Laundering in Cold Water: Detergent Considerations for Consumers

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The effectiveness (ability to whiten) of six consumer laundry detergents, three powders and three liquids, was tested using a standard procedure. Assessment of each detergent’s ability to clean (ability to remove stain, thus whiten) a standard soiled cloth in six different cold water samples was evaluated. Two of the detergents, one powder and one liquid, are new laundry products designed to function in cold water. Results were based on a standardized procedure using launder-meter treatment and reflectance colorimeter testing. Although no one detergent was very effective in whitening, the differences in the detergents were significant when compared to the original standard soiled cloth. In addition, when laundering this particular standard soiled cloth (carbon black/olive oil) in cold water, neither of the new cold water detergents were better at cleaning (whitening) the samples than the detergents without bleach or the bleach-containing detergents, and in fact, the powdered detergent with bleach performed the best in each of the tests in this study. The liquid detergent with bleach was best in comparison to other liquid detergents in only half of the tests performed.

Keywords: laundry; detergent; cold water detergents; soils; stains; standardized methods

INTRODUCTION

In almost every household in the developed world laundry detergents are used. This has resulted in the production and sale of detergents becoming an important industry. In any supermarket or shop, consumers can find many different brands of detergents, and each typically claims to have a number of special qualities. Many detergents today come in smaller packages with more concentrated formulations, meaning these packages are lightweight and easy to carry and the detergent can be used in smaller amounts (Laundry Detergent, 2007).

Although the consumer laundry detergents perform the same basic function, formulations are many and varied (Ainsworth, 1994). Today, laundry detergents may contain any number of ingredients designed to enhance the laundry process. However, laundry detergents typically contain two major ingredients, a surfactant and a builder. Surfactants (surface active agents) improve the wetting ability of water, loosen and remove soil, and emulsify, solubilize, or suspend soils in the wash (Ainsworth, 1994). Surfactants are made up of a water soluble (hydrophilic) and a water insoluble (hydrophobic) component. The hydrophilic component of a surfactant is attracted to the water molecules—there is very little attraction between the hydrophobe and the water. This results in the surfactant molecules aligning at the surface and internally so that the hydrophile is toward the water and the hydrophobe is squeezed away from the water. This internal group of surfactant molecules is called a micelle (Surfactants, 2006). Because surfactants orient...
Surfactants form micelles they can absorb solids, liquids, or gases (i.e., soil, oil, or grease). The hydrophilic ends of the molecules are oriented toward the water phase, whereas the hydrophobic ends are oriented toward the soil. Surfactants form a protective coating around the suspended soil allowing the soil to be removed from the textile (Surfactants, 2006).

The major types of surfactants used in laundry detergents on a worldwide basis are anionic, cationic, and nonionic (Ainsworth, 1994; Kirschner, 1998; McCoy, 2005). In the United States, anionic surfactants (McCoy, 2005; Morse, 1999) along with nonionics (McCoy, 2005) are the most common type found in cleaning products. Anionic surfactants are typified by the use of linear alkylbenzene sulfonates (McCoy, 2005) or linear alcohol sulfates (McCoy, 2003), whereas nonionics are typified by alcohol ethoxylates (McCoy, 2005).

Builders, the other major ingredient in consumer laundry detergents, reduce water hardness (Kirschner, 1998) by combining with divalent calcium and magnesium ions, making them less available and thus prohibiting their interference with the surfactant action (Rutkowski, 1981). Builders are used to enhance the detergent action. Most builders also provide a desirable level of alkalinity and help to suspend and disperse soils and prevent their redeposition (Ainsworth, 1994). Examples of builders used in laundry powders include sodium tripolyphosphate, sodium carbonate, sodium citrate, and zeolites (Kirschner, 1998).

Phosphate-based builders, commonly in use in consumer laundry detergents before 1990, are rarely used in the United States anymore (McCoy, 2000). By the mid to late 1990s laundry detergent makers in the United States had stopped using phosphates (Kirschner, 1997) because they have been blamed for causing eutrophication of lakes and other bodies of water. Many states have banned the use of phosphates in laundry detergents although there is no current federal restriction on phosphate usage (Kirschner, 1997). In addition, consumer laundry detergents contain many other additives, although of lesser importance to detergency, desirable for an acceptable product. Table 1 gives examples of additives that may be added to consumer laundry detergents and includes their purpose.

