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Dried milk, dried ice-mixes and processed cheese — Determination of lactose content —

Part 2: Enzymatic method utilizing the galactose moiety of the lactose

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Lait sec, mélanges secs pour crèmes glacées et fromages fondus — Détermination de la teneur en lactose —

Partie 2: Méthode enzymatique par la voie galactose

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 5765|IDF 79 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5765-2|IDF 79-2 was prepared by Technical Committee ISO/TC 34, *Food Products*, Subcommittee SC 5, *Milk and milk products*, and the International Dairy Federation (IDF), in collaboration with AOAC International. It is being published jointly by ISO and IDF and separately by AOAC International.

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ISO 5765|IDF 79 consists of the following parts, under the general title *Dried milk, dried ice-mixes and processed cheese — Determination of lactose content*:

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— *Part 1: Enzymatic method utilizing the glucose moiety of the lactose*

— *Part 2: Enzymatic method utilizing the galactose moiety of the lactose*

Annex A forms a normative part of this part of ISO 5765|IDF 79.

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Foreword

IDF (the International Dairy Federation) is a worldwide federation of the dairy sector with a National Committee in every member country. Every National Committee has the right to be represented on the IDF Standing Committees carrying out the technical work. IDF collaborates with ISO and AOAC International in the development of standard methods of analysis and sampling for milk and milk products.

Draft International Standards adopted by the Action Teams and Standing Committees are circulated to the National Committees for voting. Publication as an International Standard requires approval by at least 50 % of National Committees casting a vote.

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All work was carried out by the Joint ISO/IDF/AOAC Action Team *Lactose and lactate determination*, of the Standing Committee on *Main components of milk*, under the aegis of its project leader, Mr J. Labrijn (NL).

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Introduction

This part of ISO 5765|IDF 79 describes the enzymatic method for the determination of lactose utilizing the galactose moiety of the lactose. It is complementary to ISO 5765-1|IDF 79-1 which utilizes the glucose moiety of the lactose.

The choice of whether to use the method described in part 1 or part 2 of ISO 5765|IDF 79 depends from the amount of glucose or galactose present in the sample to be analysed. If the glucose content of a sample is considerably higher than its lactose content, it is recommended to use the method described in this part of ISO 5765|IDF 79. Conversely, for a sample with a considerably higher galactose content than its lactose content, it is recommended to use the method described in ISO 5765-1|IDF 79-1.

For samples with a low content of both glucose and galactose, either method may be used without preference. For samples with a high content of both glucose and galactose, the accuracy of the lactose determination is considerably reduced for both methods.

In heat-treated milk and milk products, a proportion of lactose may have been converted to lactulose. Lactulose cannot be determined by applying the method described in ISO 5765-1|IDF 79-1. If, however, the method in this part of ISO 5765|IDF 79 is applied, the lactulose will partially be determined as lactose. Moreover, in intensively heat-treated milk (e.g. sterilized milk) or milk products, a proportion of the lactose may be bound to protein because of a Maillard reaction. In such cases the bound lactose cannot be determined by the method described either in part of ISO 5765|IDF 79.

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Only when the good laboratory practice (GLP) rules for enzymatic analyses have been applied strictly, will reliable results be obtained. The GLP rules are stated in annex A.

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Dried milk, dried ice-mixes and processed cheese — Determination of lactose content —

Part 2: Enzymatic method utilizing the galactose moiety of the lactose

1 Scope

This part of ISO 5765|IDF 79 specifies an enzymatic method for the determination of the lactose content of all types of dried milk, of ice-mixes in dry form in the presence of other carbohydrates and reducing substances, and of processed cheese.

2 Terms and definitions

For the purposes of this part of ISO 5765|IDF 79, the following term and definition applies.

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2.1
lactose content
mass fraction of substances determined by the procedure in this part of ISO 5765|IDF 79

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NOTE The lactose content is expressed as a percentage by mass.

