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CONVERSION TABLE FOR SPECIFIC GRAVITY, DRY MATTER AND STARCH CONTENT FROM UNDER WATER WEIGHT OF POTATOES GROWN IN NORTH-INDIAN PLAINS

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ABSTRACT : Under water weight (UWW), specific gravity (SG), dry matter (DM) and starch content of potatoes were determined in tubers grown at Modipuram, Uttar Pradesh. Linear regression equations and correlation coefficients were worked out for different pairs of values. There was a positive correlation between UWW and SG (r=0.99), UWW and DM (r=0.92) and, UWW and starch content (r=0.77). Regression equations for the relationship of UWW with SG, DM and starch content are presented in this paper. Based on these equations, a conversion table has been developed for potatoes grown in North Indian plains, for the benefit of the potato processing industry.

INTRODUCTION

Specific gravity of potatoes is commonly used by the potato processing industry as a tool for quick estimation of dry matter content. Methods like brine solution (14), hydrometer (10) and weight of potatoes in air and water (3) have been used for determining specific gravity of potatoes. Relationship between specific gravity and dry matter content of potatoes has been developed by several workers (5,14,15) and this relationship has been found to vary with the variety, location, season and the year of cultivation (1,13). Specific gravity measurements are known to be influenced by factors like differences in the intercellular space in the tuber tissue (1) and the temperature of potatoes and of the water in which the potatoes are weighed. Conversion tables based on under-water weight (UWW) for specific gravity, dry matter and starch content are available in developed countries (12) for use by the potato processing industry in those countries. Such tables developed in Europe or U.S.A cannot be used in India since the relationship varies with location, variety, soil type and cultural conditions. A conversion table for potatoes grown in the hills has been developed (2) but no such table is available for potatoes grown in the plains. An attempt has been made here to work out the relationship between UWW and specific gravity, dry matter and starch content of potatoes grown at Modipuram, which falls in the major potato growing area of Indo-Gangetic plains and to develop a conversion table for the use of potato processing industry in India.

MATERIALS AND METHODS

Potato Material: A total of 78 varieties and advanced hybrids grown at the farm of Central Potato Research Institute Campus, Modipuram during the year 2002-03 and 2003-04 were used for this study (**Table 1**). A total of 99 samples which included two or three samples of the same variety belonging to different maturity stages (90 days or 105 days) were used. After curing, healthy tubers of processing grade size (50-88 mm) were selected for further studies.

Under water weight determination: Around six kg of tuber material was washed

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Table 1. Varieties and advanced hybrids used for deriving conversion table

Hybrid/ Variety	Hybrid/ Variety	Hybrid/ Variety
J/92-13	MF-1	MP/98-42
JX-576	MP/95-177	B-420 (2)
HT/97-727	TPS-13	MS/94-1118
MS/94-899	MP/97-699	HT/93-707
J/93-58	J/95-223	J/92-13
Kufri Anand	J/95-229	J/94-90
HT/92-621	JTH/C-107	MS/92-1090
J/92-164	MP/99-322	Kufri Sindhuri
Kufri Kanchan	Atlantic	J/93-139
Kufri Bahar	Kufri Chipsona-1	Kufri Badshah
MP/98-182	Kufri Chipsona-2	83-P-47
94-P-31	MP/99-260	Kufri Jyoti
J/93-4	MP/97-583	J/95-242
Kufri Sutlej	MP/99-1914	EX/A-680-16
94-P-59	MP/97-625	MP/97-1067
Kufri Pukhraj	MP/99-380	J/93-81
MS/94-1344	MP/99-406	MS/93-621
J/95-227	J/92-159	MS/97-1606
MS/94-1309	MP/94-899	JW-160
MS/90-1386	MP/99-422	MP/97-637
MS/92-2105	MP/99-1293	MP/98-115
J/93-87	MP/99-1889	MP/97-1025
MS/93-1344	MP/99-229	MP/98-177
J/93-77	MP/98-71	MP/97-644
J/93-86	MP/99-498	MP/98-178
J/92-167	MP/97-921	MP/98-172

thoroughly in water to remove adhering soil. The washed tubers were then air-dried and weighed in air in a specific gravity balance (Sky Light Industries, Ghaziabad, UP) to five kg. Wherever required, single tuber was cut to make the total weight exactly to five kg. The air weighed five kg tubers were then immersed in clean water and under water weight (UWW) was noted down.