The quality of the water is important in the success or failure of the washing process. Water usually contains impurities; the most important from a laundering

<table>
<thead>
<tr>
<th>Additive</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiredeposition agents</td>
<td>Prevent loosened soil from redepositing onto cleaned laundry</td>
</tr>
<tr>
<td>Bleaches</td>
<td>Whiten, brighten, and help with soil and stain removal</td>
</tr>
<tr>
<td>Colorants</td>
<td>Lend individuality to products or dramatize a special additive</td>
</tr>
<tr>
<td>Enzymes</td>
<td>Catalyze breakdown of specific types of soils (e.g., grass, blood) so they can be removed by the detergent</td>
</tr>
<tr>
<td>Fabric softeners</td>
<td>Control static electricity and impart softness</td>
</tr>
<tr>
<td>Fluorescent whitening agents</td>
<td>Absorb ultraviolet light, convert it, and reemit as visible blue light to enhance whiteness and/or brightness</td>
</tr>
<tr>
<td>Fragrances</td>
<td>Mask odors, provide brand identity, and impart scent to laundered fabrics</td>
</tr>
<tr>
<td>Opacifiers</td>
<td>Provide for rich, creamy appearance with liquid detergents</td>
</tr>
<tr>
<td>Processing aids</td>
<td>Provide the product with the required physical properties for its intended end use</td>
</tr>
<tr>
<td>Suds control agents</td>
<td>Stabilize or suppress sudsing</td>
</tr>
</tbody>
</table>

perspective are compounds of magnesium and calcium that cause water to be hard. Water hardness can be classified as being temporary (bicarbonates) or permanent (sulfates and chlorides) (Trotman, 1984). Temporary hardness can be removed by boiling, whereas permanent hardness can be removed by using ion exchange resins (McCarthy & Byrne, 2006). The only pure water, absent of impurities, is created by distillation (McCarthy & Byrne, 2006). The effects of hard water are typically lime deposits on fabrics and the interior of the washing machine. These deposits may cause discoloration and/or abrasion of fabrics. A proportion of the United States has water of at least 100 ppm, where under 60 ppm is considered soft. As a result, to clean to a satisfactory standard, more detergent may be required (Munson, 1991).

Laundry detergents generally come in two forms: powders (including tablets) or liquids. Powdered laundry detergents can be classified in two ways: (a) heavy duty (all purpose) products that are suitable for all types of fabrics and (b) light duty products for delicates and baby clothes (Soap and Detergent Association, 1991). Concentrated detergents were introduced in the early 1990s. These laundry products, utilizing smaller containers, essentially emerged out of concerns for disposing of the container that gets the detergent to the consumer, therefore reducing waste (Greek, 1990; Thayer, 1993). In the 1990s, laundry powders were the predominant consumer laundry products and accounted for 60% of surfactants used in laundering applications (Greek, 1990; Morse, 1999). By 2006, market share had dropped to 25% (Novozymes, 2006).

Another development in laundry detergents was the introduction of better dissolving powders. These powders through the use of a natural organic acid actually effervesce slightly when placed in water. One of their primary advantages is that these detergents rinse more cleanly than do previous products that were more difficult to dissolve (Morse, 1999). This development came about because the largest complaint of consumers regarding powdered detergents was their lack of solubility, particularly in hard water (McCoy, 2003). J. Keith Grime of Procter & Gamble explained that “the perennial balancing act is between surfactant chain length, biodegradability, and solubility. With linear alcohol sulfate surfactants, longer chain length leads to higher surfactancy and performance, offset by low hardness tolerance and limited cold-water solubility” (McCoy, 2003, p. 17). This fact presents a problem with these types of detergents when laundering in cold water, a focus of this study.

In 1990 liquid laundry detergents were a fast growing segment of the market in the United States. By 1994 it was expected that heavy duty liquid detergents would account for greater than 40% of the detergent market (Greek, 1990). Growth in liquid laundry detergents was expected to occur because of increasing bans on the use of phosphates in detergent formulations. Thus, consumers were expected to shift to liquid detergents because they were perceived to give better performance than powdered detergents without phosphates (Greek, 1990). In fact, in the early 1990s in areas where phosphates were banned as builders, liquid detergents accounted for greater than 50% of all sales (Greek, 1991).

