2. REVIEW OF LITERATURE

The review of literature pertaining to the study “EFFECT OF OPTIMIZED BREAKFAST BAR ON NUTRITIONAL AND ACADEMIC PERFORMANCE OF THE SELECTED ADOLESCENTS” is reviewed under the following headings:

2.1. Characteristics of a healthy breakfast

2.2. Benefits of breakfast
   2.2.1. General health and well-being
   2.2.2. Overall nutrition intake and dietary profile
   2.2.3. Energy and nutrient intake of breakfast eaters and breakfast skippers
      a. Energy and macronutrient intake
      b. Micronutrient intake

2.3. Breakfast skipping
   2.3.1. The increasing prevalence of breakfast skipping
   2.3.2. Definitions of breakfast skipping
   2.3.3. Reasons for breakfast skipping
   2.3.4. The correlates of breakfast skipping
      a. Demographic characteristics
      b. Lifestyle characteristics

2.4. Effect of Breakfast skipping
   2.4.1. Short-Term Effects on Cognitive Functioning
   2.4.2. Long-Term Effects on Cognitive Functioning
   2.4.3. Effects of Nutritional Status

2.5. The Role of Nutrition Education

2.6. An overview about optimized products using Response Surface Methodology (RSM)
2.1. Characteristics of a healthy breakfast

The healthiest breakfast is a "nutritious" meal rich in complex carbohydrate including fiber, moderate in protein and low in fat, salt and sugar (sucrose). For example, Rubin (2003) suggests that a serve of fresh fruit (or 100% unsweetened fruit juice) with whole grain bread or cereal (e.g., bran) and low fat (1%) or skim milk, cheese or yogurt (low in sugar) is an ideal breakfast.

This corresponds to McGinnis’ (2004) recommendation that children should follow the following Berning's three-food rule for a healthy breakfast:

1. Fruit whole or cut-up fruit or ½ cup of orange juice. Fruit supplies carbohydrates (for energy), vitamins A and C, plus a wealth of healthy antioxidants.

2. Whole grains whole wheat toasts (look for varieties with at least 3 g of fibre per slice) or hot or cold whole grain cereal. Grains provide carbohydrates, vitamin E, folic acid, and heart-healthy fiber.

3. Two eggs, 6 to 8 ounces of low-fat yogurt, 1 cup of 1% milk, or 2 tablespoons of peanut butter. These foods provide protein which is the building block for growth and for repairing most body systems; dairy sources also add bone-building calcium.

It has been observed that some children consume energy bars instead of having a proper breakfast. Rubin (2003) claims that all "energy bars" provide energy (calories), but they do not replace the nutrients in fruits, vegetables and whole grains. Energy bars vary in weight and nutrient content. Rubin states that healthy bars are those with no more than 250 calories, 3 gm. saturated fat, 8 gm. fat and 20 gm. sugar and at least 7 gm. protein and 3 gm. fiber per serving.
2.2. Benefits of breakfast

2.2.1. General health and well-being

As one of the seven specific health habits shown to be important contributors to health, the importance of regular breakfast consumption has long been recognized (Belloc et al., 1972). As an important meal of the day (Giovannini et al., 2008), breakfast has been related to long-term health outcomes (Belloc & Breslow, 1972), better quality of life, risk reduction of chronic diseases, and even decreased risk of death (Kaplan et al., 1987). For example, in a study focused on school children aged 9 to 19 years, Resnicow et al. (1991) found breakfast skippers to have significantly higher levels of plasma total cholesterol levels compared with eaters, putting them at higher risk for chronic illnesses such as cardiovascular disease.

Breakfast consumption has been related to improvement in mood, such as contentment (Wesnes et al., 2003), motivation to learn/concentrate (Hoyland et al., 2009), and overall cognitive functioning, (Mahoney et al., 2005). Breakfast skipping during childhood may adversely affect academic performance (Kim et al, 2003), as well as impair cognitive abilities in terms of attention (Benton et al., 2007), episodic memory, and immediate recall (Korol et al., 1998). Researchers have suggested a possible mechanism to be the enhanced functioning of the central nervous system owing to the supply of energy and nutrients supplied during breakfast. Glucose may play a particularly important role, (Kennedy et al., 2000). Additionally, breakfast might have favorable long-term effects on overall dietary profiles of individuals that in turn, improve cognitive functioning (Pollitt et al., 1998). Despite this, studies have been inconclusive about the direct beneficial effect of regular breakfast consumption on cognition, especially among well nourished children. Strong evidence showing precise breakfast–related neurochemical or physiological activity in relation to cognitive function is lacking (Hoyland et al., 2009).

Breakfast skipping has been linked to the psychosocial functioning of children. For example, among a group of elementary/middle-school American children, individuals experiencing food insufficiency or intermittent hunger were more likely to experience increased anxiety and demonstrate aggressive behavior (Murphy et al., 1998). Furthermore, teachers reported that such children had higher
levels of hyperactivity and absenteeism. In a separate study using data from Boston public schools, children with improved nutrient intake through participation in a school breakfast program showed better overall psychosocial functioning (Kleinman et al., 2002).

