Physical Characteristics of Some Vegetables Grown in Ahmedabad Region

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Abstract

Physical dimensions, mass, shape and bulk density of vegetables grown around Ahmedabad have been determined. Measurements were carried out on samples at the farm immediately after harvest. Pattern underlying one of the characteristic dimensions has been identified. Statistical distribution that best described the pattern in all cases was found to be two parameter Weibull. Use of cluster analysis was illustrated in case of okra to determine the number of relatively homogenous groups into which the produce can be separated. Results may be useful to those working on unit technology and technology systems for fresh produce.

(*Key words*: Physical characteristics, vegetables)

Introduction

We are developing a composite unit as a part of supply chain where fresh produce will be washed, cleaned, graded and packed before being sent to retail stores in Ahmedabad. Fruits grown in Gujarat-mango, banana, sapota, papaya, guava, ber - and vegetables grown around Ahmedabad - okra, eggplant, cabbage, cauliflower, bottle gourd, cow pea, flat bean, spinach, tomato, lemon, potato, onion - will be handled in this unit. Design of washer, grader, material transfer systems and packaging requires data on physical characteristics. Accordingly, measurements were made. In this paper, we present the measured characteristics of vegetables grown around Ahmedabad. Brief review of literature is presented first. It is followed by presentation of physical characteristic data and its analysis.

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Review of Literature

Data on the dimensions and physical characteristics of mango can be found in the works of Singh and Varma 1995, who needed these to develop corrugated fiberboard box for packaging; Joshi and Sutar 2003, who needed these to develop grader and packaging box. Latter also studied sapota. Kudachikar et. al. 2003 observed physical and chemical changes associated with fruit development in *raspuri* and *alphanso* varieties of mango as a part of their work to determine the optimum stage of maturity for harvesting. Similar work can be found in Kariyanna et.al. 1995 on *kallipatti* variety of sapota.

Data on guava can be found in the works of Agrawal et.al 2002 and Laxmi and Sudheer 2003. Some data on papya can be found in the work of Ramakrishana et.al. 2003, who investigated the effect of different packages on the physico chemical changes and shelf life of *CO-2* variety of papaya.

Viswanathan et. al. 1997 determined physical characteristics of four varieties of tomato while working on pulping mechanism. Narayanan and Shreenarayanan 2001 also reported physico-mechanical properties of two other varieties (*CO3 & Rupali*) of tomato. Some physical properties of fresh green and dried chilies can be found in the work of Shivhare et al. 1987, who studied its drying characteristics.

Review suggests that studies on physical, mechanical characteristics of fruits and vegetables are still limited. These are outcome of work on unit technology and technology system undertaken at various places. But as yet comprehensive and systematic effort to create database of physical characteristics of produce grown in various region of the country, has apparently not been made. Shortage of data is more acutely felt in relation to vegetables. Physical characteristics are primarily determined by the genetic constitution of the cultivars. But these are also influenced by agro-climatic factors and farming practices prevalent in various regions. It was therefore, decided to make the necessary measurements of vegetables grown around Ahmedabad. Physical dimensions were measured with the help of vernier caliper. Bulk density was measured by weighing the produce from a container of known volume. Container used was an upright cylinder with rigid walls. Samples for measurement were farm fresh. Work was done at the farm of large commercial growers about 15 km from

Ahmedabad. Some of the physical dimensions were analysed statistically to discern possible pattern. Cluster analysis was done in one case to illustrate its use in determining the number of relatively homogenous categories produce could be divided into if desired for purpose of grading.

Physical Characteristics

Okra (*Abelmoschus esculentus, Variety-* Mahyco Hybrid Bhinda 10)

Farmers sort the produce at the farm before dispatching it to wholesale market in Ahmedabd. Generally, they make two separate groups. Best ones are marked grade-1 and remaining grade-2. Physical dimension and length of pod in grade-1 and grade-2 are very similar. So is the weight per pod **(Table-1).** Differences are in color and maturity. Data shown relates to pods that constitute the major part of the lot. In grade-1, pods of 60 to 100 mm length constitute 88 percent of the lot, smaller than this size are negligible, longer than 100 mm are also only a small proportion 10 to 12 percent. Stem length varied from 13 to 29 mm, average being 15 mm. Mass per pod was 11 and 12 g for grade -1 and grade -2 respectively. Variation in stem length is due to the fact that no trimming is done. Average bulk density of okra was 398 kg/m^3. Shape can be called 'conical ribbed'.