In 1992, concentrated liquids were introduced to the U.S. market. These super-concentrated liquids were considered to be the next step forward—a rival to the concentrated powdered detergents (Thayer, 1993). Liquid laundry detergent sales increased significantly in 1997 at the expense of powders (Kirschner, 1998). Consumers were finding that liquids were easier to use, dissolved better into
cooler wash water, and because of a manufacturers’ shift back to less concentrated detergent formulations pricing appeared more on par with that of laundry powders (Kirschner, 1998). The growth trend for liquids was such that the market was nearing a 50–50 split with powders (Kirschner, 1998). By 2004, significant changes had occurred in laundry detergent sales. Liquid laundry detergents now controlled 75% of the U.S. detergent market with sales more than $2.4 billion, compared to that of powdered detergent sales of $850 million (Laundry Daze, 2005).

Cold water detergents were reintroduced to the U.S. detergent market in 2005. These detergents, designed to work efficiently in cold water, also provide savings to consumers by reducing energy costs (McCoy, 2006). It is estimated that U.S. consumers can save approximately $63 per year by converting to washing in cold water versus that of warm water (Petkewich, 2005). As well as monetary savings, switching to washing in cold water has environmental benefits—the reduction of energy to heat the water, thus less greenhouse gas emissions (Switch to Cold, 2006).

Cold water detergents contain surfactants, enzymes, and builders much like other current detergents. The difference is, the cold water detergents have surfactant systems that are generally more hydrophobic than typical detergent systems to allow for the cleaning of grease and oil, which are going to be harder to remove in cold water (McCoy, 2006; Petkewich, 2005). These detergents have about 20% more active ingredients than a typical detergent, so they are estimated to cost a few more pennies per wash load (Petkewich, 2005).

The purpose of the project reported in this article was to evaluate the effectiveness of six consumer detergents used for home laundering, three powders and three liquids, in terms of how effectively they cleaned a standard soiled cloth in cold water and to determine if specially designed cold water detergents newly on the market were more effective than selected other detergents in this cleaning process. Six different samples of water of varying water hardness were used for laundering tests.

EXPERIMENTAL PROCEDURE

Water

Six different water samples were used for laundering tests. Deionized water was used as one sample. This water was obtained by passing normal tap water through an ion exchange water softener (Culligan) then a Barnstead ROpure Reverse Osmosis (RO) system. Water from the RO system was then used as feed-water for a Barnstead 4-module Deionization System. This produced Type I reagent grade water (18.2 Megaohm-cm).

Five other water samples were collected from town water supplies (unsoftened tap water) of five different rural communities. These samples were solicited by an e-mail sent over the county extension agent listserv asking agents to bring water for the study. Enough water was obtained (4 gallons) from each contributing community to carry out launder-ometer tests as well as to evaluate water quality in terms of water hardness. The hardness of each water sample was tested according to the method of Schwarzenbach (Milwidsky & Gabriel, 1982). Quadruplicate samples of each community’s water were analyzed.
Standard soiled fabric (58", 147 g/m²) was purchased for this study. A 65/35 polyester/cotton, artificially soiled test fabric (EMPA-104) was purchased from Testfabrics Incorporated, West Pittston, Penn. The standard soil applied to the fabric contained a common particulate/oil-based stain of carbon black/olive oil. The soil was applied all over the fabric. This fabric type was chosen because polyester/cotton blends are the most common blend used in textile applications (Advertising Specialty Institute, 2006). The polyester/cotton blend was also chosen because oil-based stains can be particularly difficult to remove from polyester because of the hydrophobic nature of this fiber.

Fabric samples were cut to 150mm × 125mm (6” × 5”) rectangles. These samples weighed 3.10 ± 0.05 g.

Detergents

Six detergents (purchased from a local supermarket) contained the ingredients listed in Table 2. Three powdered detergents (a powder not containing bleach, a powder containing a nonchlorine bleach, and a new cold water powder) and their corresponding liquid counterparts (a liquid not containing bleach, a liquid containing a nonchlorine bleach, and a new cold water liquid) were purchased.

