SIGNIFICATION OF LACTOMETER TESTS.

By Joseph F. Geisler.

The lactometer plays such an important part in the sanitary inspection of milk, that it may not be amiss to inquire into the signification of the lactometer tests, inasmuch as the indications of the same are frequently misinterpreted. The lactometer is familiarly known as a special form of delicate hydrometer or specific gravity instrument adapted to the requirements of milk testing.

The lactometer adopted by the N. Y. City Board of Health some years ago is a glass hydrometer about twelve inches long, the stem containing the scale being about 5½ inches in length, and the bulb and weighted section making up the rest of the instrument.

There are also lactometers in use containing a delicate thermometer so that the temperature and specific gravity can be read off at once.

The instrument is so standardized that at 60° F. its 0 mark will indicate the specific gravity of water, its 100° and 120° marks a specific of 1.029 and 1.0348 which have been adopted respectively as the lowest and highest specific gravities of pure milk. The greater the space between the 0 and 120° mark on the scale the more delicate is the specific gravity indication.

The general directions for using the lactometer are as follows: "The milk to be tested should be warmed or cooled, as the case may be, to a temperature of 60° Fahr. The lactometer is placed in it, care being taken not to wet that part of the stem above the milk. The mark at which it floats is now noted. Now take the lactometer out of the milk, and observe whether the thin film adhering to it runs rapidly off, and whether the milk appears thin and bluish, and the taste of the milk is flat and watery: if such is the case, and the lactometer floats at some point less than 100—as, for instance, 90—we are reasonably certain that water has been added. If the appearance and taste are as before stated, and it

floats at some points greater than 100, it may be skimmed, or skimmed and watered."*

Much depends upon the care and judgment of the operator in the use of the instrument, and it is apparent that considerable latitude is left for the exercise of personal opinion in drawing conclusions as to the indication of the test.

Inasmuch as the lactometer indicates the *specific gravity* it is pertinent to ask—To what extent is the specific gravity an indication of the purity of the milk? Does the sp. gr. indicate the composition of the milk? To those who are conversant with the facts, the questions may seem ridiculous, but those who by their blind faith in the indications of the specific gravity have come to grief will consider the question all important.

It is a well known fact that milk contains varying percentages of fat, casein, albumen, sugar, and saline matter, suspended or dissolved in a varying percentage of water. The different constituents affect the specific gravity in different degrees and their sum total determines the specific gravity of the milk at a given temperature.

It is argued that in *pure milk* the specific gravity does not exceed certain fixed limits, so that anything beyond these extremes is *prima facie* evidence that the milk is adulterated.

Let us first give our attention to milk the specific gravity of which is within the adopted limits of 1.029 (100° Lact.) and 1.0348 (120° Lact.).

The most common form of adulteration of milk consists in the addition of water or the removal of cream, while not unfrequently both practices are resorted to simultaneously. Since fat is lighter than water the removal of cream (cream usually contains 35 to 50% of fat) raises the specific gravity, while by a careful addition of water the sp. gr. can be again lowered to its former standing.

Hence the mere indication of the sp. gr. would not reveal the adulteration. Again a milk unusually rich in fat could have some of the fat removed without increasing the specific gravity sufficiently to even raise a suspicion.

Thus taking for illustration 10 gallons of milk having a specific gravity of 1.030 and containing 4.5% of fat, we should have 1318.4

* First Annual Rep. of the New York State Dairy Commissioner, p. 96.

ozs. of milk containing 59.32 ozs. of fat. If from such a milk .9% of fat (or 11.86 ozs.), which is just 20% of the total amount of fat, were removed, it would still leave 3.6% of fat in the milk, while the sp. gr. would be raised to only 1.0306 to 1.0307, or 106° lact. Such a milk would not reveal anything definite by the lact. test, or in its physical appearance and would pass the usual routine of inspection.

There can be no question but that considerable adulterated milk passes the lactometer inspection which, even upon the adopted standards, would not be detected by the ordinary routine of chemical analysis. It is reported upon good evidence that such practices are frequently made use of in some creameries, and it is only through circumstantial evidence that such fraudulent practices can be proven sufficiently to have the perpetrators prosecuted. It is evident that such errors are all in favor of the milkman. There is a pathetic side to the question. How about the middleman ? * It is not an unfrequent occurrence to find milk at 102° to 106° lactometer, which upon chemical analysis is shown to be adulterated. The physical appearance of the milk and the manner in which it runs off the lactometer is very much affected by the reaction (degree of alkalinity or acidity), age, viscosity, the size of the fat globules and the degree of color of the fat. Milk with very small fat globules of high color, will have a better appearance than a milk with larger fat globules of lighter color, other things being equal. It is for this reason, probably, that the *lactoscope* at times gives such very erroneous results, even in the hands of skilled operators.

