SPRAY DRIED MILK OF THE SAKHA PLANT

I. QUALITY CONTROL STUDIES

S. M. Taha
Bacteriological Department, College of Agriculture, Ain-Shams University, Cario
AND
Kh. Naguib and S. Abd-el-Ghani
Food Technology and Dairy Research Laboratory, National Research Centre, Dokki, Cairo

(Received for publication January 5, 1971)

Abstract

Fifty samples of freshly spray-dried non-fat milk were taken from the Sakha plant. The quality of this powdered milk was assessed by bacteriological, chemical, and physical tests. Bacterial counts showed the following averages per gram: total viable counts, 13 $\times$ 10^6 at 30 C and 6.8 $\times$ 10^6 at 37 C; thermoduric, 1.6 $\times$ 10^6; psychrophilic, 4.5 $\times$ 10^5; non-pathogenic staphylococci, 4 $\times$ 10^5; Group D streptococci, group I comprising *Streptococcus faecium, Streptococcus durans* and *Streptococcus bovis*, 5.3 $\times$ 10^5 and group II comprising *Streptococcus faecalis* and its varieties *zymogenes* and *liquefaciens*, 9.3 $\times$ 10^4; and coliforms, 64. $\times$ 10^3. Saccharolytic anaerobes were found in 40% of the samples examined while proteolytic anaerobes and β-hemolytic bacteria were not detected. The chemical and physical tests showed the following averages: 1.9% fat, 0.21% acidity, 3.25% moisture, and 1.1 ml solubility index.

Bacteriological, chemical, and physical studies on powdered milk have been carried out by many investigators *(4, 15, 19, 20, 21, 27, 28, 30, 32)* in order to assess the quality of this product. In the U.A.R. it was not until 1962 that a plant for manufacturing dried milk was established at Sakha in Kafr-El-Sheik. The capacity of this plant is 20 tons of whole raw milk per day. As drying milk is a recent industry in our country, no attempt has been made to study the quality of the product. Therefore the present investigation was carried out to study the bacteriological quality, and some chemical and physical properties of this product. Results of this study constitute the material of another paper *(31)*, in addition to the present one.

Type of equipment and processing conditions at the Sakha plant were as follows: *(a)* on reception, milk is filtered and cream separated; *(b)* pasteurization is at 85 C for 15 sec; after rapid cooling to 4 C, milk flows through a balance tank to the pre-heater; *(c)* pre-heating is at 90 C for 20 sec just prior to vacuum concentration; the preheater is equipped with a flow diversion valve; preheated milk is delivered to a small balance tank feeding the vacuum evaporator; *(d)* the pre-heated milk is concentrated to about 40-45% solids by means of a double-effect climbing film evaporator (60 C then 40 C) connected to an indirect barometric condenser and a vacuum pump; *(e)* concentrated milk is withdrawn from the evaporator by pumping, and passes through the atomizer feed tank via a rotating disk atomizer to the spray drying chamber (inlet air 150 C - outlet air 96 C); and *(f)* the resulting powder is discharged from the main chamber and cyclone separators into a conveyor which delivers it to a sifter; The final sifted powder is discharged from sifter outlets into suitable containers.

Materials and Methods

Samples

Fifty samples of spray-dried non-fat milk produced at the Sakha plant were collected aseptically in sterile and tightly closed containers. They were immediately transported to the laboratory where they were tested.

Methods

Samples were examined bacteriologically for total viable counts at 30 and 37 C; thermoduric, psychrophilic, and β-hemolytic bacteria, adopting the methods given in *Standard Method for the Examination of Dairy Products (3)*. Staphylococcus counts were determined on S 110 medium (Difco). Differentiation between the typical colonies of the pathogenic and the non-pathogenic staphylococci was carried out according to Evans *(11)*. Proteolytic anaerobes were detected following the method reported by Mackie and McCartney *(25)*. Saccharolytic anaerobes were determined according to the method described by Chalmers *(9)*. For coliform counts the dilution frequency method (Most Probable Number, MPN) was adopted and the MPN was calculated on the basis of positive tubes using McCrady's Table as indicated in *Standard Methods for the Examination of Dairy Products (3)*. Group D streptococcus counts were determined on the modified thallous acetate tetrazolium glucose agar medium recommended by Barnes *(5)* who divided the streptococcal colonies that would grow on this medium into: Group I: *Streptococcus faecium, Streptococcus durans, Streptococcus bovis,* and a number of unclassified strains and Group II: *Streptococcus faecalis* and its varieties *zymogenes* and *liquefaciens*.