Wash Solutions

Solutions of the detergents were made up 0.5% weight/volume (w/v) dilution (Cameron & Brown, 1995; Cameron, Brown, & Meyer, 1993). Most American Association of Textile Chemists and Colorists (AATCC) standards call for 66 g of detergent in an 18 ± 1 gallon water level washing machine, which is approximately a 0.1% w/v solution. A 0.5% solution was chosen to ensure enough detergent was present in each sample, including the harder water. In addition, anticipating the consumer would use the dispenser provided with the detergent, the researchers in this study investigated the concentration the w/v solution would be if the consumer used the measuring cups/scoops provided with the detergents. Using the measure provided would have resulted in a detergent concentration of 0.25% to 0.28% for the powdered detergents and 0.32% to 0.34% for the liquid detergents, well below the w/v of 0.5% used in the study of detergent effectiveness reported in this article.
Launder-Ometer Testing

Tests were carried out using a launder-ometer (Atlas Electric Devices Co.). Washing tests were performed for 15 minutes (Cameron & Brown, 1995) using water at 20 °C (68 °F). Most laundering tests (including ANSI/ISO 4319—surface active agents—detergents for washing fabrics—guide for comparative testing of performance) typically call for washing in a standard washing machine, which is not the method chosen for this study. The launder-ometer was selected as the means for agitation of the sample with the solution. The launder-ometer provides for an accelerated test procedure because agitation is continuous whereas in washing machines agitation is intermittent. Also, the launder-ometer tests were carried out so excessive amounts of water would not be required. The 15-minute washing time was selected after investigating the agitation time options on a domestic washer (General Electric). AATCC standards typically call for between 8 and 12 minutes of agitation depending on the wash cycle chosen.

Tests were carried out at room temperature (20 °C) as all water samples had equilibrated to this temperature. This temperature was within the temperature range established for cold water use for the multinational care label symbols (Textile Industry Affairs, 2005). This recommendation indicated a water temperature not to exceed 30 °C (85 °F) and should be between 60 °F and 85 °F (Textile Industry Affairs, 2005). Five samples were washed individually each in 100ml of wash solution. After washing, the samples were rinsed in cold running water and allowed to air dry.

Measurement of Whiteness Indices

Whiteness indices of the samples were determined and used as a measure of how clean the samples were. A higher whiteness index (WI) equals a cleaner sample.

Whiteness indices were measured using a reflectance colorimeter (Color Sphere—Byk Gardner) and calculated according to American Society for Testing and Materials (ASTM) E313 (ASTM, 2004). The whiteness index is defined as the reflectance difference (see footnote 1).

Eight measurements of whiteness index were taken on each sample (samples were repositioned for each measurement, with four measurements being taken on each side of the fabric), for a total of 40 measurements for each detergent type. To measure whiteness indices of the sample, the samples were folded in half and then in half again. The sample was then placed on the colorimeter, ensuring that the sample completely covered the 1-inch port. This procedure was repeated until all four quadrants on one side of the sample had been measured. The fabric was then turned over and the process repeated to yield the eight measurements on each sample. The higher the calculated whiteness index, the greater the whiteness with a perfect reflector, or perfect whiteness, having a WI = 100 (ASTM, 2004).1

Statistical Analysis

Statistical analysis was carried out using t tests to determine the significance of the effectiveness of the detergents as evidenced by change in whiteness. The level of significance for all statistical tests was p < .05.
RESULTS AND DISCUSSION

The ratings shown in Table 3 indicate the hardness of the water samples used in the study. One water sample had a low water hardness rating of 5 ppm, which would be comparable to that of the deionized water. This and the deionized water would be considered to be soft water. Two of the water samples had hardness ratings of 78 ppm and 89 ppm and would be moderately hard. The other two had 130 ppm and 145 ppm, and they would be considered to be hard (Munson, 1991).

Whiteness indices for the standard soiled sample tested in the six detergents in deionized water are shown in Table 4. All of the detergents cleaned (whitened) the samples to some extent, with all of the samples after washing being significantly different from the control sample (unwashed standard soiled sample). However, none of the detergents were successful at returning any of the samples to a white cloth; where the white index would be 100, the best index results after washing was 23.58 (International Fabricare Institute, 2002). Based on the results reported in Table 4, it is also evident that powdered detergents were significantly better than their liquid counterparts. Even though the powdered detergents may have solubility problems due to the cold wash temperature used in this study, they all yielded significantly “whiter” results than their liquid detergent counterparts. Liquid detergents, due to their nature, have the ability to dissolve equally well in any wash temperature (Cameron et al., 1993). However, even though liquid detergents can dissolve well in different wash temperatures, repeatedly they have been found to be not as effective as powdered detergents (Cameron et al., 1993; “Detergents,” 2003) in other laundry test procedures.

