

**Central Department of Food Technology  
Central Campus of Technology  
Dharan**

**Prerequisite Bridge Course for M. Tech Food Technology Study**

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**Course Structure**

Duration: 1 year

1. Food Chemistry	100
2. Principle of Food Processing	100
3. Food Engineering	100
4. Basic and Food Microbiology	100
5. Biochemistry and Human Nutrition	50
6. Food Analysis and Quality Control	50

**Total 500 marks**

Duration: 1 year

## FOOD CHEMISTRY

**Full Marks: 100**

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|--|----|
| 1. Introduction to chemical composition of Food.   | 3  |
| 2. Classification, physical and chemical properties of food carbohydrates, monosaccharides (chemistry of glucose and fructose only), glyucose syrup (corn syrup)- general properties, manufacture (both acidic and enzymatic) and its industrial application general review of fructose, mannose and others.<br>Diasccharides: General comparative studies of sucrose, maltose, lactose and other related compounds. | 24 |
| Polysaccharides: Detailed study of starch (physical, chemical properties, industrial uses), general properties of cellulose, hemicellulose and crude fibres, chemistry of glycogen and gums.   | 16 |
| 3. Proteins: Occurrence, physical and chemical properties, peptide bond, amino acid, classification of proteins, their properties and determination of protein.  | 7  |
| 4. examples of Food protein (comparative studies of milk, meat and wheat proteins).  | 2  |
| 5. Lipids: Definition, occurrence & composition, fatty acids, fats & their physical & chemical properties, identification of natural fats & oils, manufacture of edible oil, hydrogenation. Rancidity- different types of rancidity and antioxidants. Brief discussion on salad, cooking and frying oils, shortening and margarine.  | 16 |
| 6. Pectic substances: Occurrence, structure, pectolytic enzymes, use of pectin as a jellifying agent, theories of gel formation, coagulation & cloud stability, use of pectin in food.   | 6  |
| 7. Minerals in food: Their biochemical function and composition, method of their determination- Ca, Fe, K, Na etc.   | 6  |
| 8. Vitamins in Foods: Occurrence, structure and their importance, effect of processing on vitamins.  | 6  |
| 9. Natural pigments in foods: brief chemistry of chlorophylls, carotenoids, and anthocyanins. Effect of processing and cooking.  | 8  |
| 10. Chemistry of natural food colourants such as turmeric, caramel and annatto.  | 2  |
| 11. Moisture in foods: types and chemistry, hydrogen bonding, bound water, free water, water activity, methods of moisture determination.  | 6  |
| 12. Food additives: Synthetic colour, flavour intensifiers-monosodium glutamate. Emulsifier. Artificial sweeteners (succharin, cyclamates).  | 8  |
| 13. Browning in food: Nonenzymatic browning-maillard's reaction, ascorbic acid oxidation, caramelization browning mechanism, methods of preventing browning.<br>Enzymatic browning: Mechanism, methods of prevention.  | 10 |

### **Practicals:**

1. Proximate analysis of food - determination of moisture, carbohydrate, crude protein, ash, crude fibre and fat.
2. Determination of acidity and pH of food materials.
3. Quantitative test for protein- Formal titration & kjeldahl method.
4. Carbohydrates: Estimation of reducing sugar, estimation of starch by hydrolysis.
5. Oil & fats: Determination of acid value, saponification value, iodine value, peroxide value. R.M. value, K value.
6. Estimation of ascorbic acid.
7. Estimation of minerals: Ca and Fe.

***Textbooks:***

1. Lillian Hozland Mayer. Food chemistry.
2. Owen and Fennema. Principle of food science- food chemistry.
3. Prank A Lee. Basic food chemistry.
4. J.L. Jain. Fundamental of Biochemistry.
5. Z. Berk. Brareman's introduction to biochemistry of food.
6. G.G. Birch. Sugar- science and technology.
7. Glucose syrup.
8. BS Bahl. Organic chemistry.

