Potato Res. 13 (1970): 41–58

The quality of stored main crop potatoes in Great Britain

B. M. CHURCH[1], C. P. HAMPSON[2] and W. R. FOX[2]

[1] Rothamsted Experimental Station, Harpenden, Herts., England
[2] Potato Marketing Board, London, England

Accepted for publication: 10th June, 1969

Zusammenfassung, Résumé p. 57

Summary

Surveys of stored main crop potatoes in Great Britain (1965 and 1966) provide estimates of the proportions of the crop with different degrees of each observed defect.

About 40% conformed to a premium 'Grade I' standard, and 20–25% of stores contained 60% or more of 'Grade I' potatoes and might be profitably dressed out to this grade. A quarter of the crop failed 'Grade I' because of surface mechanical blemishes. In addition, mechanical damage, disease blemishes (mostly scab, silver scurf and blight) and greening each caused rejection of 13–18%; 16% of *Majestic* and 6% of other varieties were of unacceptable shape.

Majestic suffered more from most defects than other varieties, but blight blemishes were more common for 'red' varieties. Observed disease blemishes (particularly silver scurf) increased over the storage season.

Percentages complying with alternative grade specifications can be estimated from the tabulated information.

Introduction

At the time these surveys were done there was no officially accepted specification for high-quality grades of potatoes in Great Britain. The only official grade was the Potato Marketing Board ware standard, with which potatoes had to comply in order to be declared fit for human consumption.

A consumer survey (Anon, 1964) showed that many British housewives are dissatisfied with the quality of potatoes, and a trial specification for high quality potatoes was drawn up by the Potato Marketing Board in 1964. Market research investigations (Stubbs, 1968) showed that potatoes dressed to this specification could command premiums of 20–30% above the price of unselected ware potatoes.

Whether the widespread use of a high quality grade would be economic depends greatly on the proportions of the national crop complying with the grade. This paper summarises the results of two surveys on the quality of stored main crop potatoes. The results give information on the proportion of potatoes complying with the grade, and on the relative importance of the different quality defects that could cause a potato to be rejected.

Survey methods

The sample

The farms surveyed were a stratified random sample from the Potato Marketing Board's list of growers, selected so that the number of farms chosen for a given area was approximately proportional to the total acreage grown in that area, and the farms in each potato-acreage size-group were also proportionately represented.

Each farm was visited once only in each season, and the visits were timed to coincide with the unloading of the potato stores. The visits were spread as evenly as possible over the storage season from October to April. In 1965–66 a total of 571 farms and in 1966–67 751 farms were surveyed by the field staff of the Potato Marketing Board. When possible, the same farms were visited in both years. The distribution of storage periods for the sampled stores was similar to that of the national crop, but tubers stored until April and later were somewhat under-represented (Table 1).

From each store a bulk sample of not fewer than 150 tubers was taken from the face of the bulk store or clamp by basket 'grabs' at 4–5 randomly chosen points. When the potatoes were stored in boxes, the bulk sample was made up from several boxes in a similar way. This procedure was not certain to give a fully representative sample of tubers, but any selectivity was likely to be with regard to tuber size and, for the surveys as a whole, the tuber size distribution agreed well with independent data from field sampling.

Table 1. Distribution of tonnage according to month unloaded.

Month[1]	1965–6		1966–7	
	% of national stock put on market[2]	% tubers sampled[3]	% of national stock put on market[2]	% tubers sampled[3]
Nov. or earlier[4]	3	12	4	3
Dec.	14	15	15	30
Jan.	19	18	20	33
Feb.	17	19	17	18
March	18	18	19	12
April +	29	17	25	4
Total	100	100	100	100

[1] *Monat – Mois*
[2] *% der vermarkteten Gesamtmenge – % du stock national mis sur le marché*
[3] *% der bemusterten Knollen – % tubercules échantillonnés*
[4] *November oder früher – Nov. ou plus tôt*

Tabelle 1. Verteilung der Tonnage entsprechend dem Verkaufsmonat.
Tableau 1. Répartition du tonnage suivant le mois de livraison.

Examination of the tubers

The potatoes in each sample were washed and separated by hand riddles into eight size groups. The total weight and number of potatoes on each riddle were recorded, and tubers < 38 mm minimum diameter were then discarded. The remaining tubers were individually examined for surface defects, and the extent of each type of defect was recorded (see Appendix 1).

The assessment of the amount of each defect present was necessarily somewhat subjective and the fieldmen had no special training for this survey. However, each fieldman surveyed only a few farms and their average judgment was likely to be similar from year to year.

The amount of internal defects was determined by examining a sub-sample of every tenth tuber from the main sample. Each tuber in the sub-sample was cut in half longitudinally and the presence or absence of six types of defect (hollow heart, internal bruising, rots, necroses, discolouration and frost damage) was recorded.

Information about the management of the crops, and methods of harvesting and storage was also recorded, so that any association of these factors with the quality of the tubers sampled from store could be examined.

Grade I specification

Between 1964 and 1967 the Potato Marketing Board undertook a market research study (Stubbs, 1968) to estimate the sales potential of a trial specification of potatoes, defined as Grade I, and marketed at a premium price. The grade was designed to meet the primary requirements of housewives for clean potatoes, as free as possible from damage or disease and requiring only minimum peeling and preparation, without being so exacting as to make its adoption commercially uneconomic.

The specification of Grade I for the 1965 market research study, which has been applied to individual tubers throughout this survey, is briefly as follows: Tubers must be:

(a) > 38 mm minimum diameter;

(b) true to type, clean and free from extraneous matter;

(c) free from mechanical blemishes not readily removed by peeling, and with not more than one clean cut of 25 mm or more if < 76 mm, and not more than two such cuts if larger;

(d) have no more than one-eighth of their surface area blemished by disease, and

(e) be firm, but not necessarily of natural bright colour, and have no other recorded defects.