Table 5 indicates the whiteness index results for the soiled fabric samples washed in six different detergents in water of varying hardness. All of the samples, no matter which water used, were significantly different from the control sample, indicating that the detergents are having some effect on “cleaning” the samples. The samples washed in the 5 ppm water showed no significant difference to that of the samples washed in the deionized water.

Water hardness did influence the ability of the detergents to clean (whiten) the samples. From Table 5, it is evident for the powdered detergents that as the water hardness levels increase the whiteness indices decrease. In this study the concentration of detergent added to each soiled fabric sample was controlled to a fixed amount (0.5% w/v) and remained constant in each test, leading to results that the samples washed in the 5 ppm water were significantly whiter than those of the 78 and 89 ppm waters (moderately hard water), which in turn were significantly whiter than those samples washed in the 130 and 145 ppm waters (hard water).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Water Hardness</th>
<th>Hardness Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deionized water, resistivity 18.2 MOhms</td>
<td>Soft</td>
</tr>
<tr>
<td>2</td>
<td>5 ppm</td>
<td>Soft</td>
</tr>
<tr>
<td>3</td>
<td>78 ppm</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>4</td>
<td>89 ppm</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>5</td>
<td>130 ppm</td>
<td>Hard</td>
</tr>
<tr>
<td>6</td>
<td>145 ppm</td>
<td>Hard</td>
</tr>
</tbody>
</table>

TABLE 3: Water Hardness
Results of the tests using liquid detergents showed similar performance regardless of the water hardness. None of the liquid detergents performed as well as any of the powdered detergents throughout the tests in this study. However, consumers use liquid detergents for a variety of reasons. Some good reasons to choose liquid detergents are that they typically can dissolve equally well in most water conditions of temperature and hardness. In regard to water hardness, they are probably not affected as much as powdered detergents as they contain nonionic surfactants as an ingredient. These types of surfactants are affected less by water hardness because they contain no ionic groups that are capable of combining with the calcium and magnesium ions in hard water (Cameron & Brown, 1995). Anionic surfactants, those typically used in powdered detergents, can combine with these ions and form a scum that is not water soluble and may precipitate out of solution.

Detergents 3 and 6 are two newly released cold water detergents. These detergents are designed to work effectively in cold water conditions.

### TABLE 4: Whiteness Indices (Mean and Standard Deviation) of Six Consumer Laundry Detergents in Deionized (Soft) Water

<table>
<thead>
<tr>
<th>Detergent</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.24*</td>
<td>2.44</td>
</tr>
<tr>
<td>2</td>
<td>23.58*</td>
<td>3.07</td>
</tr>
<tr>
<td>3</td>
<td>21.78*</td>
<td>3.11</td>
</tr>
<tr>
<td>4</td>
<td>11.46*</td>
<td>1.50</td>
</tr>
<tr>
<td>5</td>
<td>13.80*</td>
<td>2.41</td>
</tr>
<tr>
<td>6</td>
<td>13.48*</td>
<td>2.24</td>
</tr>
</tbody>
</table>

NOTE: Whiteness Index Control (soiled test fabric) = 5.33.

*Significantly different ($p < .05$) from control.

#### TABLE 5: Whiteness Indices (Mean and Standard Deviation) of Six Consumer Laundry Detergents in Water Samples of Varying Hardness

