FEASIBILITY STUDIES FOR PRODUCTION OF VALUE-ADDED CHEESE

by

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Abstract

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Feasibility studies for production of value-added cheese
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This study was undertaken to expand the market of dairy products, especially cheeses. The research evaluated the feasibility of producing fruit flavored value-added cheeses. Five fruit flavors studied were apple, cantaloupe, honeydew, grape, and watermelon. Juice was extracted from each fruit and added to milk before the standard cheese making process. Cheeses obtained were analyzed using 30 member sensory panel. The sensory evaluation indicated potential for producing apple flavored cheese. Further research will be needed to improve the sensory attributes of cheeses obtained from milk containing grape, cantaloupe, and watermelon juices. The production of value-added cheese using honeydew juice was not feasible.

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CHAPTER ONE

Introduction

Milk and many of its products are dietary staples of people throughout the world. It is a perishable commodity and consists of valuable nutrients such as protein, fat, carbohydrate, vitamins, and minerals. Processing technologies are applied to preserve milk in different forms such as condensed products, cream, butter, ice cream, and various forms of cheese.

Cheese is a concentrated dairy commodity produced by acid or rennet coagulation or curding milk, stirring and heating the curd, draining off the whey, collecting and pressing the curd. The cheese is ripened, cured, or aged to develop the flavor and texture. Cheese can be classified into many groups varying from raw material, texture type, interior or exterior characteristic, and composition. According to the Food and Drug Administration (FDA) in 2003, two criteria used to define cheeses are moisture content and milk fat content. Cheddar is allowed a maximum 39% of moisture content and must contain at least 50% of milkfat. Cheese is produced all over the world. In 1994 the United States was the largest cheese producer and manufactured cheese products over 3 million tons, more than one-fifth of the total world production (Banks, 1998). Ritter (2000, p. 51) stated that “In 1910, the average American ate 5 lbs of cheese per year, but that had grown to 28 lbs per year by 1998”. This is a considerable growth of cheese consumption.

Development of new cheese products will benefit both manufacturers and consumers. Manufacturers will be able to expand their market and profitability from new cheese products. Consumers will have more choice to purchase and consume various types of cheese products.

The focus of this study was to research and develop different cheeses by adding fruit juice to milk in the cheese making process. Natural nutrients from fruit extracts could improve the nutritional value of the cheese products and consumption of these products could have health benefits.

Objective of the Study

The purpose of this study was to evaluate the feasibility of value-added cheese processing using fruit juice. Two specific objectives of this study were:

1. To identify the fruit juice that could possibly be used in the cheese processing
2. To determine the most desirable fruit flavored cheese

CHAPTER TWO

Literature Review

Product Development Concept

Food industry is one of the hugest industries in the business world. The food sectors want to see success and growth in their business. Four growth strategies for the business are market penetration strategy, market development strategy, product development strategy, and diversification strategy (Lord, 2000 & Kotler 1997). Growth strategy models for business are shown in Figure 1.

Figure 1. Business growth strategy models

	Current Products	New Products
Current Markets	Market penetration strategy	Product development strategy
New Markets	Market development strategy	Diversification strategy

Source: Kotler (1997)

- Market penetration strategy is gaining more market share of current products in existing markets.
- Market development strategy (or market extension) is aiming to expand the current products to new markets.
- Product development strategy is creating the new potential product to serve current markets.
- Diversification strategy is finding the new products to target new markets.

The change of industries has been required to meet consumers' preference due to changing of consumers' need, age, habit, lifestyle, and ethnicity. The consumer always wants more information, variety, and a new eating experience. Research and development will give a better understanding of the process of food product innovation.

According to Fuller (1994) new product development is driven by several factors. These factors include the life cycle of products. Products are introduced into the marketplace and at some point the products lose customer appeal. Many food companies have aggressive growth plans and encourage risk taking. Aggressive growth plans are needed to stay competitive in the global marketplace. The changing of marketplace also requires new products that fit consumers' desires. New technology and knowledge may alter new products, make them available, and suite them to consumers. Changing of legislation, health programs, and government policy are factors that force producers to develop new products.

Best (1990, p.3) stated that "new product design demands a carefully choreographed "total concept" approach that goes beyond simply designing products that survive successive consumer test hurdles." New product development requires seven steps which are 1) setting new product development targets, 2) gathering the strategic information, 3) mapping the strategic geography, 4) creating a list of new product options, 5) setting criteria, 6) creating the portfolio, and 7) managing the portfolio (Gill, Nelson, & Spring, 1996).

New food products can be classified into several groups such as line extensions, repositioned existing products, new form of existing products, reformulation of existing

products, new packing of existing products, innovative or added-value product, and creative product (Fuller, 1994).

Meltzer (cited in Fuller, 1994, p. 7) defined “value added” and “added value” processing as “…any technique that effects a physical or chemical change in a food or any activity that adds value to a product.”

Cheese Marketing

Statistic results from Foreign Agricultural Service (2000) indicated that cheese production in the United States increased every year since 1996 to 2000. The United States, as a single manufacturing country, continues to be a major cheese producer. However, the European Union including Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, and the United Kingdom produces more than 5,000 metric tons of cheese. Table 1 shows the amount of cheese production from selected countries.

According to Wisconsin Agricultural Statistics Service (2003), total production of cheese in the United States was 748,263,000 tons in May 2002, and 740,014,000 tons in May 2003; about 250,000,000 tons of cheddar cheese was produced and 22% of the products were from the state of Wisconsin.

The increase of cheese production is driven by the availability of raw milk, the market channel of industries, consumer habits and demands, country regulations, and trade barriers. However, cheese has been consumed throughout the world and has dominated the world trade market. Robinson and Wilbey (1998) claimed that cheese consumption in Japan has been increasing because of new food habits. The consumption is also increasing in the Middle Eastern countries. The higher the personal incomes are, the higher is the demand for cheese.

Table 1

Cheese Production from Selected Countries

Country	Amount of Cheese production (1,000 metric tons)	
	1996	2000(p)
North America		
Canada	289	329
Mexico	110	135
United States	3,274	3,775
Subtotal	3,673	4,239
South America		
Argentina	390	432
Brazil	385	445
Venezuela	77	62
Subtotal	852	939
European Union		
Denmark	298	305
France	1,594	1,680
Germany	947	1,046
Ireland	92	91
Italy	90	1,000
Netherlands	688	690
Spain	160	210
Sweden	127	130
United Kingdom	364	330
Subtotal	5,220	5,482
Eastern Europe		
Poland	133	145
Romania	92	92
Subtotal	225	237
Former Soviet Union		
Russia	173	220
Ukraine	60	57
Subtotal	233	277
North Africa		
Egypt	325	370
Subtotal	325	370
Asia		
Japan	33	36
Korea	0	15
Subtotal	33	51
Oceania		
Australia*	268	367
New Zealand**	230	270
Subtotal	498	637
TOTAL	**11,059**	**12,232**

(p) Preliminary

*Year ending June 30 of the year shown

** Year ending May 31 of the year shown

Source: FAS (2000)

Cheese Definitions

Bodyfelt, Tobias and Trout (1988, p.300) define “Cheese is a dairy product made by coagulating either whole milk, part-skim (lowfat) milk, skim milk, or cream: removing much of the liquid portion while retaining the coagulum and entrapped milk solids.”

