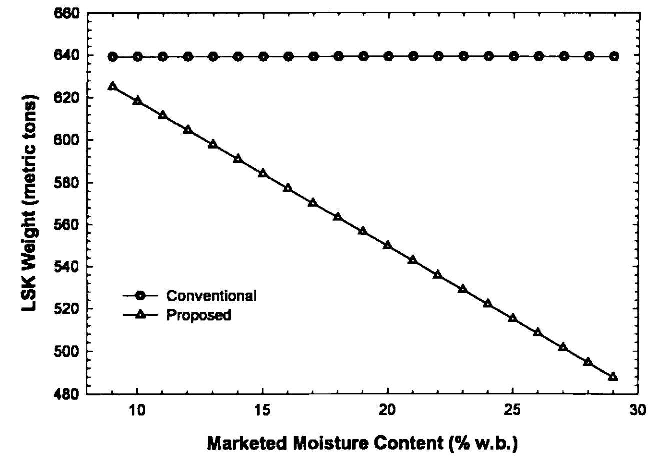

Fig. 5. Cumulative weight of loose shelled kernels in farmers stock peanuts purchased using the current USDA-prescribed and proposed equations to calculate various weight components.

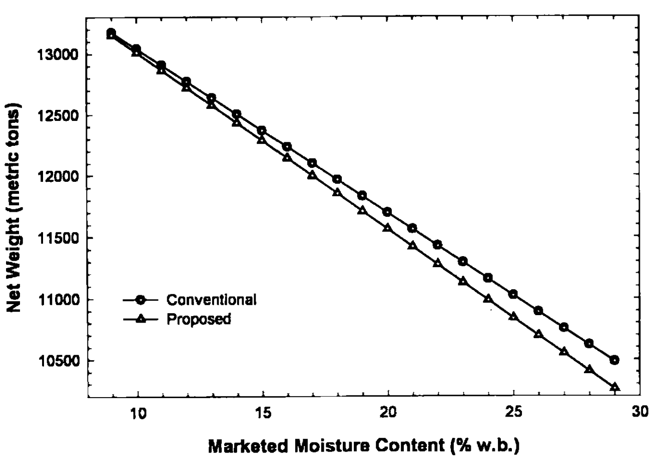

Fig. 4. Cumulative net weight of farmers stock peanuts purchased using the current USDA-prescribed and proposed equations to calculate various weight components.

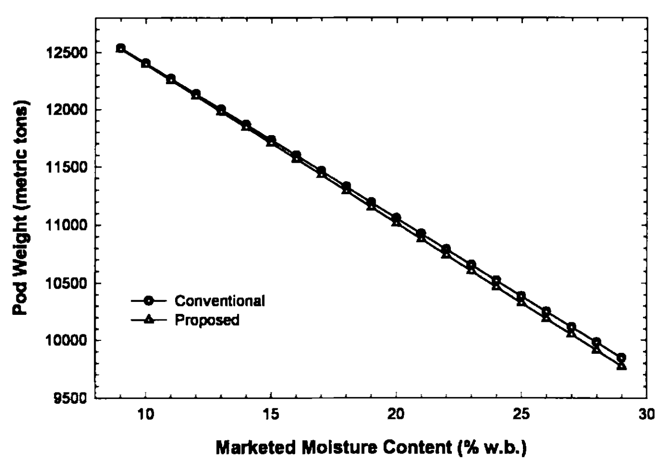

Fig. 6. Cumulative weight of peanut pods in farmers stock peanuts purchased using the current USDA-prescribed and proposed equations to calculate various weight components.

that determined using the current equations (Fig. 4).

The total LSK calculated using the equations remains constant regardless of moisture content at the time of purchase (Fig. 5). When the excess moisture in the LSK is accounted for, the LSK weight deducted from the net weight decreases as moisture content increases. At 10% moisture content, the difference in LSK purchased by the buying point is 24 mt. At 15% moisture content, the difference increases to 56 mt. Since pod weight is determined by subtracting the LSK weight from the net weight, the decreased LSK in a load of farmers stock peanuts, the weight of peanut pods changes very little, even at the buying point scale (Fig 6). Properly accounting for excess moisture in the LSK as proposed, combined with the price differential between LSK ($154/mt) and pods ($729/mt), reduces the negative impact on the grower.

Using the proposed equations will give the sheller a more accurate picture of the material being purchased, and will enable them to more effectively monitor their storage and other processing losses. The consistent and significant bias warrants changes in the current peanut price schedule to maintain equitable payments for the grower.

Summary and Conclusions

Equations to more accurately calculate the distribution of moisture among the various components of farmers stock peanuts were presented. Compared to the current method of calculation prescribed by USDA, the proposed equations result in higher values for excess moisture, reduced LSK weight, and pod weight. Using the proposed and more accurate equations would result in a reduction of no more than $30 per 5 mt load of farmers stock peanuts delivered by the farmer. As the U.S. peanut industry considers removing the upper limit on moisture content for purchasing peanuts, it should consider changing the equations used to calculate the weight of various components within the farmers stock load of peanuts. The proposed equations based on the definition of wet basis moisture content can be easily implemented, especially as the automated data acquisition during the grading process is implemented.

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