## Principle of Food Processing

**Full Marks: 100**

- |   |    |
|---|----|
| 1. Introduction, historical development of food preservation.   | 4  |
| 2. Deterioration and spoilage of foods: Definition, factors, control.   | 4  |
| 3. Post harvest operations: cleaning, storage and grading, peeling, trimming and blanching.   |    |
| 4. Hurdles concept of food preservation.  | 6  |
| 5. Food preservation by dehydration: principle, moisture content vs $a_w$ , dehydration process, drying equipments.   | 15 |
| 6. Food preservation by high temperatures: principle, pH classification of foods, pasteurization, canning, thermobacteriology, canning process, aseptic processing, spoilage of canned foods.   | 16 |
| 7. Preservation of fresh produces: principle, cellar storage, chilling storage, gas storage (MAS, MAP, CAS), freezing, freezing curve, ice crystal formation, freezing methods, freezing equipments, calculation of ton of refrigeration. | 15 |
| 8. Food preservation by preservatives: introduction, chemical, natural and biopreservatives.  | 10 |
| 9. Radiation preservation of foods: introduction, definition of units and terms, dose and dosimetry mode of action, radiation source, applications, merits and demerits of irradiation.   | 10 |
| 10. Principle of food concentrates (jam, jelly, preserves), pectin  | 4  |
| 11. Principle of food fermentation: Principle, importance, types fermented foods (wine, vinegar, beer, pickle).   | 6  |
| 12. Non-conventional methods of food preservation. Introduction to high hydrostatic pressure, high intensity pulsed electric fields etc.  | 4  |
| 13. Traditional and indigenous methods of food preservation.  | 4  |
| 14. Rice and wheat: Chemical composition; brief outline of milling process  | 6  |
| 15. Bread and biscuits: Manufacturing process (brief) and composition   | 6  |
| 16. Technology of tea, coffee and spices (ginger, large cardamom and turmeric) processing   | 6  |
| 17. Fruit juice beverages: Fruit juices, squash, cordials, nectars  | 4  |

### **Practicals:**

1. Preparation and measurement of brines and syrups.
2. Test of adequacy of blanching.
3. Dehydration of different fruits and vegetables.
4. Canning fruits, vegetables and meat.
5. Preparation of squash.
6. Preparation jam, jelly and marmalade.
7. Preparation of wine, brandy and pickles.
8. Freezing of foods.
9. Calculation of processing time (F value).
10. Visits of neighbouring food processing factories.
11. A survey of traditional and indigenous methods of food preservation.
12. Preparation of breads and biscuits
23. Milling of rice and wheat

***Textbooks:***

1. Desrosier, N.W. and Desrosier, J.N. (1987). The technology of food preservation, 4<sup>th</sup> edn. CBS Pub. Dist, India.
2. Lal G. Siddappa, G.S. and Tendor, G.L. (1998). Preservation of fruits and vegetables, ICAR, New Delhi, India.
3. Potter, N.P. (1987). Food Science, 3<sup>rd</sup> Edn. CBS pub, Dist, India.
4. Fellows, P.J. (1990). Food processing Technology- Principles and Practice, Ellice Horwood Ltd. UK.
5. Kharel, G.P. Principles of Food Preservation, (in press).
6. Rahman, M.S. (1999). Handbook of Food Preservation, Marcel Dekkar, Inc. NY.

## Food Engineering (unit operations and process engineering)

**Full Marks: 100**

### **Part A: Unit Operation:**

1. *Concept of unit operation:* 4
  - (a) mass balance (b) heat balance (c) importance and examples of mass and heat balances in food processing operations.
  
2. *Fluid flow:* 2
  - (a) Fluid pressure: relation between absolute pressure, gauge pressure and vacuum, fundamental equation of hydrostatics, measurement of pressure difference, manometers. 0 2
  - (b) Steady Fluid Flow: 3  
continuity equation, Bernoulli's eq<sup>n</sup> and its application (at least two examples).
  - (c) Flow patterns: 4  
Laminar and turbulent flow, Reynold number, flow measuring equipments (venturi meter, orifice meter, pitot tube and rotameters).
  - (d) Flow of Fluids in tubes: 4  
concept of viscosity, Newtonian and non-Newtonian fluids, velocity profile, friction factors (Fannig's and Darcy), use of Moody's diagram.
  - (e) Head losses: 4  
Head losses in tube flow, head loss in bends, joint expansions, joint contractions, valves, loss coefficients.
  - (f) Transportation of fluids: 4  
Structure and working principle of centrifugal and gear pumps, selection of pumps.
  