A full specification of Grade I is given, together with minor variants, in the report of the marketing investigation (Stubbs, 1968). The relationship of the grade to the individual damage categories in this survey is indicated in Appendix 1. In commercial practice tubers might not be washed before inspection and some tolerance of tubers not conforming to the grade would be allowed, so the proportions of crop accepted for the grade would be rather more than the survey results show.

The Potato Marketing Board found that a potential market for Grade I tubers exist-

ed at a premium of not more than 1–1½d. per lb. above normal ware prices, but that this market was likely to be severely limited by retailers' reluctance to carry stocks. With a premium of this order, crops with at least 55–60% of tubers > 38 mm qualifying as Grade I could, on certain assumptions, be dressed profitably to the grade.

Quality of the national crop

General

Table 2 shows the estimated percentages of the national crop that failed to meet the Grade I standard because of different quality defects for individual varieties. The last two rows of Table 2 give the percentages not complying with Grade I because of the presence of any defect, and imply that the average national Grade I extraction rate in each of the survey years was about 40%.

Table 2. Percentages by weight (tubers > 38 mm) rejected for Grade I for each defect, by variety.

Reason for rejection[1]	*King Edward* and *Red King*	*Kerr's Pink* and *Redskin*	*Majestic*	Others[2]	All varieties[3]	
					1965–6	1966–7
Mechanical damage[4]	16	12	17	17	13	18
Mechanical surface blemish[5]	10	16	28	40	24	24
Disease surface blemish[6]	12	18	16	10	14	15
Greening[7]	15	4	18	10	13	15
Shape[8]	6	6	16	8	10	11
Pest damage[9]	6	6	6	5	6	6
Rots[10]	5	6	4	4	5	5
Compression damage[11]	1	–	1	4	2	2
Dull/soft[12]	3	4	4	2	3	2
% rejected for any reason[13] 1965–66	48	53	64	69	58	
% rejected for any reason[13], 1966–67	58	45	67	57		61

[1] *Grund der Abweisung – Raisons d'élimination*
[2] *Andere – Autres*
[3] *Alle Sorten – Toutes les variétés*
[4] *Mechanische Beschädigung – Dommage mécanique*
[5] *Mechanisch bedingte, oberflächliche Mängel – Meurtrissure mécanique de surface*
[6] *Oberflächenmangel infolge Krankheit – Maladie de surface*
[7] *Grünwerden – Verdissement*
[8] *Form – Forme*
[9] *Schädlingsschaden – Dégâts d'animaux*
[10] *Fäulnis – Pourriture*
[11] *Druckschaden – Dommage par pression*
[12] *Matt/weich – Ramollissement*
[13] *% abgewiesen aus irgendeinem Grund – % éliminé pour l'un ou l'autre raison*

Tabelle 2. Gewichtsprozente (Knollen > 38 mm), abgewiesen als Klasse I für jeden Mangel pro Sorte.
Tableau 2. Pourcentages en poids (tubercules > 38 mm) éliminés de la Classe I pour chaque défaut par variété.

In both years almost a quarter of the crop failed to comply with the grade because of surface mechanical blemishes, and this was the most common type of defect. In addition, mechanical damage, surface disease blemishes and greening were each a cause of rejection for between 13 and 18 % of the crop. About a tenth was rejected because of unacceptable shape, including growth cracks and secondary growth, and the other recorded defects each affected between 2 and 6 % by weight of tubers examined.

Table 3. Percentages by weight of tubers > 38 mm with each damage level for individual defects†

Damage level[1]	Mechanical damage[2]		Mechanical blemishes[3]		Disease blemishes[4]		Greening[5]		Shape[6]	
	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
0	75.0*	72.8*	75.6*	76.0*	60.0*	47.1*	87.0*	84.6*	89.8*	88.8*
1	11.0*	9.0*	5.4	3.2	13.7*	17.6*	5.7	5.4	5.8	4.5
2	4.7**	5.5**	12.7	13.3	7.8*	12.3*	3.2	4.0	3.2	3.9
3	9.3	12.7	2.3	4.1	4.9*	8.3*	4.0	6.1	1.3	2.8
4			1.4	1.6	4.2	5.6				
5			2.5	1.9	2.5	3.2				
6					7.0	5.9				

Damage level[1]	Pests[7]		Rots[8]		Compression damage[9]		Dull/soft[10]	
	1965	1966	1965	1966	1965	1966	1965	1966
0	94.2*	94.2*	95.4*	94.9*	98.0*	98.0*	76.5*	74.6*
1	1.8	1.3	1.6	2.3	2.0	2.0	20.5*	23.2*
2	2.1	2.6	3.0	2.8			3.0	2.2
3	1.5	1.1						
4	0.4	0.7						

† See Appendix 1 for definitions of the amount of damage at each level – *Für die Definitionen des Ausmasses des Schadens bei jedem Grad siehe Anhang 1 – Voir Annexe 1 pour la définition de l'importance des dommages à chaque degré*

* Acceptable for Grade I – *Für Klasse I annehmbar – Accepté pour classe I*

** Acceptable only for tubers > 76 mm – *Nur für Knollen über 76 mm annehmbar – Accepté seulement pour les tubercules > 76 mm*

[1] *Grad der Schädigung – Niveau du dommage*
[2] *Mechanische Beschädigungen – Dommage mécanique*
[3] *Mechanisch bedingte oberflächliche Mängel – Meurtrissure mécanique*
[4] *Mängel infolge Krankheit – Meurtrissure de maladie*
[5] *Grünwerden – Verdissement*
[6] *Form – Forme*
[7] *Tierischer Schaden – Dégâts d'animaux*
[8] *Fäulnis – Pourritures*
[9] *Druckschäden – Dommages de pression*
[10] *Matt/weich – Ramolissement*

Tabelle 3. Gewichtsprozent an Knollen > 38 mm nach Grad der Schädigung für die einzelnen Mängel geordnet.