Moisture content and titratable acidity were determined according to the methods given in Richmond's Dairy Chemistry *(35)*. Fat content was estimated using the method given by Ling *(24)*. Solubility index was determined according to the method of Crossley as described by Davis *(10)*.

TABLE 1. BACTERIOLOGICAL ANALYSIS OF SPRAY DRIED MILK POWDER

	No. of positive samples[1]	Incub. temp. C	Minimum	Maximum	Average
Total count	50	30	4×10^5	80×10^6	13×10^6
	50	37	3.2×10^5	70×10^6	6.8×10^6
Thermoduric counts	50	30	3.4×10^4	9×10^6	1.6×10^6
Psychrophilic counts	50	7	3.6×10^4	5×10^6	4.5×10^5
Staphylococcus counts	50	37	3.1×10^4	3×10^6	4×10^5
Coliform counts	10	37	0(not detected)	5.4×10^3	6.4×10^2
Group D streptococcus counts					
group I	50	37	12×10^3	15×10^6	5.3×10^5
group II	47		0(not detected)	4.9×10^5	9.3×10^4

[1]Total samples, 50

RESULTS AND DISCUSSION

Bacteriological analysis (Table 1)

Total viable counts. As seen in Table 1, the total viable counts ranged from 4×10^5 to 80×10^6 with an average of 13×10^6 per gram at 30 C and from 3.2×10^5 to 70×10^6 averaging 6.8×10^6 per gram at 37 C. These results clearly show that incubation at 30 C for 5 days gave higher colony counts than incubation at 37 for 2 days. This confirms the data of Mattick et al. *(27)* and Hiscox *(19)*. These workers attributed this phenomenon to the inability of microbacteria, that occurred most frequently in powdered milk, to grow at 37 C. But as the pre-heating temperature used at the Sakha plant was 90 C, thus surpassing the destructive limits for microbacteria mentioned by Hiscox *(19)*, therefore the difference between the counts at 30 C and 37 C is attributed to the presence of psychrophilic bacteria, detected in high numbers (Table 1), unable to grow at 37 C *(39)*. Other types of micrococci, such as *Micrococcus varians* which has also been found in the samples studied, also are unable to grow at 37 *(2)*.

It is also quite clear that counts obtained in the current work were similar to the findings of Anderson and Stone *(4)* and Hobbs *(20)*. However, they generally were distinctly higher than those reported by other workers *(15, 28, 30)*.

High counts obtained in the current work are attributable to more than one factor, such as the bacteriological quality of the raw milk used *(27)*, and to inadequate plant cleanliness and sterility *(26, 27)*. This is also supported by the findings of Abd-el-Ghani *(1)*. During a three-year study (1967-1970) he obtained average counts of 86×10^6/ml at 30 C and 64×10^6/ml at 37 C for raw milk used for processing at the Sakha plant. He showed that unsatisfactory conditions of cleanliness led to contamination during processing and to the subsequent high counts of the finished product.

Thermoduric counts. Thermoduric counts ranged from 3.4×10^4 to 9×10^6 with an average of 1.6×10^6 per gram. The high thermoduric counts obtained in the present work are probably due to the relatively large numbers of heat-resistant organisms in the raw milk used *(1, 13, 27)* as well as to contamination during processing *(1)*. Inefficient cleaning of condensers and feed tanks were shown to be additional sources of contamination *(12)*

Psychrophilic counts. The psychrophilic counts obtained ranged from 3.6×10^4 to 5×10^6, averaging 4.5×10^5 per gram. Water supply is considered the main source of psychrophilic bacteria in the dairy industry and a second, perhaps more frequently encountered source of contamination, is improperly cleaned equipment and utensils *(40)*. However, since these organisms are destroyed by pasteurization *(9)* and by successive heat treatments during processing, their presence in the fresh dried milk samples examined could only be attributed to contamination after heating. This indicates unsatisfactory sanitary conditions in the plant, particularly lack of efficient cleaning and sanitization of equipment surfaces involved ahead of the drying chamber *(1)*.