2.2.2. Overall nutrition intake and dietary profile

Breakfast facilitates optimal growth and development through contributing to nutritional adequacy and enhanced dietary profiles, (Szajewska et al., 2010) (Dubois et al., 2009), (Ruxton et al., 1997), (Williams et al., 2007). Breakfast skippers are generally regarded to have poorer diet quality compared with eaters. In support, not only do breakfast eaters have a better intake of micronutrients (Ruxton et al., 1996), carbohydrates (Nicklas et al., 1998), protein, fiber and calcium, but are also more likely to meet the Recommended Dietary Allowance (RDA) intakes for various minerals and nutrients. For instance, a review of data from the Bogalusa Heart Study showed that 10-year-old breakfast skippers failed to meet two-thirds of RDAs for nutrients including iron, calcium, zinc, folate, vitamins A and B6. Insufficient intakes of certain nutrients are often not made up for in other meals of the day. Aside from intake of specific nutrients, eating breakfast has been related to healthier food choices. Compared with children who skip breakfast, eaters are more likely to consume nutrient-dense ‘breakfast foods’ such as milk, cereal and fruits. In addition, breakfast skippers are more likely to use nutrient supplements (Keski-Rahkonen et al., 2003).

2.2.3. Energy and nutrient intake of breakfast eaters and breakfast skippers

Optimal nutrient intake is a fundamental prerequisite for meeting the nutritional demands of growth and development in childhood, and micronutrient intakes particularly may play an important role in the reduction of disease risk and deleterious health outcomes in childhood, adolescence and adulthood. Milk was identified as one of the most frequently consumed foods by children at breakfast in the United States, Canada and Europe. Breakfast cereals, which are normally consumed with milk, are popular in the United States, Canada, the United Kingdom, Spain and Croatia, while various types of bread are also commonly eaten. Rampersaud and Colleagues reported that the changes observed in breakfast consumption in the US over a 26-year period include an increased consumption of RTEC’s, low fat milk, and juice, and a decreased consumption of wholegrain breads, high-fat milk, and eggs (Rampersaud et al., 2005).
Currently, amongst the adult South African population, the foods most commonly consumed on a daily basis have been identified as maize porridge (78%), white sugar (77%), brown bread (55%), white bread (28%), non-dairy creamer (25%), brick margarine (21%) and full cream milk (19%). Amongst 6 to 9 year old children in South Africa, the most common food items consumed on a daily basis include maize porridge (72%), sugar (76%), tea (51%) full-cream milk (35%) and white bread (33%) (Steyn et.al., 2003). Of these dominant food choices in these two South African sub-groups, it is evident that RTEC’s and juice are not common daily (and by extension breakfast) choices. In fact, South African children most commonly consume three of the above mentioned items for breakfast i.e. maize-meal porridge, brown bread and tea (Walker et.al., (1982), Wolmaran et.al., (1995) and Malherbe (1998).

Eating breakfast has generally been associated with a total improvement in food choices (such as increased consumption of milk and vegetable and decreased consumption of soft drinks and French fries) amongst children and adolescents in the US, such that breakfast skippers have been found to be more likely to have diets defined as poor or inadequate. Breakfast skipping has also been linked to with increased snacking, and particularly an increase in the intake of high fat snacks (Rampersaud et.al., 2005).

a. Energy and macronutrient intake

Rampersaud and colleagues (2005) stated that breakfast eaters appeared to have a higher total energy daily intake of energy compared with breakfast skippers, suggesting that the breakfast skippers did not consume more calories at the other mealtime in an attempt to compensate for the breakfast deficit. This was particularly true amongst female adolescents. Berkey and colleagues (2003) had similar findings in that child who reported that they never ate breakfast, maintained lower energy intakes than those who ate breakfast on a daily basis. Breakfast eaters were more likely to have higher daily intakes of total carbohydrate, protein, fat, and saturated fat, while daily fat intake (expressed as the percentage of the total daily energy consumed) were lower amongst breakfast consumer in some, but not all studies reviewed. Higher energy breakfasts (those contributing more than 25% of the daily energy allowance) were associated with a higher mean daily intake of carbohydrates.
and a lower intake of fats (again expressed as a percentage of total energy intake) when compared with lower intake of fats (again expressed as a percentage of total energy intake) when compared with lower energy breakfasts (those contributing less than 15% of the daily energy allowance). Specifically amongst preschool children, when a breakfast with more than 50% of its energy from carbohydrates was consumed, the whole diet fat content tended to be lower than when a breakfast with less than 50% of its energy was supplied by carbohydrate. Rampersaud and colleagues (2005) Compared with children and adolescents consuming lower amounts of ready to eat cereals daily energy allowance) were associated with a higher mean daily intake of carbohydrates and a lower intake of fats (again expressed as a percentage of total energy intake) when compared with lower energy breakfasts (those contributing less than 15% of the daily energy allowance). Specifically amongst preschool children when a breakfast with more than 50% of its energy from carbohydrate was consumed, the whole diet fat content tended to be lower than when a breakfast with less than 50% of its energy was supplied by carbohydrate (Rampersaud and colleagues (2005). Breakfast with a higher fat intake (>35% of energy) were associated with higher total and saturated fat intake throughout the day.23 compared with children and adolescents consuming lower amounts of RTECs or with non consumers RTEC consumers specially, had higher whole day intakes of carbohydrates refined grains and sugars (expressed as a percentage of total daily energy intake) fibre intake was also found to be significantly higher in breakfast eaters when compared with breakfast skippers (Rampersaud and colleagues (2005), Albertson, 1992 and Nicklas et.al., 1993).