3 Principle

3.1 A solution or suspension of the test portion is deproteinated to obtain a pure extract.

3.2 The purified extract of the test portion is reacted with the following enzymes and biochemical substances:

a) β-galactosidase, to split the lactose into glucose and galactose;

b) β-galactosidase dehydrogenase in the presence of nicotinamide adenine dinucleotide phosphate (NAD^+) to catalyse the oxidation of galactose into galactonic acid, the NAD^+ being reduced to NADH.

3.3 The amount of NADH is determined from the absorbance of the test solution at 340 nm.

3.4 The lactose content is calculated, which is proportional to the amount of NADH if a correction is made for the galactose present in the test sample at the start of the analysis.

4 Reagents

Use only reagents of recognized analytical grade unless otherwise specified. The water used for the preparation of the enzyme solutions shall be of at least doubly glass-distilled purity. The water used for other purposes shall be glass-distilled or of at least equivalent purity.

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Take note of the production and expiry dates of the reagents given by the manufacturer.

If an enzyme suspension is applied with other than the prescribed activity, the volume of the suspension as stated in the pipetting scheme (7.6.1) should be increased or decreased proportionally.

NOTE The reagents described in 4.4 and in 4.6 to 4.8 inclusive may be obtained commercially as a test combination, for example, Boehringer test kit. [1)]

4.1 Potassium hexacyanoferrate(II) solution, K_4 [$Fe(CN)_6$]

Dissolve 3,6 g of potassium hexacyanoferrate(II) trihydrate in water. Dilute with water to 100 ml and mix.

4.2 Zinc sulfate solution, $ZnSO_4$

Dissolve 7,2 g of zinc sulfate heptahydrate in water. Dilute with water to 100 ml and mix.

4.3 Sodium hydroxide solution, c(NaOH) = 0,1 mol/l

Dissolve 4,0 g of sodium hydroxide in water. Dilute with water to 1 000 ml and mix.

4.4 Citrate buffer solution, pH 6,6 ± 0,1

Dissolve 2,8 g of trisodium citrate dihydrate ($C_6H_5O_7Na_3 \cdot 2H_2O$), 0,042 g of citric acid monohydrate ($C_6H_8O_7 \cdot H_2O$), and 0,625 g of magnesium sulfate heptahydrate ($MgSO_4 \cdot 7H_2O$) in about 40 ml of water.

Adjust the pH to 6,6 ± 0,1 at 20 °C with sulfuric acid (2 mol/l) or sodium hydroxide solution (0,1 mol/l). Dilute with water to 50 ml and mix.

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This solution may be kept for 3 months if stored in a refrigerator set at between 0 °C and 5 °C.

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4.5 Phosphate (KH_2PO_4) buffer solution, pH 8,6 ± 0,1

Dissolve 16,6 g of potassium dihydrogen phosphate in about 80 ml of water. Adjust the pH to 8,6 ± 0,1 at 20 °C with sodium hydroxide solution (1 mol/l). Dilute with water to 100 ml and mix.

This solution may be kept for 8 weeks if stored in a refrigerator set at between 0 °C and 5 °C.

4.6 NAD^+/citrate buffer solution

Dissolve 25 mg of nicotinamide adenine dinucleotide ($C_{21}H_{27}N_7O_{17}P_2$; approximately 98 % assay) in 5 ml of citrate buffer solution (4.4).

This solution may be kept for 3 weeks if stored in a refrigerator set at between 0 °C and 5 °C.

4.7 β-Galactosidase suspension (from *Escherichia coli*), suspension in 3,2 mol/l ammonium sulfate solution, of pH 6 ± 0,1.

The activity of the suspension of β-galactosidase (EC 3.2.1.23) [5] shall be at least 60 units/ml (lactose as substrate, at 25 °C). The suspension may be kept for about 12 months if stored in a refrigerator set at between 0 °C and 5 °C. When using the suspension, the vessel containing the suspension shall be kept immersed in crushed ice.

NOTE A β-galactosidase suspension which contains not more than 0,001 % each of β-fructosidase, α-galactosidase, glucose dehydrogenase, α-glucosidase and NADH-oxidase, calculated in terms of the specific activity of β-galactosidase, has been found to be suitable.