Staphylococcus counts. The staphylococcus counts were in the range of 3.1×10^4 and 3×10^6, and averaged 4×10^5 per gram. None of the samples examined revealed the presence of typical colonies of the pathogenic types *(11)*. The presence of colonies of the non-pathogenic types of staphylococci, being non-heat resistant, is due to contamination after processing caused by improper management and cleaning *(18)*.

β-hemolytic bacteria. In none of the fifty samples examined could β-hemolytic non-sporing organisms be detected.

Proteolytic anaerobes. No proteolytic anaerobes were found in any of the samples examined.

Saccharolytic anaerobes. Stormy fermentation was observed in 40% of the samples. Presence of these organisms in dried milk was reported by Mattick et al. *(27)* and Parson and Fraser *(33)*. Saccharolytic anaerobes were derived from raw milk and being in

the highly resistant spore form, they were unaffected by the process of spray-drying *(27, 33)*.

Coliform counts. The coliform counts ranged from 0 (not-detected to 5.4×10^3, with an average of 6.4×10^2 per gram. These organisms were detected in 20% of the samples. Since the isolated coliforms proved to be non-heat resistant strains *(31)*, it can be safely assumed that coliforms initially present in raw milk used for processing were readily destroyed during the manufacturing process *(1, 27)*. Their presence in the dry milk samples examined is therefore due to postheating contamination *(27, 29)*. The same conclusion was arrived at by Abd-el-Ghani *(1)* when evaluating the bacteriological changes occurring at each stage of manufacture of spray-dried milk at the Sakha plant during 1967-1970.

Group D streptococci. Counts of group I organisms ranged from 12×10^3 to 15×10^6 with an average of 5.3×10^5 per gram and those of group II, from 0 (not detected) to 4.9×10^5, averaging 9.3×10^4 per gram. Group I organisms were present in all the samples examined (100%), while those of group II were detected in 94%. The fact that the counts of group I were much higher than the corresponding counts of group II indicates that S. *faecium*, S. *durans*, and S. *bovis*, were present in higher numbers than S. *faecalis* and its varieties. Similar results were reported by Hashimoto *(16)* and Hashimoto et al. *(17)*. The presence of Group D streptococci in spray-dried milk may be due partly to their incidence in raw milk used for processing *(1, 8)*. Because of their relatively high resistance to unfavourable conditions like heat treatment *(38)* and drying *(6)*, they may survive processing. However, recontamination after pasteurization and during processing can not be excluded *(8, 16)*.

Comparing the results regarding Group D streptococci with those of coliforms it is obvious that the counts and numbers of positive samples of the former were much higher than those of the latter. Thus all the samples that revealed presence of coliforms were also positive for Group D streptococci but the reverse was not the case. This could be attributed to the heat treatments used during processing destroying the coliforms but not all the Group D streptococci. This means that negative coliform results in the finished product do not always ensure safety from the hygienic point of view. It also indicates greater accuracy of Group D streptococci as fecal pollution indicators, at least in dried milk. This point of view has been stressed by Larkin et al. *(23)* and Raj et al. *(34)*. Buttiaux *(7)*, in discussing the value of the *Escherichiae* and Group D streptococci as indicators of contamination, regarded Group D streptococci as affording a more sensitive test for fecal contamination of food than the coli-aerogenes bacteria. Taking into consideration the heat stability *(38)* of the former, a character not possessed by the latter, the presence of coliforms will point to post-heating contamination, which is also an important criterion from the hygienic standpoint. Therefore, the presence of Group D streptococci associated with the coli-aerogenes bacteria will justify the diagnosis of fecal contamination in powdered milk.

TABLE 2. PHYSICAL AND CHEMICAL ANALYSIS OF SPRAY-DRIED MILK POWDER

	Minimum	Maximum	Average
Moisture (%)	1.33	5.90	3.25
Solubility index (ml)	0.3	2.5	1.1
Fat (%)	1.30	4.00	1.90
Acidity (%)	0.13	0.23	0.21

Physical and chemical analysis (Table 2)

Moisture content. As seen in Table 2, the moisture content ranged from 1.33 to 5.90% with an average of 3.25%. These results coincide with those reported by Napoli *(32)*.

Solubility index. The solubility index varied from 0.3 to 2.5 ml, averaging 1.1 ml. Similar results were obtained by Ibrahim *(21)*.

Fat content. The fat content ranged from 1.3 to 4%, with an average of 1.9%.