b) Micronutrient intake

Breakfast eater have higher daily intakes of micronutrients and are inclined to meet their nutrient intake recommendations when compared to those skip breakfast. Nutrients that seem predominantly affected across a variety of population groups include vitamins A and C, riboflavin, zinc, iron and calcium while iron, B vitamins and zinc intakes are improved with the inclusion of RTEC in the diet (Albertson et.al., 2003). Mean daily intakes of calcium were found to be higher in breakfast eaters when compared to breakfast skippers, and this subsequently forms part of a key nutritional issue amongst children and adolescents since peak bone calcium accretion occurs during adolescents (Rampersaud and colleagues (2005).
Ramprersaud and colleagues in fact reported that a significant number of children (in particular female adolescents) did not meet the adequate intake (AI) recommendations for calcium. In adolescents the reference intake for calcium in South Africa is 300mg and so a recommended milk intake of two cups (400-500 ml) will cover approximately 50-60% of the adolescent’s daily calcium requirements. This is a realistic recommendation for intake considering the milk can be used over porridge and breakfast cereals, with tea or coffee, and even as a solitary drink. The intake of micronutrients amongst South African children is inadequate, and since breakfast contributes a significant portion of a child’s overall nutrient intake, it has been suggested that breakfast skippers are more likely to present with micronutrient deficiencies. (Kruger et al., 2002)

2.3. Breakfast skipping
2.3.1. The increasing prevalence of breakfast skipping

Because breakfast has many benefits, breakfast skipping has become an important public health concern. As far back as 1981, breakfast was known to be the most skipped meal of the day. In analysis using nationally representative pooled samples of US children, Siega-Riz et al., (1998) found a general decline in breakfast consumption from 1965 to 1991. For instance, there was a 9% decline among children aged 8 to 10 years, although the greatest decline was observed among older adolescents.

Not many studies have reported the prevalence of breakfast skipping in Asian populations, particularly among children. A review of breakfast practices in Asian regions revealed that around 18% and 4% of Japanese high school and elementary school students skipped breakfast (consuming less than 100kcal within 2 to 3 hours of waking), respectively. In a study focused on Korean elementary school students, an average of approximately 80.5% of children from two schools consumed breakfast times or more per week. In another study comparing the dietary habits of Malaysian and Singaporean adolescents, researchers found breakfast skipping rates to be 2.7% and 6.0%, respectively. In addition, Yang et al., (2006) found that 23.6% of Taiwanese adolescents had irregular breakfast intakes (consuming breakfast 3 days or fewer from Monday to Friday). In general, these studies found that the prevalence
varied substantially across populations where inconsistent definitions of breakfast skipping/irregular breakfast consumption may partly be accountable for such differences.

2.3.2. Definitions of breakfast skipping

In a recent review on the benefits of breakfast for children and adolescents, authors noted the difficulty for comparing different findings in the subject due to the varying definitions of breakfast and breakfast skipping habit. For instance, the breakfast meal may be defined according to the time of consumption (e.g. food and beverage intake before 10am), eating occasion (e.g. first meal of the day, regardless of time it is consumed) or even limited to intake of certain ‘breakfast foods’ (e.g. cereal). How breakfast skipping is defined also varies across studies. Some define breakfast habit according to 1-day dietary surveys (hence unable to assess habit over time), breakfast frequency over a specific period of time, or use of qualitative terms (e.g. usually, sometimes) to assess breakfast skipping behaviour. Since breakfast is commonly self-defined in the literature, an inconsistency of findings across studies is not surprising (Rampersaud et al., 2009).

A major limitation of the literature on breakfast skipping and its correlates, causes, and consequences lies in the absence of a commonly agreed upon definition of breakfast skipping; this problem is illustrated in Table 1, which reviews publications from the past four decades that explicitly define breakfast skippers versus non-skippers. Table 1 shows six different definitions of breakfast skipping based within four varying timeframes of seven days/one week, three days, one day/24 hours, and “usual” breakfast eating habits. Within the seven-day category, three distinct definitions were used, ranging from skipping breakfast one time or more in the past seven days (e.g., Dubois, Girard, Potvin Kent, Farmer, & Tatone-Tokuda, 2009) to skipping breakfast at least six out of the past seven days (e.g., Timlin, Pereira, Story, & Neumark-Sztainer, 2008). As can be seen from these two different definitions, there is clearly great variability across studies in what constitutes breakfast skipping.
### Table 1: Definitions of breakfast skipping used in the literature

