**Outline for Spray Drying of Greek Yogurt**

1. Abstract
2. Goals
   1. Stable shelf-life, high quality, no need for refrigeration
      1. (Yilmaz, Sert, & Karakaya, 2010)
   2. Minimal microstructure damage
      1. (Rascon-Diaz, Tejero, Mendoza-Garcia, Garcia, & Salgado-Cervantes, 2012)
3. Alternatives
   1. Freeze-dried
      1. Advantages
         1. More nutritious product with similar texture to yogurt when rehydrated
         2. Retain lactic acid bacteria above legally mandated (in Brazil)
         3. Greater acceptance than traditional yogurt
         4. Long shelf life
         5. Higher survival rate of bacteria than spray dry
         6. Easily rehydrated
      2. Disadvantages
         1. Lower moisture content
         2. Number of colonies of lactic acid bacteria lower than traditional yogurt
         3. Cost
      3. Sources
         1. (Santos, Nunes, Silva, Rosenthal, & Pagani, 2018)
         2. (Kim & Bhowmik, Moisture Sorption Isotherms of Concentrated Yogurt and Microwave Vacuum Dried Yogurt Powder, 1994)
         3. (Kumar & Mishra, 2004)
         4. (Kim & Bhowmik, Survival of lactic-acid bacteria during spray drying of plain yogurt, 1990)
         5. (Sakin-yilmazer, Dirim, Di Pinto, & Kaymak-ertekin, 2014)
         6. (Okos, Drying Equipment, 2018)
         7. (Sengupta & Bhowal, 2017)
   2. Microwave Vacuum Dried
      1. Advantages
         1. Lower level of equilibrium moisture content
      2. Disadvantages
         1. Differences not significant between other methods when yogurt is used as raw material
      3. Sources
         1. (Kim & Bhowmik, Moisture Sorption Isotherms of Concentrated Yogurt and Microwave Vacuum Dried Yogurt Powder, 1994)
         2. (Okos, Drying Equipment, 2018)
         3. (Sengupta & Bhowal, 2017)
   3. Refractance Window
      1. Advantages
         1. Better physical properties than freeze drying
         2. Lower production temperature required than spray drying
      2. Disadvantages
         1. Worse color than freeze drying
         2. Reduction in yogurt bacteria counts
      3. Sources
         1. (Tontul, Ergin, Eroglu, Kucukcetin, & Topuz, 2018)
4. Effect on product
   1. Rheological properties
      1. (Lange, 2013)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      3. (Koc, Sakin-yilmazer, Kaymak-ertekin, & Balkir, 2014)
   2. Flavor
      1. (Yilmaz, Sert, & Karakaya, 2010)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      3. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   3. Chemical properties
      1. (Yilmaz, Sert, & Karakaya, 2010)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      3. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
      4. (Bylund, 2003)
   4. Survival of bacteria
      1. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      2. (Rascon-Diaz, Tejero, Mendoza-Garcia, Garcia, & Salgado-Cervantes, 2012)
      3. (Kim & Bhowmik, Survival of lactic-acid bacteria during spray drying of plain yogurt, 1990)
      4. (Sengupta & Bhowal, 2017)
   5. Shelf Life
      1. (Dibyakanta, Dash, Mishra, & Deka, 2018)
5. Input/output
   1. Inlet and outlet temperatures
      1. (Yilmaz, Sert, & Karakaya, 2010)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      3. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
      4. (Kim & Bhowmik, Survival of lactic-acid bacteria during spray drying of plain yogurt, 1990)
      5. (Okos, Campanella, Narsimhan, Singh, & Weitnauer, 2007)
   2. Output particle size
      1. (Yilmaz, Sert, & Karakaya, 2010)
   3. Dairy composition input
      1. (Yilmaz, Sert, & Karakaya, 2010)
      2. (Gerdes, 2009)
      3. (Bylund, 2003)
6. Energy
   1. Heat of sorption
      1. (Stencl, Janstova, & Drackova, 2010)
      2. (Kim & Bhowmik, Moisture Sorption Isotherms of Concentrated Yogurt and Microwave Vacuum Dried Yogurt Powder, 1994)
      3. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
      4. (Dibyakanta, Dash, Mishra, & Deka, 2018)
   2. Input and output temperatures, atomizer speed
      1. (Yilmaz, Sert, & Karakaya, 2010)’
   3. Preventing heat loss
      1. (Bylund, 2003)
      2. (Okos, Campanella, Narsimhan, Singh, & Weitnauer, 2007)
7. Design equations
   1. Henderson’s
      1. (Stencl, Janstova, & Drackova, 2010)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   2. Chung-Pfost’s
      1. (Stencl, Janstova, & Drackova, 2010)
   3. Clausius Clapeyron
      1. (Stencl, Janstova, & Drackova, 2010)
   4. GAB Equation
      1. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   5. BET
      1. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   6. Halsey
      1. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   7. Oswin
      1. (Koc, Yilmazer, Balkir, & Ertekin, Moisture Sorption Isotherms and Storage Stability of Spray-Dried Yogurt Powder, 2010)
   8. Shear rate
      1. (Bylund, 2003)
   9. Droplet size determination
      1. (Okos, Campanella, Narsimhan, Singh, & Weitnauer, 2007)
      2. (Okos, Drying Equipment, 2018)
   10. Pressure drop
       1. (Okos, Drying Equipment, 2018)
8. Methods
   1. Production of acid milk gel and heat-treated milk powders
      1. (Lange, 2013)
   2. Combine dairy powder with whipping protein and stabilizer
      1. (Rubenstein, 1979)
   3. Pilot scale spray dryer
      1. (Yilmaz, Sert, & Karakaya, 2010)
      2. (Koc, Yilmazer, Balkir, & Ertekin, Spray Drying of Yogurt: Optimization of Process Conditions for Improving Viability and Other Quality Attributes, 2010)
      3. (Anonymous, 2005)
      4. (Bylund, 2003)
      5. (Okos, Campanella, Narsimhan, Singh, & Weitnauer, 2007)
   4. Add cultures to nonfat milk, allow product to reach pH, dry
      1. (Gerdes, 2009)

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