Classification of Cheese

Cheese products are classified according to several criteria. In general, there are three major groups of cheese: rennet or natural cheese, fresh cheese or non-ripened cheese, and long-life cheese or processed cheese (Speer, 1998).

- Rennet or natural cheese, made from milk by using proteolytic enzymes (rennet) and acid, with a more or less pronounced proteolytic ripening process.
- Fresh cheese or non-ripened cheese, has the same manufacturing process as that of rennet cheese, but has a higher degree of acidity and is not subject to proteolytic ripening process.
- Long-life cheese (processed cheese), is mostly produced from rennet cheese and is textured by thermal treatment and made shelf stable.

However, cheese products are also classified based on (Speer, 1998 & Banks, 1998):

1. Type of process (rennet cheese, rennet acid cheese, acid curd cheese, processed cheese)
2. Type of consistency (hard, semi-soft, soft)
3. Type of milk (cow, sheep, goat, buffalo)

4. Chemical composition (Ca content in conjunction with pH, dry matter, moisture, fat)
5. Ripening process (ripened cheese and non-ripened/fresh cheese)
6. Variations in taste (herbs added, spices added)
7. Type of hole formation (large, medium, and small round holes, cracks, irregular holes, no holes)
8. Surface characteristics (blue fungus or white fungus cheese, skinless cheese)
9. Country of origin (Switzerland, England, Italy, France)

The United States requires cheese products to comply with the Code of Federal Regulation (CFR), Title 21, part 133 (FDA, 2003). The standard addresses the definition and processing method in general and in particular, cheese products.

Nutritional Value of Cheese

Cheese is a major source of protein, and fat. Nutritional values in cheese vary depending on the type of cheese. Table 2 shows the nutrient values of several kinds of cheese.

Table 2

Nutritional Composition of Cheese

Component	Parmesan	Cheddar	Edam	Feta	Cottage Cheese
Water (g)	18.4	36	43.8	58	79.9
Protein	39.4	25.2	6	20	14
Fat	32.7	34.4	25.4	21	4
Cholesterol (mg)	100	100	80	75	13
Energy (kcal)	452	412	333	250	98
Vitamin (μg)					
Vitamin A	345	325	175	--	--
Vitamin D	0.25	0.26	0.19	0.5	0.03
Vitamin E	700	530	480	370	80
Thiamine	30	30	30	40	30
Riboflavin	440	400	350	210	260
Niacin	120	70	70	200	100
Pyridoxin	130	100	90	70	80
Cobalamin	1.9	1.1	2.1	1.1	0.7
Folate	12	33	40	23	27
Pantothenate	430	360	380	360	400
Biotin	3.3	3.3	1.8	2.4	3
Mineral (mg)					
Na	1090	670	1020	1440	380
K	110	77	97	95	89
Ca	1200	720	770	360	73
Mg	45	25	39	20	9
P	810	490	530	280	160
Fe	1.1	0.3	0.4	0.2	0.1
Cu	0.3	0.03	0.04	0.07	0.04
Zn	5.3	2.3	2.2	0.9	1.6
S	250	230	--	--	--
Cl	1820	1030	1570	2350	550

Values are based on per 100 g of cheese

Source: Banks (1998)

Cheese Making Process

Kosikowski (1997, p.110) summarized the basic steps in major cheese making for fresh cheese and for curd blocks prior to ripening into seven steps. The first step is setting

milk for the purpose of preparing milk for acid or rennet curd development and the incorporation of proper microbial cultures. The second step is cutting or breaking curd aimed to speed whey removal and assist in uniform cooking throughout the curd by increasing the surface area. The next step is cooking curds in order to contract curds for more effective removal off whey, develop texture and establish moisture control. The fourth step is draining off the whey from the curds. The following step is knitting and curd transformation, the purpose of which is to transform curd into the characteristic texture of cheese desired, give time for acid development and aid in moisture control. The sixth step is salting to influence flavor, moisture, and texture. The last step is pressing to shape the cheese and close up the body. Some kinds of cheese may require special application in order to incorporate characteristic microorganisms for the specific cheese types and establish the proper environment for their growth.

Fruit Review

Apple (Malus pumila)

The apple is a common fruit grown all over the world. It originated in Western Asia to Eastern Europe (Ensminger et al., 1994). Apples have variety in color, flavor, and use. The texture of an apple is firm with light yellow to white color, but its peel colors vary from yellow, green, and red. It is also a major crop in the United States.

Variety: Granny Smith

Root (1996, p.8) stated that

> " Granny Smith, the third most popular apple in the world, also originated in the 1860s. It was a chance seedling in Marie Smith's backyard near Sidney (sic), Australia, thus, the name Granny Smith. The Granny Smith needs a long growing

season and is grown commercially in the United States mainly on the West Coast. It is a very firm, green, juicy, tart apple ideal for apple pie and contributes acidity when used in juice production."

Nutrition and chemical compositions of apples vary due to different types and other factors. Nutritional composition of apples is shown in Table 3. According to Lal Kaushai and Sharma (1995), a major constituent of apples is carbohydrate. Total carbohydrates in fresh apples account for about 15%, comprising 0.89-5.58% each of fructose and glucose, and 0.88-5.62% sucrose. The dietary fiber content of apples is presented in Table 4.