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Definitions</th>
<th>Studies Using Definitions</th>
</tr>
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<tbody>
<tr>
<td>7 Days / 1 Week</td>
<td>Missed breakfast at least 1x/week</td>
<td>Steele <em>et al.</em>, 1952</td>
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<td>Sjoberg <em>et al.</em>, 2003</td>
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<td></td>
<td></td>
<td>Dubois <em>et al.</em>, 2009</td>
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<td></td>
<td>Missed breakfast at least 4x/week</td>
<td>Pastore <em>et al.</em>, 1996</td>
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<td></td>
<td>Missed breakfast at least 6x/week</td>
<td>Keski-Rahkonen <em>et al.</em>, 2003</td>
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<td></td>
<td></td>
<td>Keski-Rahkonen <em>et al.</em>, 2004</td>
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<td></td>
<td></td>
<td>Timlin <em>et al.</em>, 2008</td>
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<td></td>
<td></td>
<td>Cheng <em>et al.</em>, 2008</td>
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<tr>
<td>3 days</td>
<td>Ate breakfast less than or equal to 1 day out of the 3 day reporting period</td>
<td>Morgan <em>et al.</em>, 1986</td>
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<tr>
<td>1 Day / 24 Hours</td>
<td>Missed breakfast on day of survey, 24-h food recall, or food record</td>
<td>Hanes <em>et al.</em>, 1984</td>
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<td></td>
<td></td>
<td>Skinner <em>et al.</em>, 1985</td>
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<td></td>
<td>Nicklas <em>et al.</em>, 1993</td>
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<td></td>
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<td>Wolfe &amp; Campbell, 1993</td>
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<td></td>
<td></td>
<td>Wolfe <em>et al.</em>, 1994</td>
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<td></td>
<td>Sampson <em>et al.</em>, 1995</td>
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<td></td>
<td></td>
<td>Siega-Riz <em>et al.</em>, 1998</td>
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<td></td>
<td></td>
<td>Nicklas <em>et al.</em>, 2000</td>
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<td></td>
<td></td>
<td>Dwyer <em>et al.</em>, 2001</td>
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<td></td>
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<td>Serra-Majem <em>et al.</em>, 2002</td>
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<td></td>
<td></td>
<td>Molcho <em>et al.</em>, 2007</td>
</tr>
<tr>
<td>“Usual Breakfast Habits”</td>
<td>Usually skip breakfast, or never or almost never eat breakfast</td>
<td>Resnicow, 1991</td>
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<td></td>
<td></td>
<td>Shaw, 1998</td>
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<td></td>
<td></td>
<td>ODea &amp; Caputi, 2001</td>
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<td></td>
<td>Boutelle <em>et al.</em>, 2002</td>
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<td>Kovarova <em>et al.</em>, 2002</td>
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<td>Berkey <em>et al.</em>, 2003</td>
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<td></td>
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<td>Videon &amp; Manning, 2003</td>
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<td></td>
<td></td>
<td>DeJong <em>et al.</em>, 2009</td>
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<td></td>
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<td>Moore, Moore, &amp; Murphy 2009</td>
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A consistent definition within the field is integral to meaningful discussion, mutual understanding and comparability across studies. Without using the same definition within a given timeframe, participants classified as “skippers” can represent virtual extremes of the breakfast consumption spectrum despite sharing the same label. It is possible that the lack of consensus on how to define breakfast skipping is obscuring analogous results while simultaneously rendering potentially informative data incomparable due to simple yet key methodological differences.
2.3.3. Reasons for skipping breakfast

Individuals skip breakfast for a variety of reasons. Recognizing reasons for skipping breakfast is potentially important for identification of methods to promote breakfast consumption. Common reasons for skipping breakfast include not liking the food served at breakfast, not wanting to eat in the morning, and a preference for sleeping over eating. Furthermore, individuals who regard themselves as too heavy may skip breakfast to lose weight. Consistent with the literature, Cheng et al. (2008) reported that the most common reason for Hong Kong primary 6 (P6) schoolchildren to skip breakfast was having insufficient time to eat. In addition, the lack of perceived parental emphasis on breakfast was an important reason for skipping breakfast. This reflects the importance of parental influence on breakfast habit among young children.

In one of the only two Australian studies (Shaw, 1998) the reasons given for skipping breakfast were almost exclusively lack of time and not being hungry in the morning. Moreover breakfast skipping was related to gender, not income, with females skipping more than three times as often as males. The other Australian study (Collins & Mannion, 1995) has not explored the reasons for skipping breakfast. While North American school nutrition programs have considered poverty to be a key issue in breakfast skipping, Shaw’s findings suggest that, for Australian adolescents, skipping breakfast is a matter of individual choice.

Bidgood and Cameron (1992) found that in Canada those below the poverty line were skipping breakfast twice as often as others, but less than one percent said that they skipped due to lack of money or food. The most common reasons given for skipping were, not liking to eat particular meals and lack of time. Similarly, Singleton and Rhoads (1982) found that the most common reasons given for skipping were no time (43%) and not being hungry (42%); less common reasons included being on a diet to lose weight, not feeling good, no one to prepare food, not liking the food served, and food not being available. Thus, stated reasons have generally involved personal choice rather than availability of food.

According to the Canadian Living Foundation, 42% of Canadian children are not eating an adequate breakfast at home (CLF, 1997). In Canada, this is not only a poverty issue. Children attend school without breakfast because families are challenged by busy, rushed schedules. The researcher found that some parents go to cook too
early to prepare breakfast for their children; others don't enjoy breakfast themselves. In addition, any children must take school bus rides very early in the morning even if they eat a breakfast they may be hungry by the time they reach school.

Shaw (1998) states that too many young girls believe that if they can eliminate this meal, they can maintain some illusion of a perfect body shape and weight. Skipping breakfast is neither a sensible weight reduction measure, nor a “boon to the sleep deprived” (Shaw, 1998), Basrur (1998) and Siega, Popkin, and Carson (1998) found that with an increased number of women in the work force and increases in hours worked has altered eating patterns for families and this means that children from all types of socioeconomic backgrounds are now at risk for breakfast skipping.

2.3.4. The correlates of breakfast skipping

a. Demographic characteristics

The literature has reported that breakfast consumption decreases with age among children (Affenito et al., 2005), (Murata et al.,, 2000), (Brugman et.al., 1998). Using a nationally representative sample of American children (aged 18 years or below), Siega-Riz et al., (1998) found that older adolescents (aged 15 to 18 years) experienced the largest decline in breakfast consumption from 1965 to 1991, with a 14.8% and 19.7% decline among boys and girls, respectively. Despite this, the pattern of breakfast consumption may be different with the increase in age beyond adolescence. For example, Keski-Rahkonen et.al. (2003) reported that older adults were less likely to skip breakfast compared with young adults. The authors postulated that this observation was due to increased meal regularity with age or general declines in breakfast consumption in younger generations.