Tableau 3. Pourcentages de tubercules > 38 mm de chaque degré de dommage pour les défauts individuels.

The proportions acceptable for Grade I were greater for *King Edward* and *Red King*, and for *Kerr's Pink* and *Redskin*, than for *Majestic*, in both years. Nearly all types of defect were more common for *Majestic* than for *King Edward* but the main difference between these varieties arose from the greater proportions of *Majestic* rejected because of surface mechanical blemishes and bad shape. *Kerr's Pink* and *Redskin* samples suffered less mechanical damage than other varieties in both years and were rarely faulted for greening.

The proportions of *Majestic* acceptable for Grade I were similar in the two years but *King Edward* and 'other' varieties had a smaller percentage rejected in 1965–66 for each defect. The difference between the estimates for *Kerr's Pink* in the two years may reflect sampling error.

Table 3 shows the estimated percentages of the national crop with different amounts of each type of defect. Varying disease is the most probable cause of year-to-year differences in the visual quality characteristics of potatoes, and over the crop as a whole, the amount of most defects was similar in the two years, except that much more of the 1966 crop had disease blemishes. Had the Grade I acceptance standard for disease been more exacting, there would have been a larger difference between the two years in the percentage of potatoes accepted, mainly because of the different amounts of silver scurf and scab (see below).

Table 4. Percentages of individual crop weights acceptable for Grade I.

Percentage of crop acceptable for Grade I[1]	*King Edward* and *Red King*	*Kerr's Pink* and *Redskin*	*Majestic*	Others[2]	All varieties[3]	
					1965–66	1966–67
		Percentage of growers[4]				
Less than[5] 20%	10	6	28	32	19	14
20%	26	26	30	21	26	28
40%	16	16	13	11	13	14
50%	18	16	13	14	17	13
60%	28	29	14	16	24	16
More than[6] 80%	2	8	2	7	1	5
Total	100	100	100	100	100	100
No. farms[7] 1965–66	136	86	282	65	569	
No. farms 1966–67	176	81	364	125		746

[1] *Prozentsatz des für Klasse I annehmbaren Erntegutes – Pourcentage de récolte acceptable en Classe I*
[2] *Andere – Autres*
[3] *Alle Sorten – Toutes les variétés*
[4] *Prozentsatz an Pflanzer – Pourcentage de producteurs*
[5] *Weniger als – Moins que*
[6] *Mehr als – Plus que*
[7] *Anzahl Betriebe – Nombre de fermes*

Tabelle 4. Prozentsatz der für Klasse I annehmbaren einzelnen Erntegewichte.
Tableau 4. Pourcentages de poids de récolte individuelle acceptable en Classe I.

Table 5. Percentages by weight acceptable for Grade I for different tuber sizes (average of two years' data).

	Minimum diameter[1]							
mm	38–	41–	44–	48–	51–	76–	82+	All[2]
inches	1½–	1⅝–	1¾	1⅞–	2–	3–	3¼+	> 38 mm
King Edward and *Red King*	54	54	54	52	42	36	32	48
Kerr's Pink and *Redskin*	57	56	54	54	50	50	43	51
Majestic	46	44	42	40	34	24	22	35
Others[3]	46	46	42	40	36	35	24	36
All varieties[4]	50	48	46	45	49	31	24	40
Per cent of total ware weight[5]	2.6	4.0	6.4	11.8	69.0	4.6	1.6	100

[1] *Kleinster Durchmesser – Diamètre minimum*
[2] *Alle > 38 mm – Tous > 38 mm*
[3] *Andere – Autres*
[4] *Alle Sorten – Toutes les variétés*
[5] *Prozent des Gesamtgewichtes an Speisekartoffeln – Pour cent du poids total de marchandise*

Tabelle 5. Gewichtsprozente an Knollen verschiedener Grösse, annehmbar für Klasse I (Mittel aus zwei Jahresergebnissen).
Tableau 5. Pourcentages par poids acceptable en Classe I dans les différentes grosseurs de tubercule (moyenne des données de deux ans).

About 40% of the national main crop put into store was of Grade I standard, but there were large differences in quality between stores. Table 4 shows that stores with 60% or more of Grade I tubers accounted for between a fifth and a quarter of the crop. Under favourable circumstances it might be more profitable to dress out the contents of such stores to the Grade I specification than to the Potato Marketing Board ware standard. Almost a third of the stores of *Majestic* and 'other' varieties contained less than 20% of Grade I potatoes, compared with *King Edward* and *Red King*, *Kerr's Pink* and *Redskin* crops, for which less than one-tenth of stores were in this category.

Table 5 shows that the percentage by weight acceptable for Grade I falls off steadily with increasing tuber size but that varietal differences in acceptability are not mainly explained by differences in average tuber size. Nearly all types of defect were more often recorded on large tubers, but the quality differences between small and large tubers arose mostly because large tubers were more often unacceptably misshapen, mechanically damaged or blemished.

Surface disease

Table 6 shows the major diseases causing surface blemishes, giving both the percentage weights of tubers with any surface disease blemishes, and the percentage weights of

Table 6. Incidence of individual surface disease blemishes.