Table 3

Nutritional Composition of Various Fruits

Composition	Apple'	Grape'	Cantaloupe''	Honeydew''	Watermelon''
Refuse (g)	-	-	45	45	50
Water (g)	67-89	72-88	90	87	90
Protein (g)	0.1-0.4	0.4-1.4	1	0.9	0.6
Fat (g)	Tr-0.4	Tr-1.4	0.1	0.1	0.1
Total sugar (g)	5.7-16.1	11.5-17.6	7	10.1	9
Other carbohydrate (g)	-	-	0.2	0.2	0.1
Vitamin A, I.U.	-	-	4200	500	300
Thiamine (mg)	0.02-0.04	0.04-0.05	0.06	0.06	0.08
Riboflavin (mg)	0.01-0.06	0.02-0.11	0.02	0.02	0.02
Niacin (mg)	0.01-0.7	0.2-0.3	0.9	0.6	0.2
Vitamin C (mg)	-	-	45	32	6
Ascorbic acid (mg)	4.0-49.0	3.0-11.0	-	-	-
Minerals (mg)					
Ca	2.0-11.0	11.0-42.0	10	6	5
Fe	0.3-0.9	0.3-1.0	0.4	0.2	0.2
Mg	-	-	17	10	11
P	-	-	390.2	14	9
K	-	-	330	330	130
Na	-	-	20	20	5
Calories	37-74	60-95	27-36	41	31-40

Values are based on 100 g fr.Wt.of edible portion
Source: ' adapted from Pratt (1971)
" adapted from Duckworth (1966)

Table 4

Dietary Fiber Content of Apple Fruit

Constituent	Mass Unit (Gram)
Moisture	86
Insoluble noncellulosic polysaccharides	
Hexoses	0.48
Pentoses	1.11
Uronic acids	0.29
Total	1.88
Total noncellulosic polysaccharides	
Hexoses	0.97
Pentoses	1.74
Uronic acids	2.83
Total	5.54
Cellulose	4.23
Lignin	0.66
Dietary Fiber excluding resistant starch	10.4

Values are based on 100 g. of dried food
Source: Lal Kaushal & Sharma (1995)

Grape (Vitis vinifera)

Grapes originated in Asia Minor, south of the Black and Caspian Seas, and can be grown in all climates (Peynaud & Ribereau-Gayon, 1971, & Patil et al, 1995). Grapes are consumed as fresh fruit, used to make wine and other products such as raisins, juice, concentrates, jellies, and others. Grapes are a juicy fruit and colored in green, red, and black. The chemical composition of grapes depends on variety and other conditions such as growth condition, geography, and temperature. Grapes contain a high amount of carbohydrate, and polyphenoloxidase enzyme (Patil et al, 1995). The nutritional composition of grapes is presented in Table 3.

Melons (Family: Cucurbitaceae)

"Melon is a plant that grows with either climbing or trailing vines with round, pointed or folded leaves with small yellow flowers (Ensminger et al., 1994, p.1442)." Several fruits and vegetables applied in this group include cantaloupe, casaba, honeydew, Crenshaw, Persian melon, watermelon, cucumber, pumpkin, squash, and gourd. Only little studies of the fruit in this group have been done in the past.

Cantaloupe and Honeydew (Cucumis melo)

Cantaloupe can also be called muskmelon, or summer melon and is of the variety *cantalupensis*, and in the United State, of the variety *reticulates*. It has netted, orange-flesh and with seeds attached to a netlike fiber in a central hollow (Ensminger et al., 1994, p.330). The origin and history of cantaloupe are unclear but might have originated in Africa, India, Russia, or China. Cantaloupe can be eaten as fresh fruit, but also be processed into a canned or frozen product (Ensminger et al., 1994). Galeb et al (2002) studied the composition and quality of cantaloupe fruit juice. The nutritional composition of cantaloupe is shown in Table 3.

Honeydew has a white, smooth rind, and light-green pulp. It is also called winter melon because it ripens late and is marketed during the winter. It also is used as fresh fruit, and as fruit balls in canned or frozen syrup (Ensminger et al., 1994, p.1442). Table 3 shows the nutritional value of honeydew.

Watermelon (Citrullus vulgaris)

Watermelon comes in a variety of shapes: round, oval, and oblong-cylindrical. It has a green surface with stripes of white. The pulp colors are red, pink, yellow, and white. The origin of watermelon is from tropical Africa. It can be cultivated in tropical, semitropical and temperate climates. It is one of the leading fruit crops of the world with an annual production of about 28.9 million metric tons (Ensminger et al., 1994). Table 3 presents constituents from watermelon. Watermelon is mainly consumed as fresh fruit. However, it can be processed into jam, pickles, juice, and other forms. Edwards et al. (2003) stated that watermelon has an antioxidant capacity and potential health benefit because it contains a great amount of lycopene. Pratt (1971) summarized the presence of enzymes in the melon tissue (Table 5).

Table 5

Enzyme Activities Identified in Melon Tissue

Enzyme	Presence (+), Absence (-), or No available data (N/A)	
	Muskmelon	Watermelon
Ascorbic oxidase	+	+
Catalase	+	N/A
Elaterase	+	-
Glucose-6-phosphate dehydrogenase	+	N/A
Glutathione reductase	+	N/A
Invertase	+	N/A
Malic enzyme	+	N/A
Peroxidase	+	N/A
Phosphoenolpyruvate carboxykinase	+	N/A
Phosphogluconic dehydrogenase	+	N/A
Polygalacturonase	-	N/A
Polyphenol oxidase	+	N/A
Proteonase	+	N/A
Pyruvic carboxylase	N/A	+
"Oxidase"		
(flavor-enzyme)	+	N/A
(copper-enzyme)	+	N/A
(ironenzyme)	+	N/A
"Oxidase"	+	+

Source: adapted from Pratt (1971)

Sensory Evaluation: Affective Method

Sensory evaluation plays an important role in product quality control and assurance, and development process. Affective methods of sensory evaluation are aimed to assess the personal response in terms of preference and/or acceptance by current or potential customers of a product. They are conducted in many areas such as product maintenance, product improvement or optimization, development of new products, assessment of market potential, product categories review, and support for advertising claims (Meilgaard et al., 1999).

One technique used to measure the sensory attribute is a 9-point hedonic scale. It is a degree-of –liking scale (Lawless & Heymann, 1998). The hedonic scale can be categorized based on like and dislike. The higher number indicates the most preference and the lower number indicates the least preference. Samples were served to panelists one at a time, and the panelists were asked to indicate their response on the scale. The obtained number is analyzed to determine the level of preference of a specific attribute in the food.

CHAPTER THREE

Methodology

Materials

Kemps' fat free skim milk and Kemps' ultra-pasteurized heavy whipping cream produced from Marigold Foods, LLC. Minneapolis, Minnesota were purchased from a local grocery store and kept in the refrigerator at 4^{O}C. The R-703 Freeze-dried Lactic Culture for Direct Vat Set (DVS), Mesophilic Homofermentative Culture, Lot number 2247254, (Date of Manufacturing: Nov 19,2001 and Best Before Date: Nov 19, 2003) was stored in the freezer. Powder Calf Rennet "Renco" strength 1: 10000 from Chr Hansen, (New Zealand) was shelved at room temperature. Both lactic acid culture and the rennet enzyme were supplied from New England Cheesemaking Supply Company, Ashfield, Massachusetts. Salt from Morton International, Inc., Chicago, Illinois was used in the process.