Studies have frequently reported that girls were more likely to skip breakfast compared with boys, (Sjoberg et.al., 2003). A possible explanation is the stronger desire for girls to skip meals in attempt to lose weight. However, a local study focused on P6 schoolchildren found that girls were less likely to skip breakfast compared with boys. Although the results were statistically non-significant and reasons for breakfast skipping were not explored according to sex, these findings suggested that the characteristics of non-Western breakfast skippers may differ from their Western counterparts.
Breakfast skipping has generally been related to lower Socio Economic Status (SES) in a study aimed at investigating the correlates of breakfast skipping, researchers found that lower educational level of Finnish adolescents and adults was significantly related with breakfast skipping behaviour. Furthermore, the family SES is an important determinant of dietary habits among children. Children with a lower family SES, or have parents of lower educational (Brugman et.al., 1998) or occupational status were more likely to skip breakfast. However, there have been studies that failed to find an association between the breakfast habit of adolescents and parental education levels or parental unemployment. Locally, Cheng et.al. (2008) suggested that breakfast eaters and skippers had comparable SES backgrounds. Specifically, the working status of mothers was not associated with breakfast skipping behaviour in their children. This suggests that socio-economic correlates of breakfast skipping need further exploration, particularly among young Chinese children.

Children and adolescents who do not live with both parents are more likely to skip breakfast. The importance of family influence on the breakfast habit of young children has previously been documented in a review by Pearson et.al. (2009), although the authors noted that research in this area requires further exploration. Food availability, behaviour modeling and family culture are postulated to play key roles for influencing the dietary behaviour of children, (DeJong et.al, 2009). Importantly, parental influence on children’s breakfast habit may be age-specific, such that younger children are under more parental control compared with older children.

Western studies have suggested that children of ethnic minorities were more likely to skip breakfast. For example, Affenito et.al. (2005) reported that African-American girls were less likely to be frequent breakfast eaters compared with their White counterparts. This therefore suggests that breakfast habits may vary across different cultures and races, warranting investigation into the breakfast consumption patterns in the understudied Chinese population.
b. **Lifestyle characteristics**

Few studies have focused specifically on examining the association between breakfast skipping and lifestyle characteristics. Some studies have linked breakfast skipping to a clustering of health-compromising characteristics, including increased smoking and alcohol use, less sleep and poorer sleeping quality, (Nishiyama *et al.*, 2009), as well as infrequent exercise and lower intake of fruits and vegetables. Compared with breakfast eaters, skippers are also more likely to skip lunch and dinner.

Effects of skipping Breakfast Craig (1986) argues that breakfast, the very name for this early morning meal, leads one to entertain certain notions about the nature of its effects. It breaks the fast and so presumably serves a restorative function. For example, for younger children in particular, probably at least 12 hours have elapsed since the last intake of food. One might therefore expect breakfast to have a beneficial effect.

According to Chao and Vanderkooy (1989), access to nutritious food during school hours affects school-aged children in two important ways. First, a morning or noon meal contributes to both quantity and quality of the total required intake of energy, protein, carbohydrates and micronutrients such as iron and calcium. Second, school-meals initiatives are generally believed to enhance the cognitive functioning of children, especially the speed and accuracy of information retrieval in working memory. The validity of the evidence linking breakfast consumption to optimal cognitive functioning and academic achievement remains in question to this day. Although a clear conclusion has not yet been reached because of a variety of factors which includes various age groups tested, various tests performed, various settings, different times of the tests, different nutritional status of the children tested, difficulties in having controlled conditions and above all different results obtained. Even so, the general consensus among researchers and educators is that breakfast is both important and necessary for the learning ability of children (McIntyre, 1993; CDE, 1995; Pollitt & Matt Hews, 1998). A review of literature on breakfast consumption and children's cognitive capacity have generally supported this opinion, with exception of few and an emphasis on the need for further research (Chao & Vanderkooy, 1989; Pollitt, 1995; McIntyre & Herel, 1998; Papamandjaris, 2000).
2.4. Effect of Breakfast skipping

2.4.1. Short-Term Effects on Cognitive Functioning

A number of studies have assessed the short-term effects of fasting on learning ability by examining classroom academic performance as well as standardized tests. Much of the research has not yielded a conclusive pattern of results. Pollitt and colleagues have been involved in this area and have conducted many studies. Some of their findings are summarized here. Short-term hunger (due to lack of breakfast) may have some adverse effects on emotional behaviour, arithmetic and reading ability, and vigilance while consuming breakfast may enhance a child's performance during the morning in reading and in the solution of arithmetic problems (Pollitt et al., 1978).

In another study Pollitt and his colleagues sought to determine whether any differences existed between children who received both breakfast and lunch at school and those who received lunch only. The students were in the first through third grades. No significant difference was found in attendance, but the children who received both breakfast and lunch obtained higher ratings in reading and arithmetic problems than the children receiving only lunch (Pollitt et al., 1978).

Pollitt, Lewis, Garza and Shulman (1982/83) completed two experiments assessing the effects of short-term fasting (skipping breakfast) on the problem solving performance of 9 to 11 year old well nourished children studied under controlled conditions. Both studies demonstrated that skipping breakfast had an adverse effect on a child's late morning problem solving performance and that this could be related to the child's metabolic status. In another study (Pollitt, 1995) it was found that an overnight and morning fast had adverse effects on children's vigilance, and short-term working memory. In at-risk subjects, a morning and overnight fast had even more adverse effects on cognition, particularly the speed of information retrieval in working memory.