Dominant surface disease[1]	% of tubers affected[2]		% of tubers with at least ⅛th surface affected[3]	
	1965–66	1966–67	1965–66	1966–67
Scab[4] (S. scabies)	17.6	26.5	2.5	3.4
Silver scurf[5] (H. solani)	8.7	13.1	5.7	6.6
Black scurf[6] (R. solani)	4.4	4.2	0.4	0.4
Blight[7] (P. infestans)	3.4	2.3	2.3	1.4
Gangrene[8] (Phoma Sp.)	1.9	0.9	0.8	0.2
Skin spot[9] (O. pustulans)	2.4	1.7	1.0	0.5
No disease dominant[10]	1.9	4.5	1.5	2.3
Any disease[11]	40.2	53.1	14.2	14.8

[1] *Vorherrschende Krankheit an der Oberfläche – Maladie superficielle dominante*
[2] *% befallene Knollen – % de tubercules atteints*
[3] *% Knollen mit wenigstens zu 1/8 befallener Oberfläche – % de tubercules présentant au moins 1/8 de la surface atteinte*
[4] *Schorf – Gale*
[5] *Silberschorf – Gale argentée*
[6] *Rhizoctonia – Rhizoctonia*
[7] *Phytophthora-Knollenfäule – mildiou*
[8] *Phoma-Knollenfäule – Gangrène*
[9] *Tüpfelfleckigkeit – Oosporiose*
[10] *Keine Krankheit vorherrschend – Aucune maladie dominante*
[11] *Irgendwelche Krankheit – Toutes les maladies*

Tabelle 6. Vorkommen einzelner, an der Oberfläche sichtbarer Krankheiten.
Tableau 6. Incidence des diverses maladies superficielles.

tubers with one-eighth or more of the surface affected and therefore unacceptable for Grade I. In 1965–66, 40% and in 1966–67, 53% of tubers had some surface blemish from disease, but in both years only about 15% had more than one-eighth of the surface affected and would for this reason have been unacceptable for the grade. Scab was the most widespread disease in both years and in 1966 a quarter of the national crop was infected .However, less than one-eighth of the surface of most tubers was affected and only 3% of the crop failed the grade because of scab. Silver scurf was the most common cause of extensive disease blemish and resulted in 6% of the crop being rejected, according to the stringent standard of the grade applied to washed tubers.

Table 7 shows the amounts of disease unacceptable for Grade I for individual varieties. *King Edward* potatoes were less often rejected because of scab, and *Majestic* more often rejected for silver scurf, than other varieties.

Two per cent of the crop was below the Grade I standard because of blight, and blight defects were much more common on *King Edward* and *Red King*, *Kerrs' Pink* and *Redskin* than on *Majestic* and other varieties. Both skin spot and gangrene affected rather more of the sampled crops of *Kerr's Pink* and *Redskin* than of other varieties.

Table 7. Percentages rejected for Grade I for individual surface disease blemishes (average of two years' data).

Dominant Disease[1]	*King Edward* and *Red King*	*Kerr's Pink* and *Redskin*	*Majestic*	Others[2]	All varieties[3]
Blight[4]	4	4	1	1	2
Scab[5]	1	4	4	2	3
Silver scurf[6]	5	5	8	4	6
Black scurf[7]	0.3	0.4	0.4	0.4	0.4
Gangrene[8]	0.5	0.9	0.5	0.3	0.5
Skin spot[9]	0.8	2.5	0.4	0.3	0.8
No disease dominant[10]	1	1	3	1	2

[1] *Vorherrschende Krankheit – Maladie dominante*
[2] *Andere – Autres*
[3] *Alle Sorten – Toutes les variétés*
[4] *Phytophthora-Knollenfäule – Mildiou*
[5] *Schorf – Gale*
[6] *Silberschorf – Gale argentée*
[7] *Rhizoctonia – Rhizoctonia*
[8] *Phoma-Knollenfäule – Gangrène*
[9] *Tüpfelfleckigkeit – Oosporiose*
[10] *Keine Krankheit vorherrschend – Aucune maladie dominante*

Tabelle 7. Prozentwerte der für Klasse I wegen einzelner krankheitsbedingter Mängel an der Oberfläche (Mittel aus zwei Jahresergebnissen) abgewiesenen Ware.
Tableau 7. Pourcentages éliminés de la Classe I pour les diverses maladies superficielles (moyennes des données de deux ans).

Internal defects

Table 8 gives the estimated percentages of tubers with different types of internal defects. Some 10–15% of tubers had internal defects but, because of the way the observations were taken the relationship between these defects and the external condition of the individual tubers could not be examined.

Association of management and farm characteristics with crop quality

Farm characteristics and details of potato practices were recorded for the surveyed farms to see if any were associated with major differences in tuber quality. These observations, in addition to those already mentioned, were: soil type, total potato acreage grown and tonnage in store, type and class of seed, chitting treatment, date of planting, use of fertilisers and irrigation, method and date of haulm destruction, methods of harvesting and storage, and dates of unloading from store.

Table 9 shows that blight damaged fewer of those crops the haulm of which had been destroyed. Although fairly consistent, this difference was small compared with the varietal differences in susceptibility to blight and indicates that haulm destruction as practised is an inefficient method of blight control. There was inadequate information to compare different methods of haulm destruction.

Table 8. Percentages of tubers with internal defects.

Type of defect[1]	1965–66	1966–67	Type of defect[1]	1965–66	1966–67
Hollow heart[2]	0.6	0.4	Internal necroses[6]		
Internal bruising[3]	6.7	4.3	spraing[7]	2.7	1.4
Internal rots			other necroses[8]	0.8	1.0
due to blight[4]	2.6	2.0	Internal discoloration[9]		
other rots[5]	0.4	1.4	black heart[10]	1.6	0.4
			other int. discol.[11]	1.5	1.9
			Frost damage[12]	0.2	0.2

[1] *Art des Schadens – Type de défaut*
[2] *Hohlherzigkeit – Coeur creux*
[3] *Fäulnis im Innern infolge Phytophthora infestans – Pourriture interne due au mildiou*
[4] *Blaufleckigkeit – Contusion interne*
[5] *Andere Fäulen – Autres pourritures*
[6] *Nekrosen im Innern – Necroses internes*
[7] *Pfropfenbildung und ähnliches – Nécrose concentrique*
[8] *Andere Nekrosen – Autres nécroses*
[9] *Verfärbung im Innern – Décoloration interne*
[10] *Schwarzherzigkeit – Coeur noir*
[11] *Andere innere Verfärbungen – Autres maladies internes de décoloration*
[12] *Frostschaden – Dommage dû au froid*

Tabelle 8. Anteil Knollen mit inneren Schäden in Prozent.
Tableau 8. Pourcentages de tubercules avec défaut interne.