3. *Heat transfer:* 6
  - (a) Conduction: Fourier's law, thermal conductivities, heat transfer through a slab and cylinder, resistances in series. Introduction to unsteady state conduction, thermal diffusivities, Biot and Fourier numbers. 6
  - (b) Convection: 6  
Natural and forced convection, surface heat transfer coefficients, overall heat transfer coefficient, dimensionless numbers and their applications, heat transfer through boiling liquids and condensing vapours ( Introduction only
  - (c) Heat Exchangers: 6  
Shell and tube heat exchangers (single shell pass and multi tube passes), LMTD, NTU, NTU analysis, parallel flow and counter flow heat exchangers, fouling factors, plate heat exchanger, design of shell and tube exchangers.
  
4. *Evaporation:* 6  
Boling point elevation, structure and working principle of central circulating evaporators, climbing and falling film evaporators, mass balance, heat balance relation between feed temperature and live steam consumed, single effect and multi-effect evaporation, accessories of an evaporator.

5. *Distillation:*

- (a) Vapour- liquid relationship, Rault's law, boiling point diagram (t-x-y graph and x-y graph) of binary mixtures. 3
- (b) Batch distillation. 2
- (c) Rectification: rectification column, and its accessories (condensers, reboilers etc working principle of rectification column, equation of operating lines, effect of feed temperature, calculation of ideal plate numbers (McCabe- Thiele diagram, Lewis method, minimum reflux method), calculation of column diameter. 6

6. *Drying:*

- (a) Psychrometry: dry bulb and wet bulb temperatures, humidity and relative humidity, dew point specific weight and specific volume, enthalpy, application of psychrometric chart in drying. 3
- (b) Mass balance, equilibrium moisture, critical moisture, drying curve, drying rate curve, calculation of drying rate and drying time. The drying models (characteristic drying curve and moisture diffusivity). 6
- (c) Dryers: Tray dryer, tunnel dryer, drum dryer, spray dryer, fluidized bed dryer, uses of dryers in food industry. 5

7. *Crystallization:*

Basic principle of crystallization, super solubility, nucleation and growth rate, factors affecting the growth rate, mass balance, energy balance, draft-tube baffle and vacuum crystallizers.

8. *Separation techniques:*

- (a) Filtration: Theory of filtration, constant rate and constant volume filtration, plate and frame filter press and its design, rotary vacuum filter. 4
- (b) Sedimentation: Terminal velocity, drag coefficient, free and hindered settling thickeners (working principle and design of thickner). Centrifugal separation, working principle of centrifugal separator and its application in food industry (cream separator as an example). 4

9. *Size Reduction:*

Rittinger, Kick and Bond's laws, equipments for size reduction (Jaw crusher, Gyratory crushers, roll crushers, hammer mill, pin and disk mill, ball mill). Sieve analysis, standard sieves, particle size and its distribution, cut off diameter, fineness modulus, uniformity index. 6

10. *Mixing:*

- (a) Homogeneity of mixing, mechanism of mixing, rate of mixing, energy consumption. 2
- (b) Liquid-liquid, solid –liquid and solid-solid mixing, homogenization (example: homogenizer in dairy industries). 2

11. *Conveying :*

introduction to belt conveyer, bucket elevator, screw conveyer, pneumatic conveyor and their application in food industries. 2

**Part –B: Process Engineering:**

12. *Process design development:*

Design: project producer, types of designs, feasibility survey, process development design, construction and operation, flow diagrams, the preliminary design,



equipment design and selection economics, comparison of different processes, equipment design and specifications, scale-up in design, safety factors.	6
13. <i>General design considerations:</i> Plant location, plant layout, preparation of lay out, plant operation and control, utilities structural design storage.	4
14. <i>Optimum design and design strategy:</i> General procedure for determining optimum conditions, comparison of graphical and analytical methods, break even chart for production schedule and its significance for optimum analysis, optimum conditions in cyclic operations. Accuracy and sensitivity of results (heat transfer and mass transfer). The strategy of linearization for optimization analysis, other mathematical techniques and strategies for establishing optimum conditions.	20