Calculation of specific gravity: The specific gravity was computed using following formula:

Specific gravity= **5000*/ [5000-UWW (in grams)]**

* Weight in air

Estimation of dry matter content: Ten tubers were taken out after determining under water weight, dried in shade and cut longitudinally in two halves from stem end to bud end. One half was discarded and another half was chopped in small pieces using a manual knife. Chopped pieces from ten halves were then mixed thoroughly and filled in three aluminium boxes. Each box contained minimum of 70 g fresh tuber tissue. The fresh weight up to three decimals was recorded and boxes were kept at 80°C in a hot air oven for six hours and then at 65°C till constant dry weight. The boxes were again weighed and dry matter content was calculated.

Quantification of starch content: The dried tuber tissue after dry matter content estimation was used for this purpose. Ten grams of dried tuber tissue was made sugar free by repeated extraction with 80% iso-propanol. The sugar free tuber tissue was dried at 70°C overnight in a hot air oven. The dried pieces were ground to a fine powder and starch was hydrolysed using 60 % perchloric acid. The glucose was estimated by anthrone method (7).

The values of correlation coefficient and regression equations were obtained using MSTAT 4.0C package of computers following the method of Gomez and Gomez (4). The conversion table was prepared using Fox Pro data base system.

RESULTS AND DISCUSSION

There was a positive correlation between UWW and specific gravity (r=0.99), UWW and percent dry matter content (r=0.92) and UWW and percent starch content (r=0.77) (**Table 2**). The R^2 and F calculated values were

Table 2. Relationship between UWW and, specific gravity, dry matter content and starch content of potatoes grown in North Indian plains (Modipuram, UP)

Parameters X	Y	Regression equation	Coefficient of correlation	R^2	F_{cal}
UWW	SG	Y = 0.99 + 0.0002x	0.99	0.99	20736.4
UWW	DM	Y = -1.45 + 0.055x	0.92	0.85	548.55
UWW	Starch	Y = -9.42 + 0.06x	0.77	0.59	136.07
SG	DM	Y = -238.5 + 0.02x	0.93	0.86	570.75
SG	Starch	Y = -268.93 + 0.03x	0.77	0.60	141.99

Table 3. Conversion table for specific gravity (SG), dry matter content (DM) and starch content from the under water weight (UWW) of 5 kg of potatoes. Soil type was sandy loam soils of Modipuram