Proportionally there is very little *pure* milk sold in bulk which will not stand the lactometer limits of 100° to 120° at 60° F. Occasionally, however, *pure* milks are found which stand only 95° to 98° on the lactometer. Their low specific gravity is due to richness in fat, and if this is of light color the appearances easily give rise to suspicion of adulteration, while the milk may be of exceptionally rich quality. It is not a very unusual thing for pure milk, which under ordinary conditions would satisfactorily

* It is evident that the middleman relying upon the lactometer tests must suffer the consequences of any erroneous indication of that instrument.

stand the lactometer test, to give readings considerably too low when such milk has been drawn for long distances over rough roads. It is probable that under some conditions the milk becomes ærated through the constant agitation in the cans. At least this seems the most plausible explanation to account for differences found between the inspection tests and those made later at the laboratory and verified by the picnometer. It is possible, too, that the stem of the lactometer used by the inspector had become soiled so as to depress the instrument lower than would otherwise have been the case. In several cases the inspection tests were as much as ten degrees too low. It must be evident that the lactometer tests are not so reliable as some believe them to be, and it is essential that duplicate samples be taken for analysis to verify the lactometer. Fortunately milk vendors are no longer subject to the barbarous practice of condemning milk by the lactometer alone, without giving or retaining a sample for further examination.' There is little doubt that the lactometer has brought innocent persons to grief, and it must also be acknowledged that it has passed many an habitual adulterator. *In experienced hands* it is a *useful instrument*, but is not infallible in its indications.

It may appear that the instrument is indirectly an inducement for milk vendors to adulterate their milk, for they can water and skim the milk, and by means of the lactometer adjust it to pass the inspection tests by this instrument. This is not fancy but is based upon fact, for there are persons who have been cunning enough to resort to the practice. To cite a case: Milk No. 20 in the table represents the analysis of a sample taken from a can of milk which had been subjected to skillful manipulation by one who was also caught in the act. *Unless the source of the milk and the quality of the milk yielded by that particular dairy* were known, it would be impossible for the analyst to certify, from the mere data of the analysis of the sample, that such a milk was adulterated. To show that the lactometer does not indicate the composition of the milk, reference to the following table will suffice.

TABLE OF ANALYSES,

Illustrating differences in lactometer degrees and composition of the milk:

Deg. Lact. at 60° F.	Sp. Gr.	% H_2O.	Solids.	% Fat.	Cas. & Sugar.	Ash.	
1. 98°	1.0284	87.661	12.339	4.409	7.212	.718	Pure Milk
2. 97.2°	1.0282	86.993	13.007	4.782	7.527	.698	" "
3. 97°	1.0281	87.094	12.906	4.860	7.346	.700	
4. 98°	1.0284	88.436	11.564	3.759	7.123	.682	
5. 98°	1.0284	89.463	10.537	3.013	6.809	.715	
6. 98.2°	1.0285	88.333	11.667	3.812	7.192	.663	
7. 101°	1.0293	88.382	11.618	3.533	7.427	.658	
8. 100°	1.0290	86.620	13.380	5.239	7.521	.620	
9. 101°	1.0293	87.145	12,855	4.709	7.477	.669	
10. 100°	1.0290	89.055	10.945	3.107	7.040	.798	
11. 96°	1.0278	88.899	11.101	3.439	7.010	.652	
12. 86°	1.0250	88.874	11.123	3.857	6.613	.646	
13. 110°	1.0320	88.927	11.073	2.767	7.581	.725	
14. 82°	1.0237	89.207	10.793	4.030	6.192	.571	
15. 106°	1.0306	88.678	11.322	3·047	7.572	·703	
16. 104°	1.0300	85.962	14.038	5.624	7.701	.713	
17. 110°	1.0320	88.927	11.073	2.767	7.581	.725	
18. 113°	1.0327	88.124	11,876	3.106	8.039	.731	
19. 89.5°	1.0260	85.779	14.221	6.370	7.188	.663	
20. 112.5°	1.0326	87.106	12.894	3.692	8.423	.779	

Milks Nos. 1 and 2 were known to be pure. The remainder had been seized by inspectors as suspected samples, of which 3, 8, 9, 16 and 19 were above the State law requirements.

In groups 1–6 and 7–10 the lactometer degrees are about the same for the respective groups, the percentage of fat and solids varying, while in 11–14 the solids are about the same and the lactometer degrees varying widely.

Nos. 16 and 19 were taken as "suspicious" samples by inspectors, but the analyses showed them to be very rich milk, the solids being about the same but the specific gravities varying widely. No. 20, although above the New York State law standard as to solids and fat, is the adulterated sample already referred to.

In the table a comparison of Nos. 7, 8, 9 and 10, which contain nearly the same percentage of solids, will show how a slight difference in the percentage of fat affects the specific

gravity. Thus between 7 and 8 the difference in fat is but .42%, and that of the lactometer degrees 10, while between 9 and 10 the difference in solids is but .32%, but the lactometer degrees 28 and the percentage of fat 1.26. Of course such differences are also attended by changes in the physical properties of the milk and can in most cases be recognized by experts.

A careful comparison of the data in the table presented will illustrate that the specific gravity alone is not an indication of the purity or composition of the milk. Lactometers ought to be restricted in their use. They are certainly useful in sorting milk, and under certain conditions sufficient to at once condemn milk absolutely. For a correct interpretation of the lactometer degrees in the examination of milk some other factors such as the percentage of total solid or fat are essential. A careful and proper use of the lactometer shows the *specific gravity* of the milk, but any inference beyond that depends largely upon the ability and experience of the operator.

ESTIMATION, BY TITRATION, OF DISSOLVED CARBON DIOXIDE IN WATER.

By Albert R. Leeds.

In the determination of the amount of lime requisite to precipitate the dissolved carbonates of lime and magnesia in natural waters, the discrepancy between the amount of carbonate remaining in solution after precipitation, and the calculated amount, is increased by failure to estimate and allow for the dissolved carbon dioxide present. This dissolved carbon dioxide interferes with the results obtained by the use of soap in the estimation of dissolved calcium carbonate. For this and many other reasons I