It is hypothesized that smaller children (<13 yrs) may be more vulnerable to the effects of overnight fasting based on their stature (Pollitt & Matthews, 1998). As such, much of the research done is conducted in elementary school children to determine the acute effects of one-time breakfast omission. The results are somewhat conflicting. In older students, results point to a potentially increased capacity to overcome possible detrimental acute effects of breakfast omission. Several
studies report a lack of significant effects of skipping breakfast on cognitive performance and mood (Cromer et al., 1990; Dickie & Bender, 1982). Many researchers did note that level of difficulty and capacity of tests to measure in-class learning may not have been appropriate and should be readjusted in future research (Dickie & Bender, 1982). Researches with adolescents indicate an increased resiliency against the detrimental effects of breakfast omission (Dickie & Bender, 1982; Cromer, Tarnowski, Stein, Harton, & Thornton, 1990; Michaud, Musse, Nicolas, & Mejean, 1991; Smith, Kendrick, & Maben, 1994; Lloyd, Rogers, & Hedderley, 1996).

Lower energy consumption at breakfast resulted in poorer performance in creativity testing and voluntary endurance among 10-year-old children participating in a Swedish study (Wyon, Abrahamsson, Jartelius, & Fletcher, 1997). Hence the content of breakfast may be an important factor. Conversely, a Chilean study found no significant differences in the cognitive test performance of 8-11 year old children who were randomly assigned to breakfast or fasting conditions (Lopez, 1993).

Benton & Parker (1998) argue that brain function is sensitive to short-term variations in the availability of nutrient supplies. This indication is particularly strong for nutritionally at-risk smaller (9 to 11 year old) children. In these children, the omission of breakfast alters brain function, particularly in the speed and accuracy of information retrieval in working memory. Although no definitive conclusions are yet justified, the evidence suggests that working memory in well-nourished children is sensitive to the effects of an overnight and morning fast. If this suggestion were to be confirmed, it would have strong implications for the role of nutrition intervention in school settings - not only for developing societies but also for the industrialized world. In other words, the omission of breakfast would make a difference in the schooling process.

### 2.4.2. Long-Term Effects on Cognitive Functioning

Longer-term studies examine the effect of repeated episodes of breakfast omission on cognitive ability over a period of weeks or months. As such, these studies may be relevant for assessing the value of school meals programs (Papamandjaris, 2000). Research in less-developed countries has also upheld the long-term benefits of School Breakfast Programme (SBP) on cognitive performance.
Children participating in a breakfast program at a farm school in South Africa demonstrated improvements in short-term memory tasks, class participation and positive peer interaction over a one year period (Richter, Rose, & Griesel, 1997). A review of studies (Dani, Burrill & Demmig-Adams, 2005) to examine long term effect of nutrition on mental functions of children concluded that consumption of breakfast has positive impacts on child’s learning capability and behaviour. A randomized trial on the effects of a SBP in Jamaica revealed that students receiving a full breakfast over the school year demonstrated improvements in attendance and nutritional status (Powell, Walker, Chang, & Grantham, 1998). Younger children participating in the study also demonstrated improvements in their mathematical ability. Another study conducted in Jamaica reported higher attendance rates and mathematical ability among students receiving breakfast over a one month period (Simeon, 1998).

Several studies have examined the impact of the US SBP, a legislated national program to reduce child hunger, on cognition and classroom performance. Results are typically from elementary schools. In Massachusetts, the introduction of the SBP positively impacted the academic performance of low-income school children (Meyers, Sampson, Weitzman, Rogers, & Kayne, 1989). In Minnesota, conversion of the targeted SBP available to needy children to a universal SBP available to all children resulted in an increase in composite math and reading percentile scores over a three year period (MDCFL, 1998).

In Pennsylvania and Maryland, participation in the SBP, both targeted and universal, was associated with improved academic and social functioning (Murphy, Pagano, Nachmani, Sperling, Kane, & Kleinman, 1998). Additionally, increased Participation in the SBP over time was associated with significant increases in these areas. In Washington State, serving a school breakfast to high school students resulted in increased capacity of the students to perform assigned tasks (Bro, Shank, Williams, & McLaughlin, 1994).

Researchers (Pollitt et.al., 1995) in Guatemala examined the cognitive performance of children who had received either a low-protein/low-energy supplement or a high-energy/high-protein supplement for the first two years of life at least ten years following cessation of supplement delivery. Subjects who had received the higher energy supplement performed significantly better on assessments
of cognition. Pollitt (1995) argues that the availability of meals programs in schools throughout the academic year increases the probability that children will eat breakfast and improve their educational status. In a slightly different type of study (Pollitt, Jacoby, & Cueto, 1998) in Peru, students receiving breakfast over a one month period demonstrated improvements in attendance and vocabulary.

Although most of the evaluations have generally upheld the value of the SBP, caution needs to be exercised in generalizing these results to broader populations given that the SBP operates primarily in economically disadvantaged areas. It must also be recognized that non-participation in the SBP is not equivalent to breakfast omission. The observed improvements in academic performance and social functioning indicate that the SBP has helped American children regardless of the factors contributing to its effectiveness (Pollitt & Matthews, 1998).