Table 9. Percentages of tuber weight unacceptable because of blight damage for crops with and without haulm destroyed.

	King Edward and *Red King*		*Kerr's Pink* and *Redskin*		*Majestic*		Other varieties[1]	
	1965–66	1966–67	1965–66	1966–67	1965–66	1966–67	1965–66	1966–67
Haulm not destroyed[2]	5.8	5.1	5.3	2.8	0.9	0.5	1.8	0.4
Haulm destroyed[3]	4.1	3.6	4.0	2.5	0.4	0.3	1.8	0.5

[1] *Andere Sorten – Autres variétés*
[2] *Kraut nicht vernichtet – Fanes non détruites*
[3] *Kraut vernichtet – Fanes détruites*

Tabelle 9. Gewichtsanteil an nicht annehmbaren Knollen (in Prozent) infolge Knollenfäuleschaden aus Ernten mit und ohne chemische Krautvernichtung.
Tableau 9. Pourcentages en poids de tubercules inacceptables pour dommages de mildiou dans les récoltes avec et sans destruction des fanes.

Table 10. Average quality of crop lifted by different methods.

% rejected Grade I for[1]	Method of lifting[2]			Approx. S.E. for horizontal comparisons[6]
	harvester[3]	elevator[4]	spinner[5]	
Mechanical damage[7]	18.0	16.0	14.9	± 0.5
Mechanical blemishes[8]	26.0	21.1	23.4	1.5
Disease blemishes[9]	13.6	13.8	16.1	1.0
Pests[10]	5.0	5.3	6.9	0.5
Rots[11]	5.9	4.1	4.7	0.4
% accepted Grade I[12]	40.1	43.1	39.4	1.6

[1] *% für Klasse I abgewiesen wegen – % éliminé de la classe I pour*
[2] *Erntemethode – Méthode de récolte*
[3] *Vollerntemaschine – Arracheuse complète*
[4] *Vorratsroder – Arracheuse à élévateur*
[5] *Schleuderradroder – Arracheuse à dents*
[6] *Ungefähre Standardabweichung für horizontale Vergleiche – E.S. approxim. pour comparaisons horizontales*
[7] *Mechanische Beschädigung – Dommage mécanique*
[8] *Mechanisch bedingte oberflächliche Mängel – Meurtrissure mécanique*
[9] *Krankheitsmängel – Maladies superficielles*
[10] *Tierischer Schaden – Dégâts d'animaux*
[11] *Fäulnis – Pourriture*
[12] *In Klasse I angenommen (%) – % accepté en Classe I*

Tabelle 10. Durchschnittliche Qualität der Ernte, Rodung mit verschiedenen Methoden.
Tableau 10. Qualité moyenne des récoltes arrachées selon diverses méthodes.

Table 10 shows for crops lifted by different methods the estimated percentages rejected for certain defects and those acceptable for Grade I. Horizontal comparisons in this table are free from any differences between varieties and years. The differences in estimated acceptability are no greater than might be from chance, but there is some indication that crops lifted by complete harvesters had above-average mechanical damage and surface blemishes. This may be because of conditions at harvest and soil type differences, on which information was inadequate. Investigations have shown that, under comparable conditions and with good management, bulk systems of harvesting and handling with a complete harvester can lift the crop more cheaply and with no more damage than harvesting by elevator-digger or spinner (Hampson and Codrington, 1967).

The percentage of tuber weight acceptable for Grade I was much the same for crops stored outdoors in clamps, pits, etc. as for those stored in buildings (Table 11). Disease blemishes and rots were both more common in field clamps, pits, etc, but this was partly compensated for by the greater proportion of tubers from indoor stores that were rejected for mechanical blemishes. Possibly more mechanical blemishes are obscured by development of disease blemishes and rots in outdoor stores.

There was no evidence of any consistent differences of crop quality associated with scale of operations, class of seed, dates of planting or harvesting or fertiliser practice. Any soil-type differences were poorly estimated, as most soils were classified as loams,

Table 11. Average quality of crop sampled from different types of store.

% rejected Grade I for[1]	Storage[2]			Approx. S.E. for horizontal comparisons[6]
	Outdoor[3]	Indoor, no ventilation[4]	Indoor with ventilation[5]	
Mechanical blemishes[7]	21.2	24.0	27.1	± 2.0
Disease blemishes[8]	16.8	12.4	14.8	1.0
Pests[9]	5.6	6.0	5.1	0.6
Rots[10]	6.3	4.1	4.5	0.4
Silver scurf[11]	7.8	5.3	4.9	0.9
Blight[12]	1.7	1.9	2.4	0.2
% accepted Grade I[13]	40.8	41.4	39.4	1.6

[1] *Für Klasse I abgewiesen wegen (%) – % éliminé de la Classe I pour*
[2] *Lagerung – Stockage*
[3] *Im Freien – Extérieur*
[4] *Im Räumen ohne Lüftung – Intérieur sans ventilation*
[6] *Ungefähre Standardabweichung für horizontale Vergleich – E.S. approx. pour comparaisons horizontales*
[7] *Mechanisch bedingte oberflächliche Mängel – Blessures mécaniques superficielles*
[8] *Krankheitsmängel – Maladies superficielles*
[9] *Tierische Schäden – Dégats d'animaux*
[10] *Fäulnis – Pourriture*
[11] *Silberschorf – Gale argentée*
[12] *Phytophthora-Knollenfäule – Mildiou*
[13] *In Klasse I angenommen (%) – % accepté dans la classe I*

Tabelle 11. Durchschnittliche Erntequalität, dargestellt anhand von Mustern aus verschiedenen Arten von Lagerhäusern.
Tableau 11. Qualité moyenne des échantillons de récolte prélevés dans différents types de magasins.