Distribution Underlying Pod Length

Length of pod varied from 60mm to 135 mm. Length data was transformed by subtracting the minimum (60mm) from actual for all 91 observations. Relative frequency diagram of (x) suggested the possibility of Weibull being the underlying distribution. This was then examined and goodness-of- fit test made. Weibull was found to describe the pattern satisfactory. Parameters were estimated using the method of moments. Particular distribution that resulted is

$$f(x) = 0.007417 \quad x^{0.7246} \quad e^{-(x/23.56)^{1.7246}}$$

x = L - 60

L = length of pod (mm), 60 being the minimum

$\chi^2_{(computed)} = 2.28$, $\chi^2_{0.05,2} = 10.597$

Cluster Analysis using Length of pod as Basis

Cluster analysis is a procedure used to find relatively homogeneous groups in the produce. Details of the procedure can be seen in Dillion and Goldstein 1984**.** Sharan et. al. 2002 used it to analyse tomato. If the produce is put in three clusters, 53 cases will be in the **first cluster** (**Table-2**). Pods in this cluster are smaller, with mean length of 75 mm and mean base diameter of 14mm. **Second cluster** contains 32 cases with mean pod length of 87 mm and mean base diameter of 15mm. **Third cluster** contained 6 cases, with mean length of 123 mm and mean base diameter of 18mm. Table also shows the mean weight and mass proportion of okra in each cluster. ANOVA indicated that the three clusters are distinctly different from each other. Numbers of clusters desired is set a *priori*. For instance one could have set it to two or four. The procedure then determines which piece belongs to which cluster and whether the clusters are different from each other. Number of clusters desired will depend on consumer preferences. We chose three for illustration.

Eggplant (*Solanum melongema* L, variety- SANDOZ Harita.)

Table-3 shows the physical aspects of fruits in both grades. Data given relate to fruits that constitute the major part of the lot. In grade-1 the fruits of horizontal-max diameter 25 to 40 mm constitute 97 percent of the lot, smaller than this size are negligible, longer than 40 mm are only a small proportion 2 to 4 percent. Whereas, in grade-2 fruits that constitutes major part of the lot are of horizontal-max diameter 40 to 50 mm which constitute 80 percent of the lot. Smaller and larger than this size are only a small proportion 4 to 14 percent and 9 to 13 percent respectively. Average mass per fruit was 18 and 45 g for grade -1 and grade-2 respectively.

Average bulk density was 501 kg/m^3 and 295 kg/m^3 for grade-1 and grade-2 eggplant respectively. Fruits in grade -2 are larger and hence the bulk density is smaller. Shape of eggplant can be called as ‘elliptical regular'.

Longitudinal Diameter

Analysis along the lines described earlier showed that distribution underlying longitudinal diameter is Weibull.

$$f(x) = 0.001164 \quad x^{1.83} \quad e^{-(x/15.72)^{2.83}}$$

X = L - 28

L = longitudinal diameter (mm), 28 being the minimum

Computed χ^2 = 0.014, $\chi^2_{0.05,3}$ = 10.597

Cabbage (*Brassica oleracea* L., Variety- SUNGRO 621-T)

Table-4 shows the physical dimension of cabbage. Data given relate to heads that constitute major part of the lot. The heads of longitudinal diameter 120 to 140 mm constitute 74 percent of the lot, smaller than this size are the remaining proportion (26%) and are of longitudinal diameter varying between 100 to 120 mm. No heads had longitudinal diameter larger than 140 mm. Average mass per head was 447 g.

Average bulk density of cabbage was 362 kg/m^3. Shape of cabbage can be called as ‘elliptical regular'.

Distribution underlying longitudinal diameter is Weibull

$$f(x) = 0.002148 \quad x^{1.372} \quad e^{-(x/19.18)^{2.372}}$$

X = L - 106

L = length of longitudinal axis (mm), 106 being the minimum

Computed χ^2 = 0.999, $\chi^2_{0.05,3}$ = 10.597

Cauliflower (*Brassica oleracea* L., Variety- SUNGRO ES-67 (OP)**)**

Table-5 shows the physical aspects of curds in both grades. Figures given are of curds that constitute major part of the lot. In grade-1 the curds of longest diameter 100 to 140 mm constitute 90 percent of the lot, smaller than this size are only a small proportion 5 to 9 percent, and longer than 140 mm are negligible. Same is true for grade-2 curds. Average weight per curd was 228 and 175 g in grade-1 and grade-2 respectively.