Titratable acidity. The samples examined showed acidity values ranging from 0.13 to 0.23%, averaging 0.21%. Comparing these results with those reported by Gould and Skiver *(14)* it can be seen that the current results were higher. This could be attributed to the low bacteriological quality of raw milk used for processing *(1)*. In this respect, several investigators *(22, 37)* reported mean acidity values of 0.17% and 0.18%, respectively, for locally produced raw milk.

REFERENCES

1. Abd-el-Ghani, S. 1970. Bacteriological changes during the different stages of manufacture of dried milk at Sakha plant. (Unpublished data).

2. Abd-el-Malek, Y., and T. Gibson. 1948. Studies in the bacteriology of milk. II. The staphylococci and micrococci of milk. J. Dairy Res. 15:249-260.

3. American Public Health Association. 1960. Standard methods for the examination of dairy products. 11th ed. Amer. Public Health Ass., Inc., New York.

4. Anderson, B. H. R., and D. M. Stone. 1955. Staphylococcal food poisoning associated with spray dried milk. J. Hyg. Camb. 53:387-397.

5. Barnes, E. M. 1956. Methods for the isolation of faecal streptococci (Lancefield Group D) from bacon factories. J. Appl. Bacteriol. 19:193-203.

6. Barnes, E. M. 1959. Differential and selective media for the faecal streptococci. J. Sci. Food Agr. 10:656-662.

7. Buttiaux, R. 1959. The value of the association *Escherichia*-Group D streptococci in the diagnosis of contamination in foods. J. Appl. Bacteriol 22:153-158.

8.Buttiaux, R., and D. A. A. Mossel. 1961. The significance of various organisms of faecal origin in foods and drinking water. J. Appl. Bacteriol. 24:353-364.

9. Chalmers, C. H. 1955. Bacteria in relation to the milk supply, 4th ed., Edward Arnold Ltd. London. 309 p.

10. Davis, P. 1962. The chemical analysis of foods. Originally written by H. E. Cox, 5th ed., J. and A. Churchill Ltd., London.

11. Evans, J. B. 1948. Studies of staphylococci with special reference to the coagulase-positive types. J. Bacteriol. 55:793-800.

12. Foster, E. M., F. E. Nelson, M. L. Speck, R. N. Doetsch, and J. C. Olson, Jr. 1958. Dairy microbiology MacMillan and Co. Ltd., London. 492 p.

13. Galesloot, Th. E., and J. Stadhouders. 1968. The microbiology of spray-dried milk products with special reference to *Staphylococcus aureus* and salmonellae. Neth. Milk Dairy J. 22:158-172.

14. Gould, I. A., and F. M. Skiver. 1945. Lactic acid and titratable acidity of commercial dried and evaporated milk in Michigan. Quart. Bull. Mich. Agr. Exp. Sta. 27:360-364. (Dairy Sci. Abstr. 7:140; 1945).

15. Hall, H. E., D. F. Brown, and H. M. Robinson. 1967. Bacteriological examination of Grade A dry milk powder. J. Milk Food Technol. 30:219-221.

16. Hashimoto, H. 1961. Hygienic studies on enterococcus group in milk, meat and their products, especially on significance as an indicator of pollution. J. Fac. Fish. Animal Husb., Hiroshima Univ. 3:503-566.

17. Hashimoto, H., I. Itah, S. Ishidi, and M. Kawaguchi. 1964. Studies on enterococcus group in market milk and dried milk. II. Identification of enterococcus group isolated from market milk and dried milk. J. Food Hyg. Soc. Japan 5:415-419.

18. Hawley, H. B., and Margaret, I. W. Benjamin. 1955. Public health problems associated with the manufacture of dried milk. II. Prevention of contamination during manufacture. J. Appl. Bacteriol. 18:493-502.

19. Hiscox, E. R. 1945. The effect of the method of reconstitution and of the temperature of incubation on the plate count of spray dried milk powder. J. Dairy Res. 14: 175-183.

20. Hobbs, B. C. 1955. Public health problems associated with the manufacture of dried milk. I. Staphylococcal food poisoning. J. Appl. Bacteriol. 18:484-492.

21. Ibrahim, S. S. 1966. Studies on drying of milk. M. Sc. Thesis, Food Technol. and Dairy Dep., Fac. Agric., Ain Shams Univ., Cairo, Egypt.