<table>
<thead>
<tr>
<th>Detergent</th>
<th>5 ppm M</th>
<th>SD</th>
<th>78 ppm M</th>
<th>SD</th>
<th>89 ppm M</th>
<th>SD</th>
<th>130 ppm M</th>
<th>SD</th>
<th>145 ppm M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.83*</td>
<td>3.15</td>
<td>18.78*</td>
<td>2.96</td>
<td>19.08*</td>
<td>3.12</td>
<td>15.44*</td>
<td>1.90</td>
<td>15.87*</td>
<td>1.69</td>
</tr>
<tr>
<td>2</td>
<td>22.97*</td>
<td>2.87</td>
<td>21.38*</td>
<td>2.81</td>
<td>20.98*</td>
<td>2.82</td>
<td>17.63*</td>
<td>2.32</td>
<td>18.21*</td>
<td>2.11</td>
</tr>
<tr>
<td>3</td>
<td>21.98*</td>
<td>2.85</td>
<td>21.30*</td>
<td>3.20</td>
<td>20.54*</td>
<td>3.09</td>
<td>15.21*</td>
<td>2.30</td>
<td>16.04*</td>
<td>2.42</td>
</tr>
<tr>
<td>4</td>
<td>11.38*</td>
<td>2.33</td>
<td>11.78*</td>
<td>1.39</td>
<td>12.84*</td>
<td>2.40</td>
<td>12.00*</td>
<td>2.26</td>
<td>11.71*</td>
<td>2.27</td>
</tr>
<tr>
<td>5</td>
<td>13.00*</td>
<td>2.98</td>
<td>14.42*</td>
<td>2.47</td>
<td>14.29*</td>
<td>2.38</td>
<td>13.51*</td>
<td>2.16</td>
<td>12.91*</td>
<td>1.73</td>
</tr>
<tr>
<td>6</td>
<td>13.18*</td>
<td>2.99</td>
<td>13.73*</td>
<td>2.31</td>
<td>14.11*</td>
<td>1.43</td>
<td>13.51*</td>
<td>1.64</td>
<td>12.87*</td>
<td>1.42</td>
</tr>
</tbody>
</table>

NOTE: Whiteness Index Control (soiled test fabric) = 5.33.

*Significantly different ($p < .05$) than control.

a. Significantly different ($p < .05$) from deionized water wash.
b. Significantly different ($p < .05$) from corresponding powdered detergent (1, 4; 2, 5; 3, 6).c. Cold water detergent (Detergent 3) significantly different ($p < .05$) from powdered detergent containing bleach (Detergent 1).d. Cold water detergent (Detergent 6) significantly different ($p < .05$) from powdered detergent not containing bleach (Detergent 4).e. Cold water detergent (Detergent 3) significantly different ($p < .05$) from bleach-containing powdered detergent (Detergent 2).f. Cold water detergent (Detergent 6) significantly different ($p < .05$) from bleach-containing liquid detergent (Detergent 5).
powders and liquids, are generally designed to work in warm water (around 90 °F, 32 °C) (Petkewich, 2005). The industry standard used for very cold water is 60 °F (16 °C) (Petkewich, 2005) (this study used water at room temperature—68 °F, 20 °C).

The results in Tables 4 and 5 indicate that in relation to the standard soiled cloth used in this study, there does not appear to be any advantage to using the cold water detergents compared to the other detergents types tested. Considering all six water samples and Detergents 1 and 3, it appears that the cold water detergent (Detergent 3) gave slightly higher whiteness indices than the regular detergent with no bleach (Detergent 1) in half of the cases. In only one of these cases however (78 ppm water) was the result significant in that the whiteness index achieved using the cold water powdered detergent was significantly whiter than the sample washed in the powdered detergent without bleach. With the liquid detergents (specifically Detergents 4 and 6), in five of the six cases, the cold water liquid gave significantly whiter results than the liquid without bleach. In the sixth case, the results were better for the cold water liquid detergent than for the liquid without bleach, but the difference was not significant; that was the sample using hard water (145 ppm).

Comparing the powdered cold water detergent to the bleach-containing detergent, in half of the cases, the bleach-containing detergent (Detergent 2) gave significantly whiter results. In both of the hard water detergent sample cases the bleach-containing powdered detergent was significantly better at producing whiter samples than the cold water detergent. However, samples washed in the liquid detergent containing bleach were not significantly different than those washed in the liquid detergent especially made for a cold water wash.

CONCLUSIONS

Water hardness and detergents were the variables in this study. The results of the launder-ometer agitation tests analyzed by the reflectance colorimeter indicated that no one detergent product showed significant results across water hardness samples. However, the research in this study found that the powdered detergents cleaned better than liquid detergents overall. Although as water hardness increased the effectiveness of the powdered detergents decreased, they nevertheless continued to perform better at cleaning the standard soiled cloth than their liquid detergent counterparts did.