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1) Boehringer test kit is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 5765|IDF 79 and does not constitute an endorsement by ISO or IDF of this product.

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4.8 β-Galactose dehydrogenase suspension (from *Pseudomonas fluorescens*), suspension in 3,2 mol/l of ammonium sulfate solution, of pH 6 ± 0,1.

The activity of the suspension of β-galactosidase dehydrogenase (EC 1.1.1.48)[5] shall be at least 8 units/ml.

The suspension may be kept for at least 6 months if stored in a refrigerator set at between 0 °C and 5 °C. When using the suspension, the vessel containing the suspension shall be kept immersed in crushed ice.

NOTE A β-galactosidase dehydrogenase suspension which contains not more than 0,01 % each of alcohol dehydrogenase and β-galactosidase, not more than 0,1 % of NADH-oxidase and glucose-reacting enzymes, and not more than 0,5 % of lactate dehydrogenase has been found to be suitable.

4.9 Lactose standard solution, $c(C_{12}H_{22}O_{11}\cdot H_2O)$ = 0,8 mg/ml.

Before use, dry the lactose monohydrate to a constant mass in a drying oven set at 87 °C.

Dissolve 400 mg of dried lactose monohydrate in water. Dilute with water to 500 ml and mix. The solution may be kept for 2 days if stored in a refrigerator set at between 0 °C and 5 °C. Warm the solution to about 20 °C just before use.

5 Apparatus

Usual laboratory equipment and, in particular, the following.

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5.1 Analytical balance, capable of weighing to the nearest 1 mg and a readability to 0,1 mg.

5.2 Glass beakers, of capacities 50 ml, 100 ml and 250 ml.

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5.3 Graduated pipettes, capable of delivering 5 ml and 10 ml, graduated in 0,1 ml divisions.

5.4 Pipettes, capable of delivering 10 ml, 5 ml, 1 ml, 0,2 ml, and 0,05 ml.

5.5 One-mark volumetric flasks, of capacity 100 ml.

5.6 Filter paper, medium grade, of diameter about 15 cm.

5.7 Filter funnels, of diameter about 7 cm.

5.8 Spectrometer, suitable for measuring at 340 nm, equipped with cells of optical path length 1 cm.

5.9 Plastic paddles, suitable for mixing the sample/enzyme mixture in the spectrometer cells.

5.10 Glass rods, of diameter approximately 6 mm and length 150 mm, for macerating the sample.

5.11 Water bath, capable of being maintained at between 20 °C and 25 °C, with rack suitable for holding the spectrometer cells (5.8) (optional; see 7.6).

NOTE Incubation of the cells in the water bath is only necessary if the room temperature is below 20 °C.

5.12 Blending apparatus, suitable for preparing suspensions of test portions of processed cheese (e.g. Ultra Turrax[2)]).

5.13 Drying oven, thermostatically controlled, capable of maintaining a temperature of 87 °C ± 2 °C.

5.14 Grinding or grating device, capable of grinding or grating cheese and of being easily cleaned.

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2) Ultra Turrax is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 5765 | IDF 79 and does not constitute an endorsement by ISO or IDF of this product.

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6 Sampling

Sampling is not part of the method specified in this part of ISO 5765|IDF 79. A recommended sampling method is given in ISO 707.

It is important that the laboratory receive a sample which is truly representative and has not been damaged or changed during transport or storage.

7 Procedure

7.1 Test to check the procedure

7.1.1 Carry out the following test to check the recovery of lactose if one or more of the following conditions apply:

a) if using a new batch of the NAD^+/citrate buffer solution (4.6), the β-galactosidase suspension (4.7) or the β-galactosidase dehydrogenase suspension (4.8),

b) if the NAD^+/citrate buffer solution (4.6) and/or the β-galactosidase suspension (4.7) and/or the β-galactosidase dehydrogenase suspension (4.8) have been stored in a refrigerator for more than 2 weeks without being used;

c) if restarting the analytical work after a period of analytical inactivity;

d) if circumstances justify carrying out such a test.

