



**THE USE OF GAMMA RAY TO UTILIZE SOME DAIRY  
INDUSTRY WASTES**

BY

**SAMIR AHMED MELIGY MOHAMMED**

B.Sc. Agric. Sci. (Food Sci. & Tech.), Ain Shams University, 1984

M. Sc. Agric. Sci. (Dairy Sci. & Tech.), Ain Shams University, 1992



A thesis submitted in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy

In

Agricultural Science  
(Dairy Science & Technology)

Department of Food Science  
Faculty of Agriculture  
Ain Shams University



1999





## Approval sheet

### THE USE OF GAMMA RAY TO UTILIZE SOME DAIRY INDUSTRY WASTES

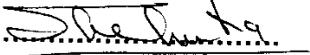
BY

**SAMIR AHMED MELIGY MOHAMMED**

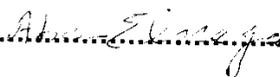
B.Sc. Agric. Sci. (Food Sci. & Tech.), Ain Shams University, 1984

M. Sc. Agric. Sci. (Dairy Sci. & Tech.), Ain Shams University, 1992

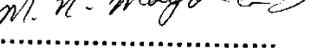
This thesis for Ph. D. degree has been approved by:

**Prof. Dr. ABDO. E. SHEHATA** 

Professor of Dairy Microbiology, and Dean, Fac. Agric. ,  
Ain Shams University.

**Prof. Dr. I. G. ABO- EL- NAGA** 

Professor of Dairy Microbiology & Technology  
Fac. Agric.,- Assuit University.

**Prof. Dr. M. N. I. MAGDOUB** 

Professor of Dairy Microbiology & Technology  
Fac. Agric.,- Ain Shams University.

Date of Examination: 25 / 8 / 1999





## **THE USE OF GAMMA RAY TO UTILIZE SOME DAIRY INDUSTRY WASTES**

**BY**

**SAMIR AHMED MELIGY MOHAMMED**

B.Sc. Agric. Sci. (Food Sci. & Tech.), Ain Shams University, 1984

M. Sc. Agric. Sci. (Dairy Sci. & Tech.), Ain Shams University, 1992

### **Under The Supervision Of:**

**Prof. Dr. M. N. I. EI-MAGDOUB**

Professor of Dairy Microbiology & Technology

Fac. Agric., Ain Shams University.

**Prof. Dr. E. O. FAYED**

Professor of Dairy Microbiology and Technology

Fac. Agric., Ain Shams University.

**Prof. Dr. A. A. I. HAMMAD**

Professor and Head of Irradiation Microbiology

Dept., NCRRT; Cairo.



## **Acknowledgments**

The words of thanks and gratefulness are not enough to express my deep gratitude, and sincere appreciation to **Prof. Dr. M. N. I. MAGDOUB**, Professor of Dairy Microbiology and Technology, **Prof. Dr. E. O. FAYED** Professor of Dairy Microbiology and Technology; Ain Shams University and **Prof. Dr. A. A. I. HAMMAD** Professor and Head of Irradiation Microbiology Department, National Center for Radiation Research and Technology (**NCRRT**).

Great appreciations would be expressed to the staff members and my colleagues in **Cairo MIRCEN** and Food Science Department Faculty of Agriculture, Ain Shams University, as well as at the Irradiation Microbiology Department, (**NCRRT**).



## Abstract

**Samir Ahmed Meligy. The use of gamma ray to utilize some dairy industry wastes. Unpublished Ph.D.thesis. Food Science Department, Faculty of Agriculture, Ain Shams University, 1999.**

Waste disposal of dairy industry has many economic and environmental burdens. Therefore, the workplan was undertaken to gain optimum fermentation condition for gellan gum production by *Sphingomonas paucimobilis* EMCC 2011 growing in milk permeate. This was implemented through four main parts.

The first part was performed to achieve an ample fermentation protocol. The highest production of gellan gum (11.2 g/L) with high viscosity in milk permeate by EMCC 2011 strain was achieved with initial pH of 7.0, inoculum level of 15%, agitation rate of 150 rpm and incubation at 30°C for 60 hr. Supplementation of milk permeate with 0.5 g/L MgSO<sub>4</sub>, 3.0g/L KH<sub>2</sub>PO<sub>4</sub> and 3.0 g/L yeast extract, increased the production of gellan gum to 13.5 g/L. With gamma irradiated (0.25 kGy) strain EMCC 2011, gellan gum production was increased to 14.75 g/L. Presence of 0.5 g/L triton x-100 in the fermentation medium increased gellan gum production, being 15.94 g/L. Scale-up the achieved fermentation protocol using immobilized irradiated cells, in a 5 liter fermentor, obviously increased the total yield of gellan gum. The overall rheological parameters reveal the similarity of both the standard gellan and the produced one. This study indicates that gellan gum could be locally produced at economical costs. Besides, the use of milk permeate as a bacterial growth medium markedly reduced the BOD<sub>5</sub> of milk permeate before drainage. High quality yoghurt and ice cream with preferable texture and consistency, were produced with adding gellan as a stabilizing agent to the milk used for making yoghurt and to the ice cream mix by the rates of 0.05% and 0.1%, respectively.

**Key words:** gellan gum - milk permeate- *Sphingomonas paucimobilis*- growth promoters- gamma irradiation - surfactants- sponge immobilization.