UWW (g)	SG	DM (%)	Starch (%)	UWW (g)	SG	DM (%)	Starch (%)	UWW (g)	SG	DM (%)	Starch (%)
250	1.052	12.4	5.6	299	1.064	15.1	8.6	348	1.075	17.8	11.5
251	1.053	12.4	5.7	300	1.064	15.2	8.6	349	1.075	17.9	11.6
252	1.053	12.5	5.7	301	1.064	15.2	8.7	350	1.076	17.9	11.7
253	1.053	12.5	5.8	302	1.064	15.3	8.8	351	1.076	18.0	11.7
254	1.053	12.6	5.9	303	1.065	15.3	8.8	352	1.076	18.0	11.8
255	1.053	12.7	5.9	304	1.065	15.4	8.9	353	1.076	18.1	11.8
256	1.054	12.7	6.0	305	1.065	15.4	8.9	354	1.076	18.1	11.9
257	1.054	12.8	6.1	306	1.065	15.5	9.0	355	1.077	18.2	12.0
258	1.054	12.8	6.1	307	1.066	15.5	9.1	356	1.077	18.3	12.0
259	1.054	12.9	6.2	308	1.066	15.6	9.1	357	1.077	18.3	12.1
260	1.055	12.9	6.2	309	1.066	15.7	9.2	358	1.077	18.4	12.1
261	1.055	13.0	6.3	310	1.066	15.7	9.2	359	1.078	18.4	12.2
262	1.055	13.1	6.4	311	1.066	15.8	9.3	360	1.078	18.5	12.3
263	1.055	13.1	6.4	312	1.067	15.8	9.4	361	1.078	18.5	12.3
264	1.056	13.2	6.5	313	1.067	15.9	9.4	362	1.078	18.6	12.4
265	1.056	13.2	6.5	314	1.067	15.9	9.5	363	1.079	18.6	12.4
266	1.056	13.3	6.6	315	1.067	16.0	9.5	364	1.079	18.7	12.5
267	1.056	13.3	6.7	316	1.068	16.0	9.6	365	1.079	18.8	12.6
268	1.056	13.4	6.7	317	1.068	16.1	9.7	366	1.079	18.8	12.6
269	1.057	13.4	6.8	318	1.068	16.2	9.7	367	1.079	18.9	12.7
270	1.057	13.5	6.8	319	1.068	16.2	9.8	368	1.080	18.9	12.7
271	1.057	13.6	6.9	320	1.069	16.3	9.8	369	1.080	19.0	12.8
272	1.057	13.6	6.9	321	1.069	16.3	9.9	370	1.080	19.0	12.9
273	1.058	13.7	7.0	322	1.069	16.4	10.0	371	1.080	19.1	12.9
274	1.058	13.7	7.1	323	1.069	16.4	10.0	372	1.081	19.1	13.0
275	1.058	13.8	7.1	324	1.069	16.5	10.1	373	1.081	19.2	13.0
276	1.058	13.8	7.2	325	1.070	16.5	10.1	374	1.081	19.3	13.1
277	1.059	13.9	7.3	326	1.070	16.6	10.2	375	1.081	19.3	13.2
278	1.059	13.9	7.3	327	1.070	16.7	10.3	376	1.082	19.4	13.2
279	1.059	14.0	7.4	328	1.070	16.7	10.3	377	1.082	19.4	13.3
280	1.059	14.0	7.4	329	1.071	16.8	10.4	378	1.082	19.5	13.3
281	1.059	14.1	7.5	330	1.071	16.8	10.5	379	1.082	19.5	13.4
282	1.060	14.2	7.6	331	1.071	16.9	10.5	380	1.082	19.6	13.5
283	1.060	14.2	7.6	332	1.071	16.9	10.6	381	1.083	19.6	13.5
284	1.060	14.3	7.7	333	1.072	17.0	10.6	382	1.083	19.7	13.6
285	1.060	14.3	7.7	334	1.072	17.0	10.7	383	1.083	19.8	13.6
286	1.061	14.4	7.8	335	1.072	17.1	10.8	384	1.083	19.8	13.7
287	1.061	14.4	7.9	336	1.072	17.1	10.8	385	1.084	19.9	13.8
288	1.061	14.5	7.9	337	1.072	17.2	10.9	386	1.084	19.9	13.8
289	1.061	14.5	8.0	338	1.073	17.3	10.9	387	1.084	20.0	13.9
290	1.062	14.6	8.0	339	1.073	17.3	11.0	388	1.084	20.0	13.9
291	1.062	14.7	8.1	340	1.073	17.4	11.1	389	1.085	20.1	14.0
292	1.062	14.7	8.2	341	1.073	17.4	11.1	390	1.085	20.1	14.1
293	1.062	14.8	8.2	342	1.074	17.5	11.2	391	1.085	20.2	14.1
294	1.062	14.8	8.3	343	1.074	17.5	11.2	392	1.085	20.2	14.2
295	1.063	14.9	8.3	344	1.074	17.6	11.3	393	1.085	20.3	14.2
296	1.063	14.9	8.4	345	1.074	17.6	11.4	394	1.086	20.4	14.3
297	1.063	15.0	8.5	346	1.075	17.7	11.4	395	1.086	20.4	14.4
298	1.063	15.0	8.5	347	1.075	17.8	11.5	396	1.086	20.5	14.4

(Contd.)

Table 3. (*Contd.*)