Average bulk density was 269 kg/m^3 and 201 kg/m^3 for grade-1 and grade-2 cauliflower respectively. Shape of cauliflower can be called as ‘unequal irregular'.

Distribution underlying longest diameter is Weibull

$$f(x) = 0.0003838 \quad x^{1.521} \quad e^{-(x/32.68)^{2.521}}$$

X = L - 87

L = actual longitudinal diameter (mm), 87 being the minimum

Computed χ^2 = 0.2129, $\chi^2_{0.05,2}$ = 10.597

Bottle gourd (*Lagenaria siceraria, Variety-* SANDOZ Moris**)**

Generally, farmers make two separate groups. Best ones are marked grade-1 and remaining grade-2. Grade -2 gourds generally, are not sent to the market. **Table-6** shows the physical aspects of gourds. Examination of lots at the APMC market as expected revealed the same. Data given are of gourds that constitute major part of the lot. Gourds of length 150 to 250 mm constitute 70 percent of the lot, smaller than this size are negligible and longer than 250 mm are about 25 percent. Average mass per gourd was 339 g.

Average bulk density of bottle gourd was 565 kg/m^3. Shape of bottle gourd can be called as ‘cylindrical regular'.

Distribution underlying length is Weibull

$$f(x) = 0.000101 \quad x^{1.279} \quad e^{-(x/81.279)^{2.279}}$$

X = L - 139

L = length of gourds (mm), 139 being the minimum

Computed χ^2 = 0.723 $\chi^2_{0.05,2} = 10.597$

Cow Pea (*Vigna unquiculata* L.)

Table-7 shows the physical aspects of pods in both grades. Examination of lots at the APMC market as expected revealed the same. Physical dimension and length of pod in grade-1 and grade-2 are very similar. So is the weight per pod. Data given relates to the pods that constitute major part of the lot. In grade-1 the pods of 130 to 190 mm length constitute 75percent of the lot, smaller than this size are only a small proportion 13 to 16 percent, longer than 190 mm are negligible. Same is true for grade-2 also. Average mass per pod 2.5 g. Average bulk density of cow pea was 240 kg/m^3. Shape of cow pea can be called as ‘cylindrical regular'.

Distribution underlying pod length is Weibull

$$f(x) = 0.00003830 \quad x^{0.669} \quad e^{-(x/65.246)^{2.669}}$$

X = L - 96

L = length of pod (mm), 96 being the minimum

Computed χ^2 = 1.046 $\chi^2_{0.05,5} = 16.748$

Flat Bean (*Lablab purpureus* L. syn. *Dolichos lablab*)

Physical dimension and length of pod in grade-1 and grade-2 are very similar. So is the weight per pod. **Table-8** shows the physical dimensions of pods in both grades. Examination of lots at the APMC market as expected revealed the same. Data given relates to the of pods that constitute major part of the lot. In grade-1 the pods of 60 to 100 mm length constitute 80 percent of the lot, smaller than this size are negligible, longer than 100 mm are only a small proportion 2 to 15 percent. Same is true for grade-2 also. Average mass per pod was 4 g in grade-1 and 5 g in grade-2. Average bulk density of flat bean was 332 kg/m^3.

Distribution underlying pod length is Weibull

$$f(x) = 0.003127 \quad x^{0.8818} \; e^{-(x/29.293)^{1.8818}}$$

X = L - 60

L = actual length of pod (mm), 60 being the minimum

Computed $\chi^2 = 0.1767$ $\chi^2_{0.05,2} = 0.597$

Spinach *(*Spinacia oleracea*)*

Table-9 shows the physical dimension of spinach. Examination of lots at the APMC market as expected revealed the same. Data given relates to the leaves that constitute major part of the lot. Leaves of 80 to 130 mm length constitute 81 percent of the lot, smaller than this size are negligible, longer than 130 mm are only a small proportion 13 to 16 percent. Average length of leaf stem was 90 mm and average mass per leaf was 2.6 g. Average bulk density of spinach was found to be 118 kg/m^3.

Potato (***Solanum tuberosum*** **L.)**

Table-10 shows the physical aspects of a sample of potato. Data given relates to the potatoes that constitute major part of the sample. Potatoes of 50 to 100 mm longitudinal diameter constitute 84 percent of the sample, smaller than this size are a small proportion 13 percent, larger than 100 mm are negligible. Average weight per potato was 51 g and average sphericity was 86 percent. Average bulk density of potato was 675 kg/m^3.