Granny Smith green apples (*Malus pumila*), watermelon (*Citrullus vulgaris*), honeydew, cantaloupe (*Cucumis melo*), and red seedless grapes (*Vitis vinifera*) were purchased from the local grocery store in Menomonie, Wisconsin. The fruits were stored in the refrigerator at 4-5^{O}C and utilized within one week after purchase.

Methods

Fruit Preparation Process

The fruits were washed, peeled, deseeded and cut in small pieces. The fruit juices were obtained using a juice extractor (Model 67800, Type CJ09, Series A2820AT, Hamilton Beach/Proctor-Silex, Inc.) and filtrated through cheesecloth. Juices were heated to 60-65^{O}C for 15 seconds. The pH of fruit juice was measured using a pH meter (Model

IQ 240, Scientific Instruments). The pH meter was calibrated following the company instruction guideline. The process of fruit preparation is shown in Figure 2.

Figure 2. Processing steps for fruit juices production

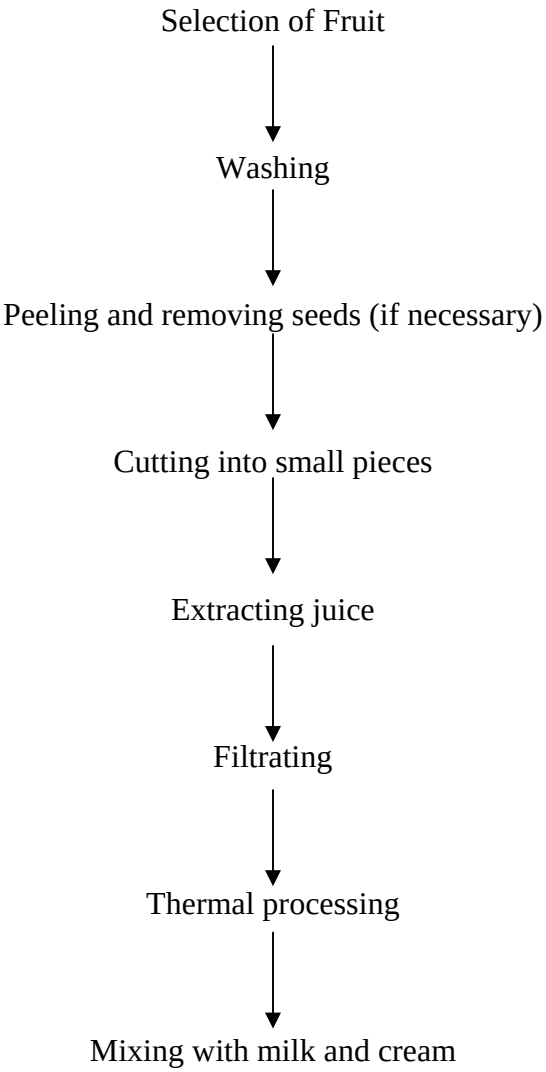
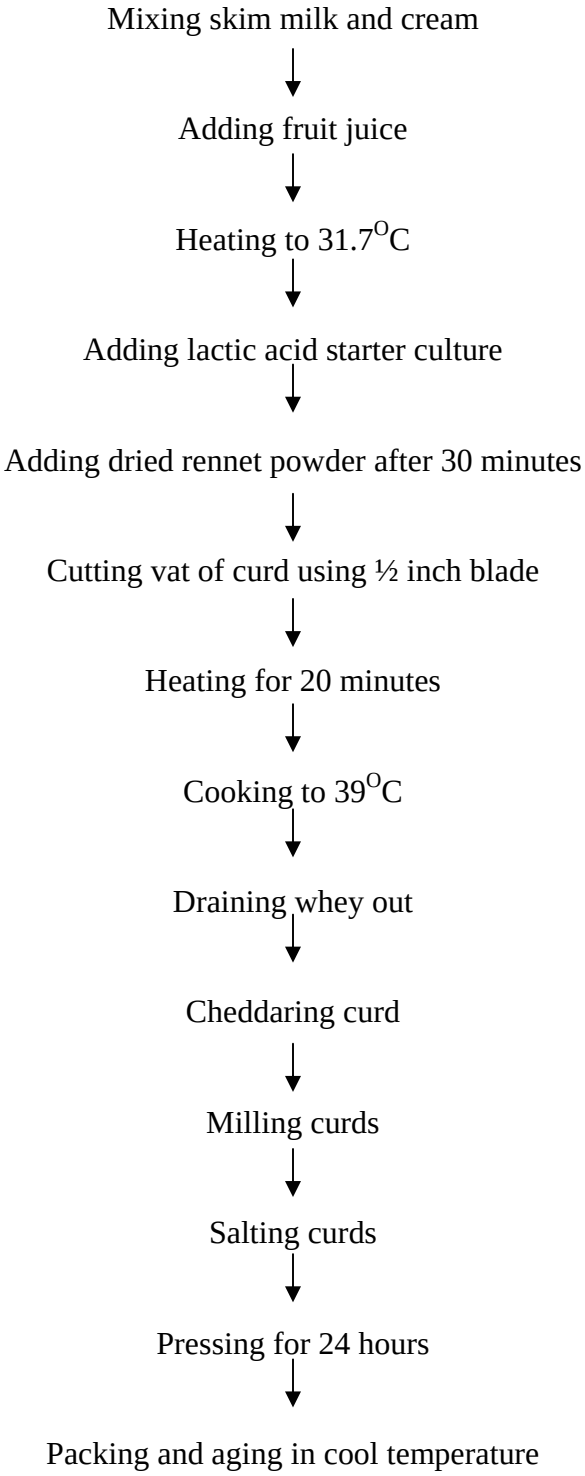


Figure 3. Processing steps for fruit flavored cheese making production



Cheese Making Process

The skim milk (90%) and cream (10%) were mixed together in a stainless steel container. The fruit juice (10%) was added to the milk and stirred together. The mixture was heated in a waterbath to 31.7^{O}C and lactic acid starter culture (0.02 % w/w) was added to the mixture. After 30 minutes, dried rennet powder (0.01 % w/w) was added in the mixture, and allowed to set for at least 75 minutes to gel. After the gel (curd) was strong enough, the curd was cut using a ½ inch blade and heated for 20 minutes. The curd was cooked to 39^{O}C by increasing the temperature at the rate of 1.8^{O}C every 5 minutes. At the end of this step titrateable acid (TA) should be at 0.16-.018 %. The curd was collected by draining the whey and it was cheddared until the TA reached 0.32-0.42%. The curd was milled, salted (2.5% w/w salt) and pressed for 24 hours. The cheese was packed in a vacuum bag and stored in the refrigerator at 4-5^{O}C for 2 weeks. The fruit flavored cheese making process is shown in the Figure 3.