## Contents

	<b>Page</b>
1. Introduction-----	<b>1</b>
2. Review of Literature-----	<b>3</b>
2.1. Microbial fermentation of whey and permeate-----	<b>3</b>
2.2. Microbial polysaccharides-----	<b>4</b>
2.3. Appropriate conditions for polysaccharides production-----	<b>9</b>
2.3.1. Nutritional factors-----	<b>9</b>
2.3.1.1. Nitrogen source-----	<b>9</b>
2.3.1.2. Carbon source-----	<b>11</b>
2.3.2. Promoters-----	<b>13</b>
2.3.2.1. Minerals-----	<b>13</b>
2.3.2.2. Surfactants-----	<b>15</b>
2.3.3. Propagation conditions-----	<b>15</b>
2.3.3.1 .Incubation temperature-----	<b>15</b>
2.3.3.2. Agitation-----	<b>17</b>
2.3.3.3. Inoculum volume-----	<b>18</b>
2.3.3.4. pH-----	<b>18</b>
2.4. Polysaccharides in dairy industry-----	<b>20</b>
2.4.1. Yoghurt-----	<b>24</b>
2.4.2. Ice cream-----	<b>27</b>
2.5. Gellan gum-----	<b>30</b>
2.5.1. Production-----	<b>30</b>
2.5.2. Properties and nature -----	<b>35</b>
2.5.3. Application -----	<b>39</b>
2.6. Gamma irradiation-----	<b>43</b>
2.6.1. Radiation resistance ( $D_{10}$ )-----	<b>43</b>
2.6.2. Effect on fermentation Process-----	<b>46</b>

3. Materials and Methods-----	48
3.1. Materials-----	48
3.1.1. Bacterial Cultures-----	48
3.1.1.1. Gellan producing strain-----	48
3.1.1.2. Yoghurt culture-----	48
3.1.2. Media-----	48
3.1.2.1. Growth and preservation media-----	48
3.1.2.2. Production media-----	48
3.1.2.2.1. Standard medium (SM)-----	48
3.1.2.2.2. Modified standard medium (MSM)-----	48
3.1.2.2.3. Standard fermentation medium (SFM)-----	49
3.1.3. Standard culture-----	49
3.1.4. Additives-----	49
3.1.5. Irradiation efferent-----	50
3.1.6. Raw milk-----	50
3.2. Experimental Procedures-----	50
3.2.1. Strain productivity-----	50
3.2.1.1. Growth curve-----	50
3.2.1.2. Productivity-----	51
3.2.2. Maximization of productivity-----	51
3.2.2.1. Fermentation conditions-----	51
3.2.2.2. Growth promoters-----	53
3.2.2.3. Irradiation-----	53
3.2.2.3.1. D <sub>10</sub> - value-----	53
3.2.2.3.2. Strain productivity-----	54
3.2.2.4. Surfactants-----	56
3.2.3. Cell immobilization-----	56
3.2.4. Fermentation by Immobilized cells-----	56
3.2.5. Utilization of Gellan in dairy products-----	57
3.2.5.1. Yoghurt-----	57

3.2.5.2. Ice cream-----	58
3.3. Methods of analysis-----	58
3.3.1. Fermentation process-----	58
3.3.1.1. Growth curve-----	58
3.3.1.2. Biomass dry weight-----	58
3.3.1.3. Gellan gum yield-----	59
3.3.1.4. Lactose content-----	59
3.3.1.5. Biochemical Oxygen Demand-----	59
3.3.1.6. Viscosity-----	59
3.3.1.7. D <sub>10</sub> - Values-----	59
3.3.2. Rheological parameters-----	60
3.3.3. Yoghurt-----	61
3.3.3.1. Titratable acidity and pH value-----	61
3.3.3.2. Lactobacilli count-----	61
3.3.3.3. Streptococci count-----	61
3.3.3.4. Coliform count-----	61
3.3.3.5. Yeast and Mould count-----	61
3.3.3.6. Rate of curd syneresis-----	61
3.3.3.7. Viscosity-----	61
3.3.3.8. Sensory evaluation-----	61
3.3.4. Ice cream mix-----	62
3.3.4.1. Titratable acidity-----	62
3.3.4.2. pH value-----	62
3.3.4.3. Specific gravity-----	62
3.3.4.4. Weight per gallon-----	62
3.3.4.5. Viscosity-----	62
3.3.4.6. Freezing point-----	62
3.3.5. Ice cream.-----	63
3.3.5.1. Specific gravity-----	63
3.3.5.2. Weight per gallon-----	63

3.3.5.3. Overrun-----	63
3.3.5.4. Melting resistance-----	63
3.3.5.5. Sensory evaluation-----	63
3.3.4.6. Total viable count-----	63
3.3.5.7. Coliforms count-----	64
3.3.5.8. Detection of Salmonella-----	64
3.3.5.9. Staphylococci count-----	64
3.3.5.10. Psychrotrophic bacterial count-----	64
3.3.6. Statistical analysis-----	64
4. Results and Discussion.-----	65
Part (1): Achieving ample fermentation protocol-----	65
Section (A). Growth intensity and productivity-----	65
1. Growth intensity-----	65
2. Productivity-----	73
Section (B).Optimization of fermentation conditions-----	85
Section (C). Adding growth promoters.-----	108
Section (D). Gamma irradiation-----	117
Section (E). Surfactants-----	122
PART(2). Scale- Up fermentation process-----	129
PART(3). Evaluating properties of gellan gum.-----	132
PART(4).Application of Gellan gum in some dairy products-----	135
Section (A). Yoghurt-----	135
1. Microbial properties-----	135
2. Titratable acidity and pH-----	137
2.1. Titratable acidity-----	137
2.2. pH values-----	139
3. Viscosity-----	139
4. Curd syneresis rate-----	140
5. Sensory properties-----	142