Onion (*Allium cepa* L.)

Table-11 shows the physical aspects of a sample of onion. Data given relates to the bulbs that constitute major part of the sample. Onion of 40 to 80 mm longitudinal diameter constitute 81 to 87 percent of the sample, smaller than this size are a small proportion 13 to 19 percent, longer than 80 mm are negligible. Average bulk density of onion was 596 to 643 kg/m^3.

Lemon (*Citrus limon* (L.) Burm. F.)

Table-12 shows the physical aspects of a sample of lemon. Data given relates to the fruits that constitute major part of the sample. Fruits with 30 to 50 mm longitudinal diameter constitute 93 percent of the sample, smaller than this size are negligible, longer than 50 mm are only a small proportion 7 percent. Average sphericity was 94 percent. Average bulk density of lemon was 575 kg/m^3. The shape can be called as 'spherical regular'.

Pointed Gourd (*Trichosanthes dioica Roxb*)

Table-13 shows the physical aspects of a sample of parval. Data given relates to the gourds that constitute major part of the sample. Gourds of 50 to 90 mm length constitute 80 percent of the sample, smaller than this size are only a small proportion 16 percent, longer than 90 mm are negligible. Bulk density was 447 kg/m^3.

Chili (*Capsicum annuum*)

Table-14 shows the physical aspects of a sample of chili. Data given relates to the fruits that constitute major part of the sample. Fruits of 50 to 80 mm length constitute 77 percent of the sample, smaller than this size are only a small proportion 16 percent, longer than 80 mm are negligible. Average mass per chili was 3 g. Bulk density was 295 kg/m^3.

French Bean (*Phaseolus vulgaris* L.)

Table-15 shows the physical aspects of a sample of french bean. Data given relates to the pods that constitute major part of the sample. Pods of 100 to 170 mm length constitute 70 percent of the sample, smaller than this size are negligible, longer than 170 mm are only a small proportion 23 percent. Average mass per pod was 5 g. Bulk density was 271 kg/m^3.

Bitter gourd (*Momordica charantia*)

Table-16 shows the physical aspects of a sample of bitter gourd. Data given relates to the gourds that constitute major part of the sample. Gourds of 60 to 120 mm length constitute 63 percent of the sample, smaller than this size is small proportion 27 percent, longer than 120 mm are negligible. Average mass per gourd was 29 g. Bulk density was 400 kg/m^3.

Gilora

Table-17 shows the physical aspects of a sample of gilora. Data given relates to the fruits that constitute major part of the sample. Gilora of 40 to 70 mm length constitute 80 percent of the sample, smaller than this size is only small proportion 16 percent, longer than 70 mm are negligible. Average mass per gourd was 8 g. Bulk density was 498 kg/m^3.

Summary and Conclusion

Measurement of physical dimension, mass, bulk density was made on farm fresh samples of vegetables grown in Ahmedabad region. Results can be useful for design of unit technology and technology systems of fresh produce.

Physical dimensions of all major commodities are described satisfactorily by Weibull distribution. Cluster Analysis was carried in one case to illustrate the manner in which homogeneous grouping can be made of the produce if desired by the consumers. This would be useful procedure of analysis to those working on size graders. The procedure also yields mass proportion of different groups, which could be used for pricing.

Table-1: Some Physical Characteristics of Okra		
	Grade-1	Grade-2
Length of pods	60 - 100 mm	60 - 100 mm
Base diameter (mean)	15 mm	16 mm
Stem length (mean)	15 mm	15 mm
Weight per pod (mean)	11 gm	12 gm
Shape	Conical ribbed	Conical ribbed
Bulk density	398 kg/m^3	398 kg/m^3

Table-2: Characteristics of okra (grade-1) in Three Clusters					
Cluster	Number of pieces	Mean weight (g)	Mass proportion (%)	Mean base diameter (mm)	Mean length (mm)
1	53	10.5	55	14	75
2	32	11.4	36	15	87
3	6	15.3	9	18	123
Total	91		100		
ANOVA : SSQ (between) = 6456.77 (DF = 2); SSQ (within) = 21.89 (DF = 89) F (ratio) = 294.9 ; $F\ (2,89)_{0.05}$ = 19.48					

Table-3: Some Physical Characteristics of Eggplant		
	Grade-1	Grade-2
Horizontal-Max diameter	25-40 mm	40-50 mm
Longitudinal diameter (mean)	42mm	57 mm
Mean weight per fruit	18 gm	45 gm
Shape	Elliptical regular	Elliptical regular
Bulk density	501 kg/m^3	295 kg/m^3