UWW (g)	SG	DM (%)	Starch (%)	UWW (g)	SG	DM (%)	Starch (%)	UWW (g)	SG	DM (%)	Starch (%)
397	1.086	20.5	14.5	432	1.095	22.5	16.6	467	1.103	24.4	18.7
398	1.087	20.6	14.5	433	1.095	22.5	16.7	468	1.103	24.5	18.8
399	1.087	20.6	14.6	434	1.095	22.6	16.7	469	1.103	24.5	18.8
400	1.087	20.7	14.7	435	1.095	22.6	16.8	470	1.103	24.6	18.9
401	1.087	20.7	14.7	436	1.095	22.7	16.8	471	1.104	24.6	18.9
402	1.088	20.8	14.8	437	1.096	22.7	16.9	472	1.104	24.7	19.0
403	1.088	20.9	14.8	438	1.096	22.8	17.0	473	1.104	24.7	19.1
404	1.088	20.9	14.9	439	1.096	22.9	17.0	474	1.104	24.8	19.1
405	1.088	21.0	15.0	440	1.096	22.9	17.1	475	1.105	24.8	19.2
406	1.089	21.0	15.0	441	1.097	23.0	17.1	476	1.105	24.9	19.2
407	1.089	21.1	15.1	442	1.097	23.0	17.2	477	1.105	25.0	19.3
408	1.089	21.1	15.1	443	1.097	23.1	17.3	478	1.105	25.0	19.4
409	1.089	21.2	15.2	444	1.097	23.1	17.3	479	1.105	25.1	19.4
410	1.089	21.2	15.3	445	1.098	23.2	17.4	480	1.106	25.1	19.5
411	1.090	21.3	15.3	446	1.098	23.2	17.4	481	1.106	25.2	19.5
412	1.090	21.4	15.4	447	1.098	23.3	17.5	482	1.106	25.2	19.6
413	1.090	21.4	15.4	448	1.098	23.3	17.6	483	1.106	25.3	19.7
414	1.090	21.5	15.5	449	1.099	23.4	17.6	484	1.107	25.3	19.7
415	1.091	21.5	15.6	450	1.099	23.5	17.7	485	1.107	25.4	19.8
416	1.091	21.6	15.6	451	1.099	23.5	17.7	486	1.107	25.5	19.8
417	1.091	21.6	15.7	452	1.099	23.6	17.8	487	1.107	25.5	19.9
418	1.091	21.7	15.7	453	1.099	23.6	17.9	488	1.108	25.6	20.0
419	1.092	21.7	15.8	454	1.100	23.7	17.9	489	1.108	25.6	20.0
420	1.092	21.8	15.9	455	1.100	23.7	18.0	490	1.108	25.7	20.1
421	1.092	21.9	15.9	456	1.100	23.8	18.0	491	1.108	25.7	20.1
422	1.092	21.9	16.0	457	1.100	23.8	18.1	492	1.108	25.8	20.2
423	1.092	22.0	16.0	458	1.101	23.9	18.2	493	1.109	25.8	20.3
424	1.093	22.0	16.1	459	1.101	24.0	18.2	494	1.109	25.9	20.3
425	1.093	22.1	16.2	460	1.101	24.0	18.3	495	1.109	26.0	20.4
426	1.093	22.1	16.2	461	1.101	24.1	18.3	496	1.109	26.0	20.4
427	1.093	22.2	16.3	462	1.102	24.1	18.4	497	1.110	26.1	20.5
428	1.094	22.2	16.4	463	1.102	24.2	18.5	498	1.110	26.1	20.6
429	1.094	22.3	16.4	464	1.102	24.2	18.5	499	1.110	26.2	20.6
430	1.094	22.4	16.5	465	1.102	24.3	18.6	500	1.110	26.2	20.7
431	1.094	22.4	16.5	466	1.102	24.3	18.6				

also very high for UWW and specific gravity and UWW and dry matter, but was relatively lower for UWW and starch content (**Table 2**). These correlation coefficients are higher than that obtained by Ezekiel *et al*. (2) for potatoes grown in the hills as well as for potatoes grown at different locations in the plains. The correlation coefficient between specific gravity and dry matter (r=0.93) was also higher than that obtained by Verma *et al*. (14) for two different locations in the plains i.e. Jalandhar and Patna. It has been found that both specific gravity and dry matter content vary with the variety and the location (9,11,13). Variations have also been observed in UWW from year to year and location to location (12). Starch content was positively correlated with specific gravity (r=0.77) and dry matter content (r=0.79).

Based on the regression equations shown in **Table 2**, a conversion table for dry matter, starch content and specific gravity from UWW of 5 kg of potatoes was developed (**Table 3**).

The minimum value obtained for UWW in the samples was 250 and therefore, the UWW in the conversion table begins with 250 and ends at 499. This kind of relationship between specific gravity and dry matter/starch content has been derived under different conditions (6, 8, 14). In the earlier works done in India (14), brine solution method was used for the determination of specific gravity. Normally a triple beam balance is used in potato processing industries for determining weight of potatoes in air and under water. Secondly, earlier relationships worked out in the country used specific gravity values for deriving dry matter content whereas our conversion table can be used to derive values for specific gravity, dry matter and starch content from UWW.

A conversion table giving values for these parameters has been developed for potatoes grown in the Netherlands (12). When compared to this conversion table developed for the Dutch potato processing industry, for a given UWW, the specific gravity values are either similar or higher by 0.001 but the dry matter content was lower by 0.048 to 0.576%. The starch content was lower by 0.626 to 1.746%, for a given UWW but for a given dry matter value, the starch content was lower by 0.545 to 1.04%. This comparison clearly shows that conversion tables available in the developed countries cannot be used for potatoes grown in India.

The UWW, dry matter content and specific gravity are known to vary with the location and hence an equation developed for one location may not hold good for another location. This point is brought out clearly when the values given in **Table 3** are compared with values of a conversion table developed for the hills (2). When compared to that table, for a given UWW, the specific gravity is higher by 0.002 to 0.006 and the dry matter is lower by 3.9 to 4.7%. The starch values are lower by 1.8 to 3.9%. This further shows that conversion table developed for potatoes grown in the plains in India can not be used for potatoes grown in the hills in India and *vice versa*. It is hoped that the potato processing industry in India will find this conversion table useful as it can give an idea about the specific gravity, dry matter and starch content of potatoes grown in North Indian plains, for a given under water weight.

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