Subjective Measurements

Sensory Panel Selection

Thirty voluntary untrained panelists (16 females, and 14 males) were drawn from the University of Wisconsin-Stout, Menomonie, Wisconsin. All panelists were asked to sign a consent form (Appendix A). None of the panelists were allergic to dairy products, and fruit used in this study.

Sample Preparation

Apple cheese, watermelon cheese, cantaloupe cheese, grape cheese and control cheese were cut approximately in cubic shape (1 inch x 1 inch x 1 inch) and wrapped with plastic food wrap to maintain the flavor. The samples were presented individually in

a control cup and served at room temperature. Each sample was assigned a 3-digit code number randomly generated by sensory evaluation software.

Sensory Procedure

All necessary sample, panel and test controls were applied to prevent bias from panelists. All panelists were given verbal instructions on the definitions of terms used on questionnaire, and sensory procedure. Example of questionnaire was shown in Appendix B. They were asked to evaluate and rate the samples with respect to their own preferences for overall appearance, texture, color, and overall flavor attributes using a 9-point hedonic scale indicating the following:

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like Nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Panelists made their selection and provided their input directly into a computer equipped with Sensory Information Management System (SIMS) software (version 3.1) by Sensory Computer Systems, L.L.C.

Data Analysis

Data were gathered from the main computer connected with the SIMS program, and were analyzed using Statistical Package for the Social Science (SPSS) software (version 10.0). Descriptive analysis was used as a statistical tool. The significant differences among the means were determined at the 5% level using two-way analysis of variance (ANOVA). Means separation was calculated using the Ducan test.

CHAPTER FOUR

Result and Discussion

Mixing of Milk with Fruit Juices

Addition of fruit juice to milk and cream altered the pH of the mixture. The pH values of fruit juices and the mixtures after addition of fruit juice were measured and presented in Table 6. The average pH of milk used in this study was 6.90. According to Sherbon (1988), the pH of cow's milk is between 6.5 and 6.7, 6.6 being the most usual value. The pH of milk used in this study was slightly higher. The pH of mixture decreased after addition of apple juice, cantaloupe juice, and grape juice. Honeydew and watermelon juices slightly increased the pH value of the mixture.

Table 6

pH Value of Fruit Juice and Mixture

Treatment	pH	
	Fruit juice	Mixture
Apple	3.23	6.23
Cantaloupe	6.44	6.71
Grape	3.72	6.54
Honeydew	6.99	6.92
Watermelon	5.82	6.93

Average pH of milk = 6.90

The appearance of the mixture indicated no coagulation of milk upon addition of apple, cantaloupe, grape, and watermelon juices. However, the addition of honeydew

juice coagulated the mixture. Further studies will be needed to understand the effect of fruit juices on coagulation of milk.

Cheese Curd Appearance and Color

The color of cheese curds was similar to fruit juice with the exception of grape flavored cheese. The individual curd pieces were less cohesive than the control and were smaller in size. The production of honeydew cheese was unsuccessful because the particles were very small and did not allow whey draining. The particles also tasted bitter. Further research will be needed to understand the effect of honeydew juice on cheese making process.

Figures 4 (a-e). Cheese curd color and appearance during processing

Figure 4a. Control cheese curd (during draining off whey)

Figure 4b. Apple flavored cheese curd (after salting step)

Figure 4c. Cantaloupe flavored cheese curd (after salting step)

Figure 4d. Grape flavored cheese curd (after salting step)

Figure 4e. Watermelon flavored cheese curd (during draining off whey)

Sensory Evaluation of Fruit Flavored Cheeses

Panelists rated their preferences of value-added cheese samples including apple, cantaloupe, grape, watermelon, and control cheeses on a scale of 1-9, 1 representing the lowest sensory score and 9 representing the highest sensory score. The analysis of variance (ANOVA) was used to determine the significance of added fruit juice in the cheese making process and variation among panelists on sensory attributes such as appearance, texture, color, and flavor. Frequency data of their preferences of each

attribute were used to compare the control sample with fruit flavored cheese samples. The mean separation data of value-added cheese samples for each attribute was done using the Ducan statistic analysis method ($p \leq 0.05$).

Overall Appearance of Fruit Flavored Cheeses

The effect of fruit flavors on the overall appearance of fruit flavored cheeses was highly significant (Table 7). In addition, the difference among panelists on their scoring of overall appearance was also highly significant. The apple flavored cheese was better or equal to the control cheddar cheese as indicated by the panelists' preference for apple cheese (Figure 5). The overall appearance score of apple flavored cheese (7.57 ± 1.10) was higher than the control cheese (Table 8). The cantaloupe flavored cheese was preferred over grape and watermelon flavored cheeses.

Table 7

Analysis of Variance for Overall Appearance Preference Rating

Source of Variance	**Sum of Square**	**df**	**Mean Square**	**F**	**P**
Treatment	231.427	4	57.857	25.252	.000
Panelist	165.393	29	5.703	2.489	.000
Error	265.773	116	2.291		
Total	5837.000	150			