### ***Practicals (Lab)***

1. Mass and energy balance: evaporation, distillation and drying.
2. Determination of Newtonian viscosity using Canon-Fenske capillary viscometer, tube flow viscometer and Brookfield viscometer.
3. Determination of Reynolds's number using tube flow viscometer.
4. Measurement of outflow using venturimeter, orificemeter, Vane and hotwire anemometer.
  - (a) Evaluation of pump performance (brake horsepower, efficiency and head loss) of centrifugal and gear pumps.
  - (b) workshop practice: motors, valves, fittings, pumps etc.
5. Determination of thermal conductivity, thermal diffusivity and specific heat capacity of food materials. Determine surface heat transfer coefficient through unsteady (lumped method) heat transfer.
6. (a) Comparative study of countercurrent and parallel heat exchangers. Determine overall heat transfer coefficient and LMTD of the exchanger system.
  - (b) Study of plate heat exchanger Study of central circulating, climbing and falling film evaporators. Study of boiling point elevation.
7. (a) Determination of ideal plate (column) numbers by Lewis and McCabe Thiele method.
  - (b) Study of rectification column.
8. (a) Drying of grains, correlation between temperature ratio and time.
  - (b) Determination of characteristic drying and drying rate curve for pasty foods.
  - (c) Production SMP & WMP in a pilot scale spray dryer and determination of (%) product recovery.
9. Study of constant rate and constant pressure filtration in a plate and frame filter press.
10. Study of centrifugal separators (cream separator), separation efficiency.
11. Determination of terminal velocity and drag coefficient during unhindered settling.
12. Study of pin and disk, hammer and roller mills. Particle size distribution.
13. Study of belt, chain, screw, bucket and pneumatic conveyers.
14. Layout of food plants.
15. Construction and establishment of food plants (Project work).

***Textbooks:***

1. McCabe, W.L., Smith, J.C, and Harriot, P. Unit operations of chemical engineering.
2. Geankophis, C.J. Transport Processes and Unit Operations.
3. Toledo, R.T. Fundamentals of Food Process Engineering.
4. Rizvi, SSH. And Mittal, G.S. Experimental Methods in Food Engineering.
5. Heldman. D.R. and Singh, R.P. Food Process Engineering, 3<sup>rd</sup> Edition.
6. Sahay, K.M. and Singh, K.K. Unit Operations of Agricultural Processing.
7. Peters, M.S. and Timmerhaus, K.D. Plant Design and Economics for Chemical Engineering.
8. Holman, J.P. Heat Transfer.

## BASIC AND FOOD MICROBIOLOGY

**Full Marks: 100**

1. Introduction & scope of microbiological science.	4
2. Use of different types of microscope.	5
3. Morphology, reproduction and cytology of bacteria, yeast, mould, Rickettsia, virus & protozoa.	12
4. Nomenclature, classification, diagnostic features of major groups.	8
5. Physical and chemical factors influencing the control of microorganisms including thermal death time, Z, F and D value.	10
6. General principal and application of serology and immunology.	8
7. Bacterial nutrition and metabolism.	10
8. Growth, reproduction, transformation, conjugation, transaction, mutation and spore formation of microorganism and study of growth curve.	18
9. Microbiology of meat and meat products, milk and milk products, fruits and vegetables and their products, cereals and their products, egg and egg products, spices and food additives.	25
10. Principles of food plant sanitation.	4
11. Food contamination, infections, intoxication and mycotoxin.	10

### ***Practicals:***

1. Microscopy and micrometry.
2. Cleaning and sterilization of glasswares.
3. Preparation of nutrient media and technique of inoculation.
4. Staining techniques:- (a) Monochrome staining (b) Negative staining (c) Gram staining.
5. Isolation of pure culture.
6. Identification of bacteria: (a) Culture characteristics (b) Morphological characteristics, (c) Agglutination test for Salmonella, (d) Biochemical characteristics (e) Acid and gas production from sugar (f) Starch hydrolysis (g) IMVIC test (h) Gelatine liquifacation, (i) Hydrolysis (j) Catalase test.
7. Anaerobic culture method.
8. Growth characteristics of bacteria: a) Direct and plate count method b) Generation time (c) Factors influencing- (pH, temp., acid, sugar, and salt etc) the growth of microorganisms, examination of moulds important in foods.
9. Microbiological examination of water, sugar, spice, salt, different types of fresh and processed foods.
10. Microbiological examination of tablewares and kitchenwares.
11. Microbial examination of meat and milk products.