Table-4: Some Physical Characteristics of Cabbage (Grade-1)	
Longitudinal diameter of the heads	120-140 mm
Horizontal-Max diameter (mean)	108 mm
Mean weight per head	447 gm
Shape	Elliptical regular
Bulk density	362 kg/m^3

Table 5: Some Physical Characteristics of Cauliflower		
	Grade-1	Grade-2
Longest diameter of the curd	100 - 140 mm	100 - 140 mm
Mean weight per curd	228 gm	175 gm
Shape	Unequal irregular	Unequal irregular
Bulk density	269 kg/m^3	201 kilogram/m^3

Table 6: Some Physical Characteristics of Bottle gourd (Grade-1)	
Length of gourds	150 - 250 mm
Maximum diameter (Mean)	55mm
Mean weight per gourd	339 gm
Shape	Cylindrical regular
Bulk density	565 kg/m^3

Table 7: Some Physical Characteristics of Cow pea		
	Grade-1	Grade-2
Length of pods	130 - 190 mm	130 - 190 mm
Diameter (mean)	4.5 mm	4.5 mm
Mean weight per pod	2.5 gm	2.5 gm
Shape	Cylindrical regular	Cylindrical regular
Bulk density	240kg/m^3	240kg/m^3

Table 8: Some Physical Characteristics of Flat bean		
	Grade-1	Grade-2
Length of pods	60 - 100 mm	60 - 100 mm
Width (mean)	14 mm	15 mm
Mean weight per pod	4 gm	5 gm
Bulk density	332 kg/m^3	332 kg/m^3

Table 9: Some Physical Characteristics of Spinach	
Length of leaves	80 - 130 mm
Max. width of leaf (mean)	63 mm
Length of leaf stem (mean)	90 mm
Mean weight per leaf	2.5 gm
Bulk density	118 kg/m^3

Table 10: Some Physical Characteristics of potato		
	Indore	**Deesa**
Longitudinal diameter of potato	50 - 100 mm	50 - 100 mm
Maximum Horizontal diameter (mean)	59 mm	59 mm
Minimum Horizontal diameter (mean)	58 mm	51 mm
Mean weight per potato	50 g	52 g
sphericity	86 %	84 %
Bulk density	675 kg/m^3	625 kg/m^3

Table 11: Some Physical Characteristics of Onion				
	Nasik (red)	**Nasik (white)**	**Saurashtra**	**Rajasthan**
Longitudinal diameter of onion in the sample (mm)	40 - 80	40 - 80	40 - 80	40 - 80
Maximum Horizontal diameter (mean)	56 mm	58 mm	57 mm	53 mm
Minimum Horizontal diameter (mean)	55 mm	54 mm	54 mm	52 mm
Bulk density (kilogram/$m^{3)}$	614	643	596	643

Table12: Some Physical Characteristics of Lemon	
Longitudinal diameter of fruits in the sample	30 - 50 mm
Maximum Horizontal diameter (mean)	36 mm
Minimum Horizontal diameter (mean)	36 mm
Mean weight per fruit	27 gm
Mean sphericity	93 %
Shape	Spherical regular
Bulk density	575 kg/m^3

Table 13: Some Physical Characteristics of Pointed gourd	
Longitudinal diameter of gourds in the sample	50 - 90 mm
Diameter (mean)	32 mm
Mean weight per fruit	28 gm
Bulk density	447 kg/m^3

Table 14: Some Physical Characteristics of Chili	
Length of fruit in the sample	50 - 80 mm
Diameter (mean)	12 mm
Mean weight per fruit	3 gm
Bulk density	295 kg/m^3

Table 15: Some Physical Characteristics of French bean	
Length of pods in the sample	100 - 170 mm
Width of pod (mean)	11 mm
Thickness of pod (mean)	8 mm
Mean weight per pod	5 gm
Bulk density	271 kg/m^3

Table 16: Some Physical Characteristics of Bitter gourd	
Length of gourds in the sample	60 - 120 mm
Diameter of gourd (mean)	30 mm
Stem length (mean)	20 mm
Mean weight per gourd	29 gm
Bulk density	400 kg/m^3

Table 17: Some Physical Characteristics of Gilora	
Length of gilora in the sample	40 - 700 mm
Diameter (mean)	17 mm
Mean weight	8 gm
Bulk density	498 kg/m^3

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