Table 8

Comparison of Means of Value-added Cheeses

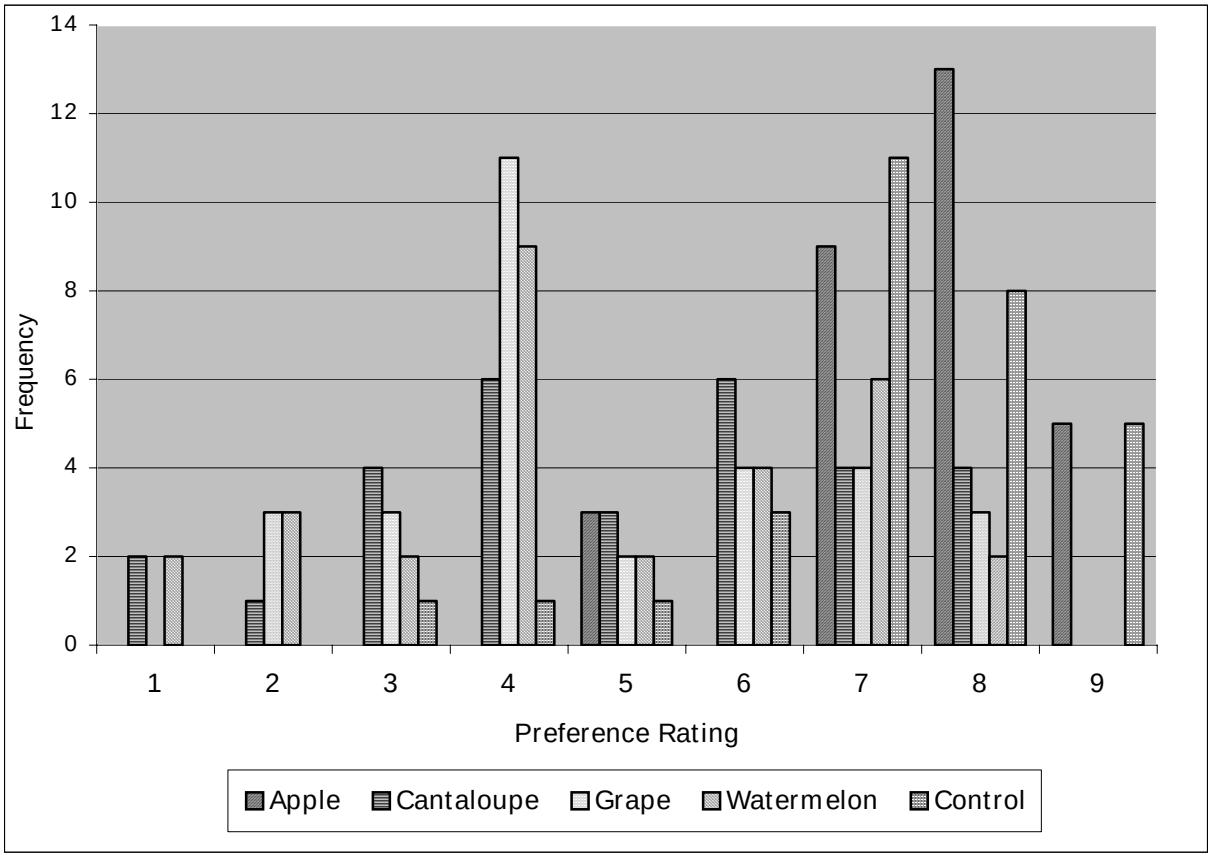
Treatment	Attribute			
	Appearance	Texture	Color	Flavor
Apple	7.57 ± 1.10^{a}	7.20 ± 1.49^{a}	7.47 ± 1.14^{a}	7.27 ± 1.70^{a}
Cantaloupe	5.03 ± 2.04^{b}	5.03 ± 1.69^{c}	5.83 ± 1.91^{b}	5.23 ± 2.30^{c}
Grape	4.83 ± 1.82^{b}	6.10 ± 1.77^{b}	4.27 ± 2.08^{c}	6.10 ± 1.65^{b}
Watermelon	4.73 ± 2.03^{b}	5.13 ± 1.94^{c}	4.97 ± 2.28^{c}	4.57 ± 2.11^{c}
Control	7.20 ± 1.42^{a}	7.10 ± 1.27^{a}	7.53 ± 1.20^{a}	6.73 ± 1.66^{ab}

Means in a column followed by different superscripts are significantly different ($p \leq 0.05$)

Hedonic Scale: 9-Like extremely, 1-Dislike extremely

Sample size = 30

Figure 5. Panelists' overall appearance preference rating of value-added cheeses



Scale: 1 =Dislike Extremely, 9 = Like Extremely

Sample size = 30

Texture of Fruit Flavored Cheeses

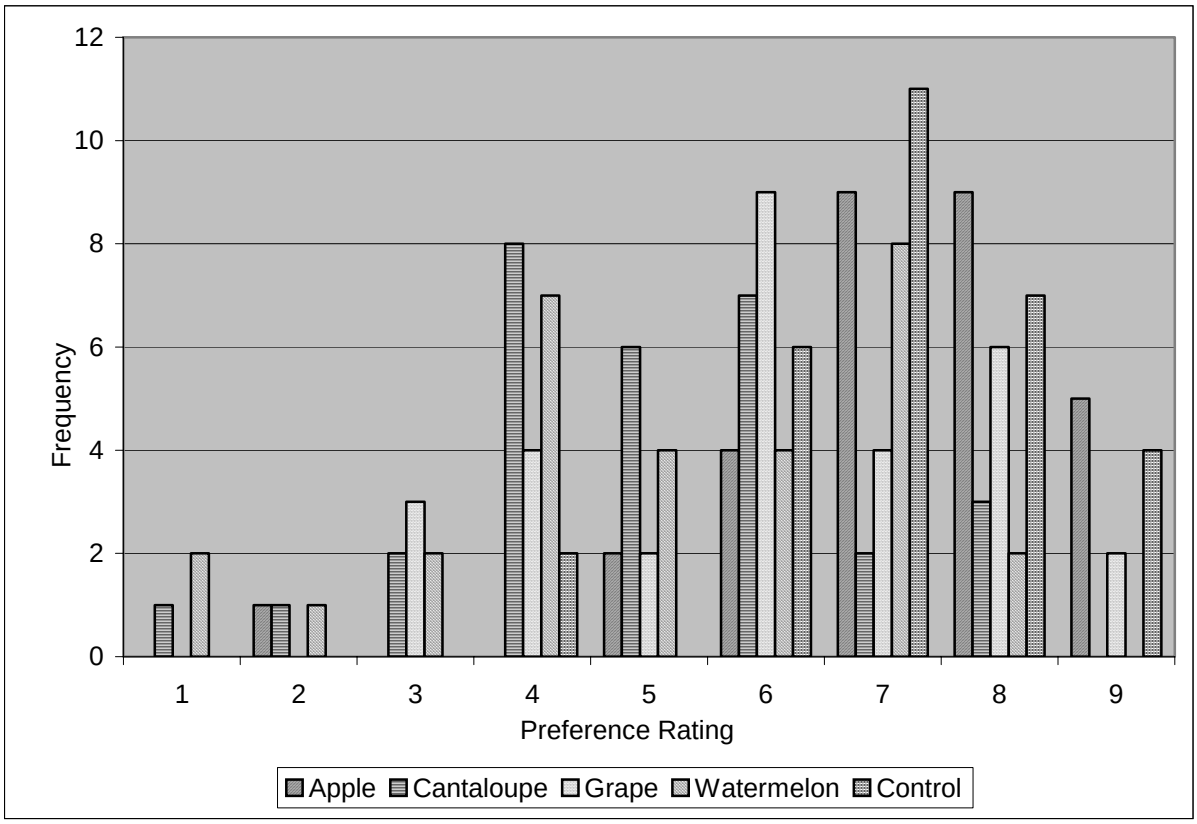
The effect of fruit flavors on the texture of fruit flavored cheeses was highly significant (Table 9). In addition, the difference among panelists on their scoring of texture was also highly significant. Although the frequency distribution for texture of apple flavored cheese (Figure 6) was lower than that of the control, the overall texture score of apple flavored cheese (7.20$\pm$1.49) was higher than the control cheese (Table 8). The texture of grape flavored cheese was preferred over the cantaloupe and watermelon cheeses.