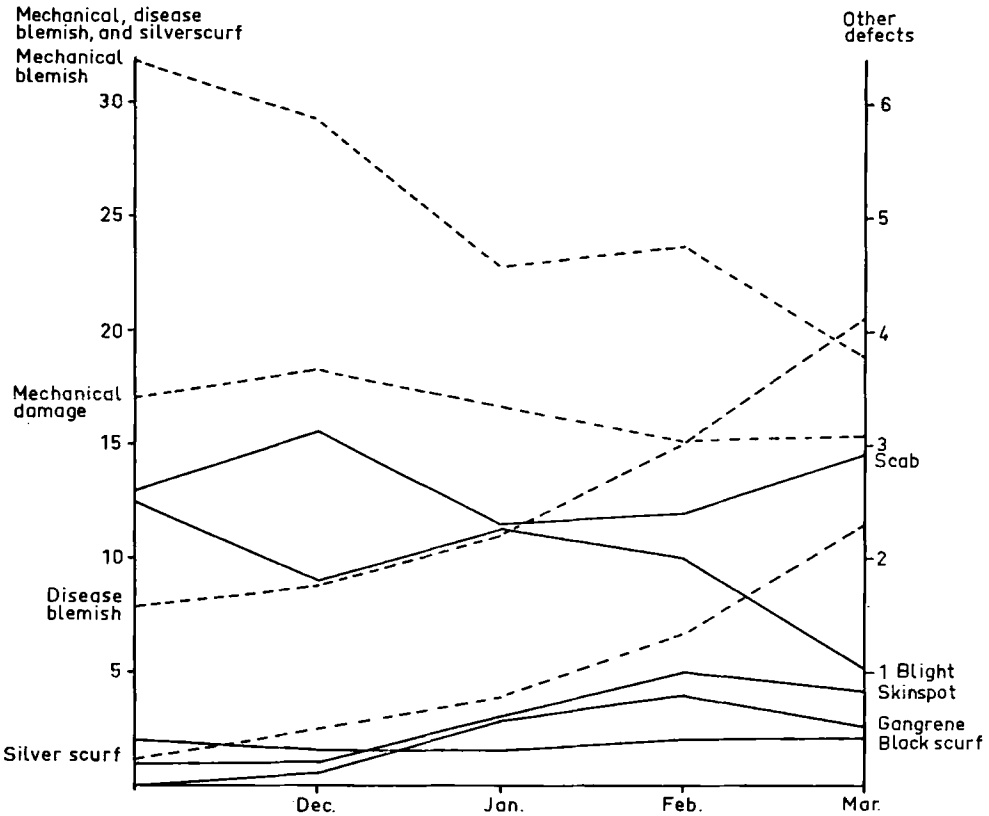
Table 12. Percentages of tuber weight acceptable for Grade I at different dates from store.

	Date store unloaded[1]					
	Before Dec[2]	Dec.	Jan.	Feb.	March	April +
King Edward and *Red King*	59	46	50	45	50	43
Kerr's Pink and *Redskin*	50	52	49	56	58	36
Majestic	32	34	36	39	38	27
Others[3]	23	27	48	40	37	27
All varieties[4] 1965–66	36	38	43	46	47	35
1966–67	39	39	41	40	38	27
Average[5]	38	38	42	43	43	31

[1] *Datum der Auslagerung – Date d'enlèvement de magasin*
[2] *Vor Dez. – Avant déc.*
[3] *Andere – Autres*
[4] *Alle Sorten – Toutes les variétés*
[5] *Mittel – Moyenne*

Tabelle 12. Gewichtsanteil an Knollen zu verschiedenen Zeiten während der Lagerung, annehmbar für Klasse I.
Tableau 12. Pourcentages de poids de tubercules acceptables en Classe I à différentes dates de conservation.

Fig. 1. Percentages by weight for different defects by dates unloaded from store.



Mechanical, disease blemish, silver scurf – *Mechanische und krankheitsbedingte Mängel und Silberschorf – Blessure superficielle mécanique, maladie superficielle et gale argentée*
Mechanical blemish – *Mechanisch bedingte oberflächliche Mängel – Blessure superficielle mécanique*
Mechanical damage – *Mechanische Beschädigungen – Dommage mécanique*
Disease blemish – *Krankheitsmängel – Maladie superficielle*
Silver scurf – *Silberschorf – Gale argentée*
Other defects – *Andere Schäden – Autres défauts*
Scab – *Schorf – Gale*
Blight – *Phytophthora-Knollenfäule – Mildiou*
Skinspot – *Tüpfelfleckigkeit – Oosporiose*
Gangrene – *Phoma-Knollenfäule – Gangrène*
Black spot – *Rhizoctonia – Rhizoctonia*

Abb. 1. Verschiedene Schäden in Gewichtsprozent an den Auslagerungsdaten.
Fig. 1. Pourcentages par poids de divers défauts et dates d'enlèvement du magasin.

and only 4% of the sampled crops were irrigated so that any effect of irrigation could not be estimated.