***Textbooks:***

1. W.C. Frazier & D.C. Westhoff. Food Microbiology. Tata Mcgraw Hill publishing company Ltd. New Delhi.
2. James M. Jay. Modern Food Microbiology. CBS publisher and Distributors, NewDelhi.
3. Pelczar, Reid & Chan. Microbiology. Tata McGraw Hill publishing, New Delhi.
4. Thomas D. Brock and Modigan. Biology of Microorganisms.

***Reference Books:***

1. M.R.Adams & M.O. Moss. Food Microbiology. New age international (P) Ltd. Publisher New Delhi.
2. R.K. Robinson. Dairy Microbiology Vol.-I, II. Elsevier Applied Science Publishers, London.
3. M.H. Brown. Meat Microbiology. Elsevier Applied Science Publishers, London.
4. Betty C. Hobbs. Food Poisoning and Food Hygiene.

***Practical Books:***

1. W.T. Harrigan & Margaret E. Mccance. Laboratory Methods in Food and Dairy Microbiology.
2. S.P. Gupta. Laboratory Methods in Food and Dairy Microbiology. Academic Press, London.
3. Association of official Analytical Chemists. Bacteriological Analytical Manual, 7<sup>th</sup> edn.
4. Maheswari & Dubey. Practical Microbiology. Tata MacGraw Hill Publishing House, New Delhi.
5. J.B.K.C. & B.K.Rai, Experiments in Basic Food Microbiology., Ekta Book.

## BIOCHEMISTRY AND HUMAN NUTRITION

**Full Marks: 50**

### ***A. Biochemistry***

1. Biochemistry and its scope, composition of living matter, biophysical concepts of acid, pH, buffers, oxidation and reduction concepts. 3
2. Introductory cell biochemistry. Separation of subcellular components and their biochemical functions, structure of membranes. 3
3. Enzymes: General properties, coenzymes and factors, kinetics and mechanism of action, inhibitors and activators. 4
4. Carbohydrate metabolism: glycolysis; oxidation, oxidative phosphorylation and elements of bioenergetics. 4
5. Lipid metabolism. 3  
Oxidation of fatty acids. Biosynthesis of fatty acids and fats.
6. Protein metabolism. End product of protein metabolism. Intermediary metabolism of amino acids and urea cycle. 3
7. In-borne errors of metabolism and enzyme deficiency diseases. 2
8. Nucleic acids: biochemical functions. 2
9. Mineral metabolism: Biochemical functions of minerals. Iron metabolism. 2

### ***Practicals:***

1. Ninhydrin reaction with proteins.
2. Millon's reaction with proteins.
3. Separation of proteoses from peptones by saturation with  $(\text{NH}_4)_2 \text{SO}_4$ .
4. Qualitative analysis of carbohydrate.
5. Quantitative estimation of protein.
6. Quantitative determination of enzyme activity with salivary amylase.
7. Estimation of activity of papain.
8. Study on the effect of pH and substrate concentration on enzymic activity.

### ***Human Nutrition:***

11. Introduction: definition, terminology, nutrition & development. 2
12. Nutritional physiology: Human body composition. 3
13. The Food: Nutrients & their functions, nutritional classification food, energy value of foods, energy and nutrients requirements and allowances, digestion absorption and metabolism, food groups, nutritional quality of protein, food composition table & its uses. 7
14. Malnutrition and nutrient deficiency disorders: 3  
Definition, form & types of malnutrition, protein energy malnutrition, endemic goitre, vitamin A deficiency disorder, nutritional anemia.
15. Diet: Balance diet. 1
16. Infant food, weaning food and supplementary foods. 4
17. Enrichment and fortification. 1
18. Nutritional status: Definition and factors affecting the nutritional status, Assessment of nutritional status. 4

**Practicals:**

1. Determination of energy value of food- Bomb calorimeter.
2. Preparation of weaning food.
3. Preparation of balanced diet.
4. Nutrition survey: Anthropometric survey.
5. Food consumption survey.