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7.1.2 Pipette 5,0 ml and 10,0 ml respectively of the lactose standard solution (4.9) in each of two 100 ml volumetric flasks (5.5). Add about 50 ml of water to each flask. Proceed as specified in 7.5 and 7.6.

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7.1.3 Calculate the lactose monohydrate content of the lactose standard solution (4.9) according to equation (3) (see 8.1), but using the following values:

V_3 is the volume of the lactose standard solution (4.9), V_3 = 500 ml;

V_4 is the volume of the lactose standard solution used (7.1.2), V_4 = 5 ml and 10 ml respectively;

V_5 is the total volume of the diluted lactose standard solution (7.1.2), V_5 = 100 ml.

7.1.4 Taking into account the purity of the lactose monohydrate, the recovery obtained for both dilutions (7.1.2) shall be within the range 100 % ± 2 %.

If the recovery is not within this range, check the reagents, the operating technique, the accuracy of the pipettes and the condition of the spectrometer. Take the required action to obtain appropriate results. Repeat the test to check the procedure until satisfactory test results are obtained.

7.2 Preparation of test sample

7.2.1 Dried milk and dried ice-mixes

Transfer the test sample to a container, provided with an airtight lid, of capacity about twice the volume of the sample. Close the container immediately. Mix the sample thoroughly by repeatedly shaking and inverting the container.

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7.2.2 Processed cheese

Remove the rind, smear or mouldy layer of the cheese so as to provide a representative test sample of the cheese as it is usually consumed. Grind or grate the test sample using an appropriate grinding or grating device (5.14). Mix the ground or grated mass quickly and, if possible, grind or grate a second time. Again mix thoroughly. If the test sample cannot be ground or grated, mix it thoroughly by intensive stirring and kneading.

If delay is unavoidable, transfer the test sample to a container, provided with an airtight lid, of capacity about twice the volume of the sample to await analyses. Close the container immediately. Take all precautions to ensure proper preservation of the test sample and to prevent condensation of moisture on the inside surface of the container.

As soon as possible after grinding, grating or stirring and kneading or after the forced delay, transfer the test sample to a 250 ml glass beaker (5.2). Add the same amount of water and form a thorough suspension of the mixture with the blending apparatus (5.12).

7.3 Test portion

Weigh, to the nearest 1 mg, 1 g or more (see below) of the test sample (7.2.1) or test sample suspension (7.2.2) in a 100 ml beaker (5.2). Dissolve or suspend the test portion in at least 20 ml of water preheated to between 40 °C and 50 °C, using a glass rod (5.10) or blending apparatus (5.12) respectively. Transfer the contents of the beaker quantitatively to a 100 ml volumetric flask (5.5). Dilute with water to approximately 60 ml and mix.

Consider the following facts when determining the mass of the test portion to be taken:

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— the test portion should be representative of the complete test sample;

— the content of lactose in the spectrometer cell should preferably be between 5 μg and 100 μg;

— the absorbance (A_2) of the solution in the spectrometer cell, for galactose in the test sample (see 8.1), should lie between 0,1 and 0,4;

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— if the mass fraction of lactose in the sample is less than 0,2 %, more than 1 g of test portion will be required. In that case, the volume of fat, protein and other substances precipitated in 7.5.1 can have a significant influence on the volume of the solution (see V_3 in 8.1).

7.4 Reagent blank test

Carry out a blank test in duplicate. Proceed as specified in 7.5 and 7.6 by using all reagents but omitting the test portion.

7.5 Deproteination

7.5.1 Add, in the following order, to the test solution or suspension (7.3) in the 100 ml one-mark volumetric flask:

— 5,0 ml of potassium hexacyanoferrate(II) solution (4.1),

— 5,0 ml of zinc sulfate solution (4.2), and

— 10,0 ml of sodium hydroxide solution (4.3), while swirling thoroughly after each addition.

Dilute with water to 100 ml mark and mix thoroughly.

Allow the mixture to stand for 30 min. Do not remix the contents of the volumetric flask prior to filtration.

7.5.2 Filter the supernatant liquid through a filter paper (5.6), discarding the first fraction of the filtrate.

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