The average quality of tubers coming from store at different times of the year is influenced by any deterioration that occurs in store and by farmers tending to keep longer those crops initially thought to be of good keeping quality. There is also the possibility of 'drift' in quality assessment standards over the storage season. Table 12 shows that the average quality decreases when potatoes are stored beyond the end of March, but there is little evidence of general deterioration before then. Indeed, the acceptability of *Majestic* samples (and samples of all varieties in 1965–66) was greater in the early months of the year than in the autumn.

Over the storage period there was a steady increase in the percentage of tuber weight unacceptable because of disease blemishes and rots, and some reduction in the percentage rejected for mechanical damage or blemishes (Fig. 1). The smaller observed incidence of mechanical damage later in the storage season may partly reflect selective storage of crops with little mechanical damage, and evidence of mechanical damage may also be obscured by the spread of disease blemishes or rots.

Much of the increase in disease blemishes over the storage season is attributable to silver scurf. Both skinspot and gangrene were more often recorded in crops stored for several months, but there was less blight in the crops stored longest, unless evidence of blight was obscured by other defects. Quality differences over the storage period are not attributable to variety, although *Majestic* potatoes are on the average stored rather longer than *King Edward.*

Effect of changes in the definition of Grade I

The effects of any changes in the Grade I specification on the proportion of the crop acceptable for the grade can readily be calculated from the survey data. The effect of small changes can be approximated from information in this paper as follows, by assuming that presence or absence of a particular defect is independent of the occurrence of other defects.

Let P be the percentage of tuber weight $>$ 38 mm and conforming to the Grade I standard. Let the standard be amended in relation to the *i*th defect. From Table 5, for changes in the permitted size, and Table 3 for all other changes, it is possible to find q_i, the percentage of tuber weight rejected on account of the *i*th defect for Grade I and also q_i', the corresponding percentage under the revised grade. Then P′, the new value of P, can be approximated by the expression:

$$P' = P\,\frac{(100-q_i')}{(100-q_i)}$$

Other changes can be allowed for by multiplying by further factors of the form $(100-q_i')/(100-q_i)$.

As an example, the effect of two changes in the Grade I specification can be combined:

a. Minimum size increased from 38 mm to 41 mm for all varieties: $q_1 = 0$, $q_1' = 2.6$ from Table 5.

b. Tubers with up to 160 mm^2 greening acceptable (i.e. code 1 as well as code 0 to comply with the grade): $q_2 = 14.2$, $q_2' = 8.6$ from Table 3, averaging two years' data.

The percentage of the crop conforming to the revised grade is:

$P' = 40(97.4/100)(91.4/85.8) = 41.5\%$

The result of following this procedure for a more complex series of changes agreed closely with the percentage calculated directly from the survey data.

APPENDIX 1

Coding of tuber defects and 'Grade I' requirement

Levels acceptable for 'Grade I' are indicated by an asterisk (*) before the code number.

Type code or level *Description*

Mechanical damage

*0. Mechanical damage not more than 1.5 mm deep and removable by one slice of the peeler.
*1. As 0, but with one clean cut not more than 25 mm long.
2.[1] As 0, but with two clean cuts not more than 25 mm long.
3. More seriously damaged tubers.

Mechanical surface blemishes

*0. Free of mechanical blemishes and russetting to an extent acceptable for washed, premium-graded prepack.
1. Unacceptable[2] because of surface scratches and hair cracks only.
2. Unacceptable[2] because of skin russetting or netting only.
3. Unacceptable[2] because of brown dots caused by lentical rotting only.
4. Unacceptable[2] because of more than one of the above surface blemishes.

Disease surface blemish (extent)

*0. none
*1. not more than a trace of tuber surface area blemished
*2. not more than 1/16th of tuber surface area blemished
*3. not more than $\frac{1}{8}$ of tuber surface area blemished
4. not more than $\frac{1}{4}$ of tuber surface area blemished
5. not more than $\frac{1}{2}$ of tuber surface area blemished
6. more than $\frac{1}{2}$ of tuber surface area blemished

[1] Tubers > 76 mm are acceptable with two clean cuts.
[2] For washed premium-graded prepack.

Predominant disease

0. none
1. no one disease dominant, or unidentified disease
2. scab
3. silver scurf
4. black scurf
5. surface blight
6. gangrene
7. skin spot

Greening

*0. none
1. not more than 320 mm ($\frac{1}{2}$ square inch) of surface greened
2. not more than 650 mm^2 of surface greened
3. more than 650 mm^2 of surface greened

Shape

*0. characteristic of variety, acceptable
1. marked irregularities, unacceptable
2. growth cracks beyond peeler depth
3. secondary growth

Pest damage

*0. none
1. slug damage, potato acceptable for ware
2. slug damage, potato unacceptable for ware
3. wireworm damage
4. other pest damage

Rots (as distinct from the corky wound-healing tissue which develops in mechanical damage lesions)

*0. none
1. not more than a trace of soft or wet rotting caused by disease, i.e. that would be readily removable on peeling
2. more than a trace of soft or wet rotting caused by disease that would result in the potato being rejected for a ware sample

Compression damage

This damage occurs as a flattened or depressed area and is caused by the pressure of one potato on another, or on ducts, walls, etc.

*0. none
1. compression damge

Dull/soft

*0. firm and of good colour
*1. firm but of dull appearance, i.e. lacking natural bright colour
2. not firm

Zusammenfassung

Die Qualität eingelagerter Speisekartoffeln in Grossbritannien

Auf Grund von Erhebungen in 571 Betrieben in den Jahren 1965–66 und in 751 Betrieben in den Jahren 1966–67 wurden in Grossbritannien die Anteile eingelagerter Speisekartoffeln mit verschiedenen Graden jeder Art der beobachteten Mängel berechnet.