Table 9

Analysis of Variance for Texture Preference Rating

Source of Variance	Sum of Square	df	Mean Square	F	P
Treatment	128.440	4	32.110	18.120	.000
Panelist	189.073	29	6.520	3.679	.000
Error	205.560	116	1.772		
Total	6129.000	150			

Figure 6. Panelists' texture preference rating of value-added cheeses



Scale: 1 =Dislike Extremely, 9 = Like Extremely

Sample size = 30

Color of Fruit Flavored Cheeses

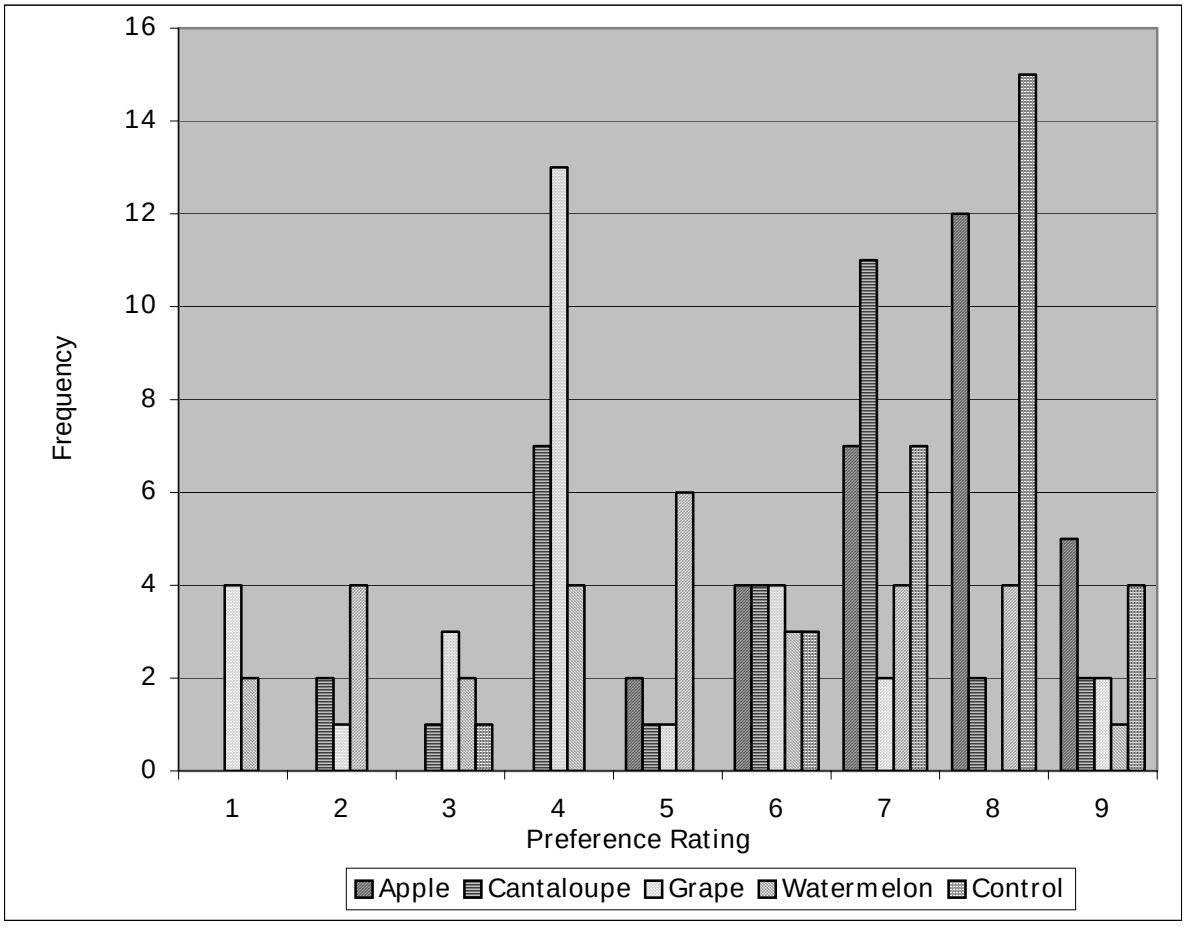
The color of all fruit flavored cheeses, except grape, was very attractive (Figure 4.a-e). The effect of fruit flavors on the color of fruit flavored cheeses was highly significant (Table 10). In addition, the difference among panelists on their scoring of color was also highly significant. The panelists' preference of apple flavored cheese was comparable to that of the control (Figure 7). As shown in Table 8, the color score of apple flavored cheese (7.47$\pm$1.14) was approximately equal to that of the cheddar cheese (7.53$\pm$1.20). The color of cantaloupe flavored cheese was preferred over the grape and watermelon flavored cheeses.

Table 10

Analysis of Variance for Color Preference Rating

Source of Variance	**Sum of Square**	**df**	**Mean Square**	**F**	**P**
Treatment	258.040	4	64.510	30.424	.000
Panelist	215.973	29	7.447	3.512	.000
Error	245.960	116	2.120		
Total	6144.000	150			