2.4.3. Effects of Nutritional Status

Much of the research examining the effects of breakfast on cognition has been done by comparing the effects on adequately nourished versus malnourished children. In Jamaica, studies have illustrated the differential effects of breakfast omission on adequately nourished versus malnourished children. In three studies, the cognitive performance of undernourished and at risk children was negatively affected by the omission of breakfast, whereas the performance of the well-nourished controls was not affected (Chandler et al., 1995). Research on Peruvian school children from poverty stricken areas has demonstrated similar results. Nutritionally at-risk boys from poverty stricken centres were more adversely affected by breakfast omission as compared to their not-at-risk counterparts in tests of discrimination and short-term memory (Cueto, Jacoby, & Pollitt, 1998).

Many of the researchers reporting these results cautioned against making direct inferences to populations that do not have the same characteristics of under-nourishment. The performance of the undernourished children on the verbal fluency test improved when they were given breakfast, whereas that of the adequately nourished children did not (Chandler, Walker, Connolly, & Grantham, 1995). In brief, the performance of undernourished children was adversely affected by skipping breakfast on the tests of cognition, discrimination, short term memory and verbal fluency while no change in performance was observed for well nourished children when they skipped their breakfast.
2.5. The Role of Nutrition Education

Because children spend a large amount of time in educational environments, schools have been identified as key venues for the implementation of nutrition intervention programs (Mullen & Shield, 2004). There is some evidence that nutrition education programs that contain only school-based components can be effective in improving health knowledge. For example, The Shape It Up program, which promotes healthy eating and exercise at school, has been presented to almost 90,000 elementary students in over 257 New Jersey schools. This program teaches children about the food pyramid, the importance of eating fruits and vegetables, the benefits of drinking milk and water, and how to keep a healthy heart. These workshops significantly improved children’s responses to a health knowledge questionnaire (Jan et al., 2009). This suggests that targeting the school-based setting may be sufficient to increase nutrition knowledge; however, this type of program is not always successful at increasing consumption of healthy foods.

A seven-week program addressing healthy food choices and the importance of physical activity through informational handouts and motivational posters resulted in a significant improvement in nutrition knowledge, compared to a no intervention control group (Minnerath, 2009). Children who participated in a three-year school-based nutrition education program that encouraged healthy eating through increased awareness of healthy food choices in multiple settings (home, school, etc.), made healthier food choices (Ellis, 2008). In addition, Ellis (2008) reported that the children who took part in this nutrition program had an overall decrease in body mass indices. The effectiveness of changing eating behavior over time raises the possibility that longer nutrition education programs may produce better behavioral outcomes.

Wardle and Huon (2000) found that while nutrition education encouraged consumers to make healthier choices in general, children did not always consider healthy food desirable. When told a particular beverage was healthy, children were less likely to consume it and less inclined to ask their parents to buy it in the future, compared to the same drink without the healthy label. These findings are consistent with recommendations that nutrition education should not only inform children about healthy choices, but also encourage more positive perceptions of nutritious and healthy foods (Douglas, 1998).
Seaman and Kirk (1995) have argued that traditional methods of nutrition education that capitalize on memorization and regurgitation of facts may be tedious and ineffective, whereas interactive and practical nutrition education, involving hands on learning, such as cooking classes or computer-based methods (McCullough, 2004), tend to be more effective in promoting a positive behavioral change in children. Of these, the best-known and publicized programs have been those initiated by the USDA.

The Team Nutrition program, which was established by the Food and Nutrition Service of the USDA in 2002, is a multifaceted program that provides nutrition education to both children and parents, offers support for food services at schools, and promotes healthy eating and physical activity (USDA, 2009). Because pilot testing demonstrated that behavioral changes are more marked when multiple channels of communication are employed, this program involves a wide variety of media, such as computer games, colorful posters, and interactive online worksheet materials that are catered towards children and their parents. This suggests that programs that provide children with a variety of messages about healthy eating in both the home and school environment may be more effective in improving eating habits. However, specific behavioral outcomes from this study have not yet been measured. Based on the successful implementation of this program, the USDA has initiated other similar programs such as the “Eat Smart. Play Hard.TM” program, which provides families with the resources necessary to continue nutrition education in the home environment. Current research suggests that these modes of education are feasible with sufficient support and cooperation among staff and site leaders (USDA, 2009). However, the effectiveness of this particular school-home based program has not yet been evaluated.

Not all comprehensive nutrition education programs that focus on providing messages about healthy eating across the home and school environments have demonstrated behavioral change. For example, one such program, which was based on the “5-A-Day” fruit and vegetable campaign, entailed bi-weekly lessons encouraging fruit and vegetable consumption. In addition to the classroom education component, students identified fruits and vegetables in their lunch, and trained monitors reported whether students consumed these foods. Finally, parents were sent
nutritional information and cookbooks to facilitate healthy eating at home. The researchers reported a positive impact on nutrition knowledge, but moderate and variable results for eating behavior changes (Blom-Hoffman, Kelleher, Power & Leff, 2004).

The lack of specific formalized exposure to fruits and vegetables as part of the program limited actual eating behavior modification. Because research has often supported repeated exposure as an effective method for increasing children’s consumption and reducing food neophobia (Gerrish & Mennella, 2001; Pliner, 1982; Wardle, Herrara, Cooke & Gibson, 2003), some programs have incorporated exposure-based interventions. For example, Reverdy et al., 2008 found that nutrition education that encourages novel healthy food consumption and provides the opportunity to taste novel foods, decreased neophobia in children aged 8-10 compared to age-matched controls. This research illustrates that the combination of information and exposure-based education can effectively enhance children’s liking and acceptance of healthy foods.