22. Khorshid, M. A. 1964. Studies on some physical and physico-chemical properties of Egyptian buffalo and cow milk. M.Sc. Thesis. Food Technol. and Dairy Dep., Fac. Agric., Ain Shams Univ., Cairo, Egypt.

23. Larkin, E. P., W. Litsky, and J. E. Fuller. 1955. Fecal streptococci in frozen foods. I. A. bacteriological survey of some commercially frozen foods. Appl. Microbiol. 3:98-101.

24. Ling, E. R. 1956. A text book of dairy chemistry. Part II. Practical, 3rd ed. Chapman and Hall Ltd., London. 140 p.

25. Mackie, T. J., and J. E. McCartney. 1956. Handbook of practical bacteriology. 9th ed. E. and S. Livingstone Ltd., Edinburg and London.

26. Maleszenski. J. 1961. Causes of discrepancies in the results of microbiological analyses of dried milk. Przeg. Mleez 9:24-26. (Dairy Sci. Abstr. 25:1752; 1963).

27. Mattick, A. T. R., E. R. Hiscox, and E. L. Crossley. 1945. The effect of temperature of pre-heating, of clarification and bacteriological quality of the raw milk on the keeping properties of whole milk powder dried by the Kestner spray process. Part II. The effect of the various factors upon the bacterial (plate) count of the intermediate products and of the final powder. J. Dairy Res. 14:135-144.

28. McDivitt, M. E., P. P. Huppler, and A. M. Swanson. 1964. Bacteriological changes during the manufacture of nonfat dry milk. J. Dairy Sci. 47:936-941.

29. Mossel, D. A. A. 1956. Aufgaben und Durchführung der modernen hygienisch-bakteriologischen Lebensmittelüberwachung. Wien. tierärzt. Wschr. 43:321, 596.

30. Mull, L. E., and K. L. Smith. 1965. Some observations on the bacterial quality of instant non-fat dry milk in consumer packages. J. Milk Food Technol. 28:188-191.

31. Naguib, Kh., S. M. Taha, and S. Abd-el-Ghani. 1972. Spray dried milk of the Sakha plant. II. Identification of predominating micro-organisms J. Milk Food Technol. (*In press*)

32. Napoli, I., A. Canuti, and F. Salvadori. 1959. Analysis of dry skim milk. Latte 33:89-92. (Dairy Sci. Abstr. 22:570, 1960).

33. Parsons, A. T., and J. R. Fraser. 1951. The bacteriological quality of national dried milk. J. Dairy Res. 18: 34-42.

34. Raj, H., W. J. Wiebe, and J. Liston. 1961. Detection and enumeration of fecal indicator organisms in frozen sea foods. II. Enterococci. Appl. Microbiol. 9:295-303.

35. Richmond's dairy chemistry. 1953. Revised by J. G. Davis and F. J. Macdonald, 5th ed., Charles Griffen and Co. Ltd., London. 560 p.

36. Richter, B. 1959. Examination of dried milk. Mh. Vet. Med. 14:612-615. (Dairy Sci. Abstr. 23:3555; 1961).

37. Sayed-Ahmed, Nawal. 1963. Comparison of the rate of acid development in buffalo and cow milk. M.Sc. Thesis. Food Technol. and Dairy Dept., Fac. Agric., Ain-Shams Univ., Cairo.

38. Shattock, P. M. F. 1955. The identification and classification of *Streptococcus faecalis* and some associated streptococci. Ann. Inst. Pasteur Lille. 7:95-100.

39. Thomas, S. B., D. Ellison, D. G. Griffiths, E. Jenkins, and K. J. Morgan. 1950. Heat resistant bacteria in raw milk. Part I. Comparison of thermoduric colony counts on yeastrel milk agar incubated for 2 days at 37 C and 4 days at 30 C. J. Soc. Dairy Technol. 3:187-190.

40. Witter, L. D. 1961. Psychrophilic bacteria. A review J. Dairy Sci. 14:983-1015.

NATIONAL RESTAURANT ASSOCIATION

(Continued from Page 34)

The NRA and its individual members work cooperatively with public health officials, organizations concerned with the health and welfare of our citizens and with other groups concerned with food sanitation to develop and improve procedures, the use of which will result in the foodservice industry maintaining a high level of sanitation excellence.

As part of its ongoing program of assistance to the foodservice operator, the Association develops and distributes booklets, charts and audio-visual programs for foodservice employees on the subjects of food pro-

(Continued on Page 44)