Figure 7. Panelists' color preference rating of value-added cheeses



Scale: 1 =Dislike Extremely, 9 = Like Extremely

Sample size = 30

Flavor of Fruit Flavored Cheeses

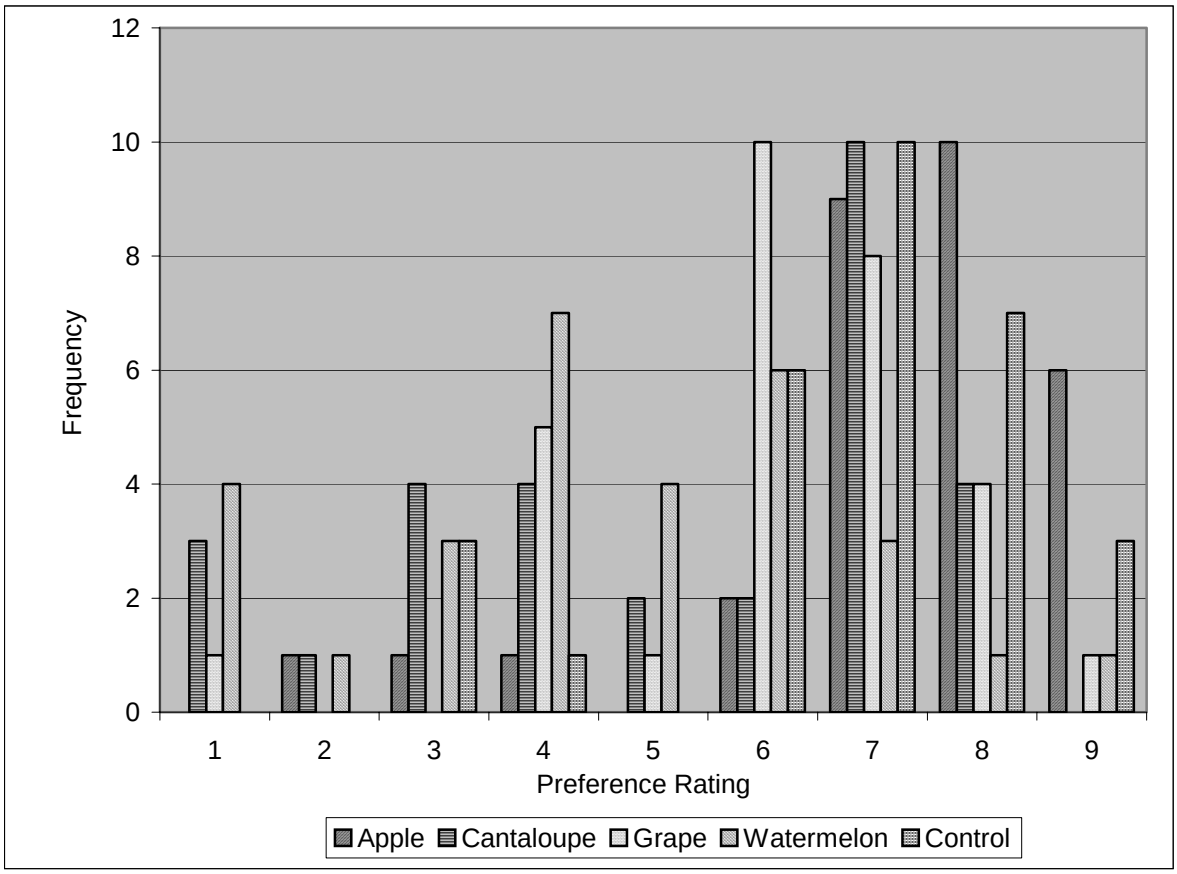
The contribution of fruit juices on the flavor of different cheeses was highly significant (Table 11). In addition, the difference among panelists on their scoring of flavor was also highly significant. The apple flavored cheese scored very well compared to the control as shown in Figure 8. Although the statistical difference was not significant (Table 8), the flavor score for cheese containing apple juice (7.24$\pm$1.70) was higher than that of the control (6.73$\pm$1.66). Surprisingly, the grape flavor was preferred over that of cantaloupe and watermelon.

Table 11

Analysis of Variance for Flavor Preference Rating

Source of Variance	Sum of Square	df	Mean Square	F	P
Treatment	143.773	4	35.943	16.222	.000
Panelist	268.140	29	9.246	4.173	.000
Error	257.027	116	2.216		
Total	6033.000	150			

Figure 8. Panelists' Flavor Preference Rating of Value-added Cheeses



Scale: 1 =Dislike Extremely, 9 = Like Extremely

Sample size = 30

CHAPTER FIVE

Conclusion and Recommendation

Conclusion

The addition of fruit juices to milk altered the pH of the mixture. In most cases (except honeydew) no coagulation of milk was observed. The individual curd pieces of fruit flavored cheeses were less cohesive than the control and were smaller in size.

Among the fruit juices tested apple juice gave the best result in terms of overall appearance, texture, color, and flavor. Although cheeses were produced from milk containing cantaloupe, watermelon, and grape juices at 10% level, the panelists' preference for these cheeses was not marginal. Further research will be needed to improve the sensory attributes of these cheeses.

Recommendation

Future research should be directed toward:

1. Studying the effect of fruit juices on bacteria fermentation of lactose and enzymatic coagulation of casein
2. Studying the effect of fruit juices on flavor development during ripening
3. Evaluating the effect of increasing fruit juice level
4. Investigating nutrient composition, microbial contamination of fruit cheese products
5. Evaluating shelf-life
6. Improving the appearance and texture of value-added cheeses in order to increase the consumers' preference

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Appendix A

Consent Form

I understand that by returning the/this questionnaire, I am giving my informed consent as a participating volunteer in this study. I understand the basic nature of the study and agree that any potential risks are exceedingly small. I understand that all of the samples from this study will consist of cheese product produced from cow milk. The ingredients include lactose, milk mineral, and several kinds of fruit juices (apple, watermelon, grape, cantaloupe etc). I also understand the potential benefits that might be by including fruit juice in cheese products. I am aware that the information is being sought in a specific manner so that only minimal identifiers are necessary and so that confidentiality is guaranteed. I realize that I have the right to refuse to participate and that my right to withdraw from participation at any time during the study will be respected with no coercion or prejudice.

NOTE: Questions or concerns about the research study should be addressed to Pimrutai Monphongchai, the researcher, Graduate Student, Food and Nutrition Department, UW-Stout, phone (715) 233-0598, or Dr. Gour Choudhury, the research advisor, Associate Professor, Food and Nutrition Department, UW-Stout, phone (715) 232-1623.

Questions about the rights of research subjects can be addressed to Sue Foxwell, Human Protections Administrator, UW-Stout Institutional Review Board for the Protection of Human Subjects in Research, 11 Harvey Hall, Menomonie, WI, 54751, phone (715) 232-1126.

Appendix B

Sensory Evaluation Questionnaire

Fruit Flavored Cheddar Cheese

Questioner Number_____

The samples may include lactose, milk minerals, apple, watermelon, cantaloupe, and others. If you are allergic to any ingredients, please notify researcher before participating in this study.

Please rinse your mouth before starting. Evaluate all products in front of you by looking at them and tasting them. Be sure to rinse your mouth with water before tasting the next sample. Using the following scale, rate each sample by writing the number which best describes your response to the characteristics listed in the table below:

Scale

9 Like extremely
8 Like very much
7 Like moderately
6 Like slightly
5 Neither like or dislike
4 Dislike slightly
3 Dislike moderately
2 Dislike very much
1 Dislike extremely

Sample #	Overall appearance	Texture	Color	Overall Flavor

Comments: _____
_____
_____