2.6. An overview about optimized products using Response Surface Methodology (RSM)

Response surface methodology (RSM) is a statistical technique that has been successfully applied in the development and optimization of cereal products (Ylimaki et al., 1988; Toufeili et al., 1994; Gallagher et al., 2003b). Response surface methodology (RSM) is an effective tool for optimizing industrial food processes and ingredient combinations (Hu, 1999). It relates product properties by using regression equations that describe interrelations between input variables and product properties.

In RSM, several factors are simultaneously varied. The multivariate approach reduces the number of experiments, improves statistical interpretation possibilities, and evaluates the relative significance of several affecting factors even in the presence of complex interactions. It is employed for multiple regression analysis using quantitative data obtained from properly designed experiments to solve multivariable equations simultaneously. There are several work has been carried out on optimization of vegetables by RSM method (Uddin et al., 2004, Corzo et al., 2004 and Eren et al., 2007; Singh et al., 2007 and Singh et al., 2008).
The RSM is important in designing, formulating, developing, and analyzing new scientific studying and products. It is also efficient in the improvement of existing studies and products. The most common applications of RSM are in Industrial, Biological and Clinical Science, Social Science, Food Science, and Physical and Engineering Sciences. Since RSM has an extensive application in the real-world, it is also important to know how and where Response Surface Methodology started in the history. According to Hill and Hunter, RSM method was introduced by G.E.P. Box and K.B. Wilson in 1951 (Wikipedia 2010).

Box and Wilson suggested to use a first-degree polynomial model to approximate the response variable. They acknowledged that this model is only an approximation, not accurate, but such a model is easy to estimate and apply, even when little is known about the process. Moreover, Mead and Pike stated origin of RSM starts 1930s with use of Response Curves (Myers, Khuri, and Carter 1989).

Oktem et al. (2005) used response surface methodology with a developed genetic algorithm (GA) in the optimization of cutting conditions for surface roughness. S. Sharif et al. (2006) used factorial design coupled with response surface methodology in developing the surface roughness model in relation to the primary machining variables such as cutting speed, feed, and radial rake angle.

Hussain et al., (2011) found the optimized effect of germination temperature and time on concentration of phytic acid and tannin wheat and mungbean seed. The effect of germination temperature and time on phytic acid and tannin were analyzed by using the Response Surface Methodology. The minimum optimal values from multiple response optimizations were 379.9 and 481.9 mg/100 g phytic acid content for wheat and mungbean seeds, 295.7 and 395.8 tannin content for wheat and mungbean seeds respectively. It was concluded that germination of seeds significantly decreased phytic acid and tannin content in wheat and mungbean.

Asare et al., (2004) worked in response surface methodology (with central composite rotatable design) to investigate the product properties of extruded rice-cowpea-groundnut blends in a single screw extruder. The combined effect of cowpea
(0-20%), groundnut (0-10%), and feed moisture (14-48%) levels were used for formulation of the products. The models developed suggested that the optimal process variables for the production of a puffed snack with an enhanced nutrition and spongy structure from a rice-cowpea-groundnut blend are low feed moisture of 14-20% and maximum additions of 20% cowpea and 10% groundnut. A lack-of-fit test showed no significance, indicating that the models adequately fitted the data.

Junsoo et.al., (2002) Response Surface Methodology (RSM) was applied to optimize the extraction procedure for the determination of vitamin E in tomato and broccoli samples. The effects of varying the amount of 60% potassium hydroxide (KOH), saponification time, and final ethanol concentration (EtOH) on the tocopherol contents were evaluated to optimize extraction and saponification steps by RSM. The optimized parameters were obtained by ridge analysis. Based on the ridge analysis, optimum conditions found were: ml 60% KOH, 8.4–8.9; saponification time (min), 50.7–54.3 at 70°C; and %EtOH, 30.1–35.0. Under the optimized conditions, the experimental values agreed with values predicted by ridge analysis. The analytical method validation parameters such as accuracy, precision, limit of detection, limit of quantification, and specificity were calculated to ensure the method's validity.

Andrikopoulos et.al., (1991) found the optimum conditions for the extraction of crude phenolics from whole grain and bran of soft and hard wheat were determined using Response Surface Methodology (RSM). A second-order polynomial model was used for predicting the response. Regression analysis showed that more than 89% of the variation was explained by the models. Canonical analysis of surface responses revealed that the stationary surface was a saddle. The optimal conditions for the TAA obtained using ridge analysis were 54%, 61 °C, 64 min and 49%, 64 °C, 60 min, for whole grain and bran of soft wheat, respectively. Under the optimum conditions the corresponding predicted response values for TAA were 56.5 and 63 TE. The crude phenolics were extracted under optimum conditions to check the validity of the model. The experimental values agreed with those predicted, thus indicating suitability of the model employed and the success of RSM in optimizing the extraction conditions.
Bennion & Bamford et.al., (1997) investigate the optimum formulation for production of a Malaysian traditional baked cassava cake was determined using Response Surface Methodology (RSM). Effects of amount of ingredients such as sugar (10–30%) and coconut milk (15–35%) on the textural characteristics (hardness and chewiness) and sensory qualities (colour, firmness, cassava flavour and overall acceptability) of cakes were investigated. The coefficients of determination, $R^2$ of all the response variables were higher than 0.8. Based on the response surface and superimposed plots, the basic formulation for production of Malaysian traditional baked cassava cake with desired sensory quality was obtained by incorporating with 25% of sugar and 20% of coconut milk.