**Textbooks:**

1. White, A and Hondler, F. Principle of Biochemistry. Mcgrow Hill Kozakusta Ltd, Kokya, New Delhi. 1978.
2. Lehninger, A.L. Biochemistry. Work Publishing Inc. New York. 1975.
3. J.L. Jain. Fundamental of Biochemistry. S.Chand & Company Ltd. 1992.
4. Swaminathan, M. Advance text book on food and nutrition vol-1 & 2. Printing & Publishing Co. Ltd. Mysore, India. 1993.
5. King F.S. and Burgess, A. Nutrition for Developing Countries. ELBS with Oxford Univerisyt Press. 1992.
6. Sumati R. Mudambi and Rajgopal, M.V. Fundamental of food and Nutrition. Wiley Eastern Ltd. 1993.
7. Shubhangini A joshi. Nutrition and Dietetics. Tata Mcgrow Publishing Co.Ltd. 1992.
8. Harfog A.P. and Starerer W.A. Manual for Social Surveys and Food Habits and Consumption in Developing Countries. Pudor Wagenonger. 1985.

## FOOD QUALITY CONTROL & ANALYSIS

**Full Marks: 50**

1. Introduction to the concept of food quality control.	1
2. Quality and its function, quality assurance in food industries & functions of quality control organization.	2
3. Quality attributes of foods: (a) Size and shape (b) Colour & gloss (c) Texture-visual & objective attributes (b) Aroma of foods -introductory ideas.	2
4. Introduction- sensory evaluation of foods and beverages.	2
5. Toxicological and legislative aspects of food additives.	3
6. Water contamination in the food industries.	2
7. Extraneous matters in foods and their methods of detection and removal.	2
8. Good Laboratory Practice.	1
9. Laboratory layout and design, operation and maintenance of different types of laboratory.	3
10. Role of Q.C. chemist in food establishments.	1
11. Hazard analysis and critical control points.	1
12. Food contamination and adulteration, quality control under different stages of food processing. Quality assurance and sampling technique.	2
13. Food standards- formulation.	2
14. Food control system in Nepal.	3
15. Food laws development and enforcement, inspection, grading and certification of food.	3
16. A study of international food regulations. Functions of Codex Alimentarius Commission.	2
17. Terminologies and concept of Good Manufacturing Practice (GMP) and Generally Recognized as Safe (GRAS).	2
18. ISO 9000 series.	1
19. Introduction to TQM.	2
20. Statistical quality control-quality control chart.	2
21. Strengthening of QC network in context of WTO.	2
22. Errors & accuracy in analysis of food materials, sampling & preparation of samples for analysis.	2
23. Proximate analysis of food products i.e. estimation of moisture, ash, carbohydrate, crude fibre, crude protein, crude fat.	3
24. Study of the methods of determination of additives like sulfur dioxide.	1
25. Study of the methods of determination of trace metals like tin, lead, arsenic.	1
26. Analytical methods applied in dairy products like milk, ice cream, butter..	5
27. Analysis of food stuffs with reference to the standards of quality fixed for jam, jelly, canned fruits & vegetables, pickles, squash, vinegar, rice, wheat.	5

### ***Practicals:***

1. Proximate analysis of wheat flour, biscuit, milk.
2. Extraction, separation & identification of water & oil soluble food colours.
3. Detection or estimation of trace metals: Iron, arsenic (depending on the facilities available).

4. Estimation of food additives like  $\text{SO}_2$ .
5. Analysis of food stuffs with reference to the standards of quality fixed for jam, canned fruits & vegetable, milk.
6. Checking of water contamination & extraneous matters in food.
7. Sensory evaluation of foods.
8. Test of adulteration: Baudouin test, Halphen test, Holde test, Hexabromide test, Metaril yellow, Starch in milk, Argemone oil test.
9. Complete analysis of table salt
10. Stability of fats and fatty foods by AOM.

***Textbooks:***

1. Ranganna, S. Hand book of analysis of and quality control of fruit and vegetable products. 2nd edn. Tata McGraw-Hill pub. New Delhi. 1996.
2. Sadasivam, S. and A. Manikam. Biochemical Methods in Agricultural Sciences. India. 1992.
3. Plummer, D.T. An introduction to practical biochemistry, 3rd edn. Tata Mc-Graw-Hill Pub. India. 1987.
4. AOAC. Official Methods of analysis of the association of official analytical chemists. 13th edn. Washington D.C. 1980.
5. Egan, H., R.S. Kirk and R. Sawyer. Pearson's chemical analysis of foods 8th edn. Churchill livingstone, New York. 1981.
6. S.M. Herschdoerfer. Quality control in the Food Industry vol. 1,2,3.
7. Jerry Banks. Principle of Quality Control. Wiley Johan Wiley and Son, New York.