Ungefähr 40 Gewichtsprozent aller Knollen über 38 mm entsprachen dem Standard der Qualitätsklasse I, in dem sie folgende Anforderungen erfüllten:

1. Sortentypisch, sauber und frei von fremden Dingen.

2. Frei von mechanisch bedingten Verletzungen, die durch das Schälen nicht sofort entfernt werden können, sowie mit nicht mehr als einem glatten Schnitt von 25 mm Länge bzw. länger bei einer Knollengrösse unter 76 mm, aber nicht mehr als zwei solchen Schnitten bei grösseren Knollen.

3. Nicht mehr als zu einem Achtel der Oberfläche mit Krankheiten befallen.

4. Fest, nicht notwendigerweise von natürlicher, kräftiger Farbe, aber ohne andere beobachtete Mängel. (Siehe Tabelle 2.)

20 bis 25 Prozent der Lager enthielten 60 Prozent oder mehr Kartoffeln der Klasse I, und unter günstigen Umständen dürfte es vorteilhafter sein, den Inhalt solcher Lager als Qualitätsklasse aufzuarbeiten, denn als Standardware (Tabelle 4).

Ein Viertel der Ernte war infolge mechanisch bedingter oberflächlicher Mängel unannehmbar für Klasse I. Mechanische Beschädigungen, die tiefer sind als Schältiefe, Mängel durch Krankheiten an der Oberfläche (meistens Schorf, Silberschorf und *Phytophthora*-Knollenfäule) sowie Grünwerden verursachen Abweisungen von je 13 bis 18 Prozent der Ernte. Etwa 16 Prozent der Sorte *Majestic* und 6 Prozent von andern Sorten waren in der Form unannehmbar (Tabelle 2 und 7).

Majestic litt unter fast allen Mängeln mehr als andere Sorten, aber Mängel an der Oberfläche infolge Knollenfäule waren bei *King Edward* und andern 'roten' Sorten häufiger (Tabelle 7). Grössere Knollen wiesen die meisten Schadenarten in grösserer Zahl auf als kleine Knollen, aber die Grössenunterschiede waren nicht verantwortlich für die Qualitätsunterschiede zwischen den Sorten (Tabelle 5). Die Erhebung ergab keine grösseren Unterschiede in der Qualität, verbunden mit Unterschieden in Ernte- und Lagerungsmethoden oder andern Betriebspraktiken (Tabelle 9 bis 11). Während der Lagerung stieg der beobachtete Befall mit oberflächlichen Krankheitssymptomen an, aber derjenige der mechanischen Mängel nahm ab (Tabelle 12 und Abb. 1).

Es wurde ein Beispiel angeführt, aus dem hervorgeht, wie der Prozentanteil der Ernte, der die Bedingungen der Klasse I erfüllt, mit Hilfe von Informationen in dieser Publikation geschätzt werden kann.

Résumé

La qualité des pommes de terre de récolte principale conservées en Grande-Bretagne

Afin d'estimer les proportions de pommes de terre de principale récolte de Grande-Bretagne montrant, à différents degrés, chaque type de défaut, on a effectué des enquêtes dans 571 fermes en 1965–66 et dans 751 fermes en 1966–67.

Environ 40% en poids des tubercules > 38 mm correspondaient à la classe I standard, soit:

1. Conformité du type, propre, absence de matière étrangère.

2. Absence de meurtrissure mécanique non réellement éliminée en pelant les tubercules et pas plus qu'une coupure propre de 25 mm ou plus si le tubercule est > 76 mm, ou pas plus que deux semblables coupures si le tubercule est plus gros.

3. Un huitième maximum de la surface endommagée par une maladie.

4. Ferme, pas nécessairement de couleur naturellement brillante mais sans autre défaut visible. (Voir Tableau 2.)

Environ 20–25% des magasins contenaient 60% ou plus de pommes de terre de Classe I et, dans des circonstances favorables, il peut être utile de classer le contenu de tels magasins en première classe plutôt que comme marchandise standard (Tableau 4).

Un quart de la récolte est inacceptable en Classe I en raison de blessures mécaniques de surface. Les dommages mécaniques de profondeur supérieure à l'épaisseur de la peau, les surfaces endommagées par une maladie (gale ordinaire, gale argentée et mildiou), le verdissement, chacun de ces défauts entraîne l'élimination de 13 à 18% de la récolte. Environ 16% de *Majestic* et 6% des autres variétés sont de forme inacceptable (Tableau 2 et 7).

Majestic souffre de presque tous les défauts plus souvent que les autres variétés, mais les surfaces atteintes de mildiou sont plus fréquentes chez *King Edward* et les autres variétés 'rouges' (Tableau 7). Les gros tubercules montrent plus souvent que les petits la plupart des types de défaut, mais les différences de grosseur ne justifient pas les différences entre les variétés (Tableau 5). L'enquête ne découvre aucune différence majeure de qualité liée à des différences de méthodes de récolte et de stockage ou d'autres pratiques de la ferme (Tableau 9–11). Au cours de la saison de stockage on observe une augmentation des surfaces endommagées par les maladies et une diminution de celles causées par les blessures mécaniques (Tableau 12 et Fig. 1).

Un exemple est donné de la façon d'estimer le pourcentage de la récolte qui s'accorderait complètement aux spécifications Classe I en utilisant les données ce la publication.

References

Anon., 1964. Report on a consumer survey. Potato Marketing Board.

Hampson, C. P. & Codrington, C. de B., 1967. Studies on the relative efficiency of different systems of harvesting and handling potatoes into store 1965–66 and 1966–67. *Potato Marketing Board Report* No. 3, 6 pp.

Stubbs, R., 1968. The marketing of quality graded potatoes. *Potato Marketing Board Report* No. 4, 29 pp.