Because of the inverse relationship with powdered detergents, consumers are advised to increase the amount of detergent placed in the washer in proportion to the hardness of the water and the size of the load. It was also clearly evident that using this particular standard soiled cloth (carbon black/olive oil) that the cold water detergents were no better at cleaning (whitening) the samples than either the detergents without bleach or the detergents containing a nonchlorine bleach in cold water. This would imply that if consumers were to consider laundering in cold water then it is not necessary to purchase a specially formulated detergent. However, it should be noted that the standard soiled fabric used in this study was heavily soiled as evidenced by its initial whiteness index (5.33 on a 100-point scale). Cold water detergents may yield improved results if the textiles are not as heavily soiled or if a prewash treatment is used. This study was not designed to answer these questions.

Obendorf (as cited in Petkewich, 2005) raised two concerns about the use of cold water in laundry and the use of cold water detergents. Cold water is whatever
runs from the tap. In many areas of the country this can be extremely cold—approaching that of freezing in winter months. Also, textiles washed in cold water may actually come out “dirtier” than before due to the redeposition of live microbes (Petkewich, 2005). It has been suggested and it bears repeating here that heavily soiled items be washed in hot water even if in the future cold water detergent formulations address the problems mentioned (Petkewich, 2005). Washing in hot water will in most cases yield better results from a detergency standpoint for a number of reasons. First, most soil substances will dissolve more readily the higher the temperature. Second, soils are more easily suspended or emulsified in warmer water, which makes them easier to remove from soiled surfaces (Cameron & Brown, 1995).

Hardin (as cited in Petkewich, 2005) also was concerned about cold water washes. Textiles are always going to clean better with increasing temperature—this is particularly true if the transference of bacterial or viral illnesses is of concern within a household. However, he acknowledged that compared to generations ago, we do not typically get clothes as dirty as we used to, so for washing lightly soiled items these types of detergents will probably be fine (Petkewich, 2005).

Cold water detergents came about because people were requesting this type of laundering, and there is no doubt that laundering in cold water has the benefit of potential savings in energy costs. It is predicted that a typical consumer may save up to $63 per year by switching to cold water from warm water assuming seven loads of laundry per week and a water heater set at 140 °F (60 °C) (Petkewich, 2005). If consumers have water heaters set at a lower temperature (120 °F, 49 °C) then the savings would most likely be lower. It is also anticipated that these types of detergents may have more of an impact in Europe where consumers tend to wash only in hot water. Nielson stated that “in Europe, the consumption of energy for laundry washing is equivalent to [the energy produced by] 10 midsized nuclear power plants” (as cited in McCoy, 2006, p. 17). Thus, there is the potential for great savings in reducing wash temperatures from 40 °C to 60 °C (those typically used in Europe) to 20 °C (Nielson as cited in McCoy, 2006). Also, in Europe, washing machines typically have electrical heating elements to heat the wash bath, as their washing machines only have cold water inlets and therefore heat the water to the desired wash temperature as needed. This would also mean that the energy consumption of the home water heater is not part of the cost to do laundry because of the separate heating elements contained within the washer.

The reason for these differences is that most washing machines in Europe are front loading (90%) and these machines rely on electrical heaters to bring the water to the desired wash temperature. In contrast, front loading machines account for only about 5% of the U.S. domestic market. Also, energy consumption of front loading machines in terms of water (40% to 60%) and energy (30% to 70%) is typically much less than a top loading machine (Washing Machines, 2007).

Further research in evaluating laundering in cold water needs to be conducted. This study evaluated the effectiveness of two types of detergent in six different water types, using one type of standard soiled fabric. To gain a better understanding of the effectiveness of laundering in cold water, other types of soiled fabrics need to be evaluated. Other standard soiled fabrics are available and should be tested because some stains are often more difficult to remove than others. Available soiled fabrics include samples such as cotton soiled with blood, cocoa, red wine, or a combination of blood/milk/ink and polyester/cotton soiled with blood/milk/ink.
addition, other detergents should also be tested, perhaps by using consistent water hardness in one study and varied hardness in another study. Also, a study or studies to compare the results of laundry tests conducted using Standards of ANSI or AATCC with the use of standard procedures that do not use the same procedures, such as using a launder-ometer rather than using an intact washing machine, may be conducted to assess the effectiveness of various methods of testing and assessment.

Although it is unlikely that there is a “best” or “worst” detergent, it would be beneficial to know more about how to make decisions regarding which laundry detergent to select for which purpose; similarly, which ones to recommend and which ones to avoid and which ones work as well at a moderate price as those with the super price tag. No positive significant differences in performance were found in washing with the new cold water detergents tested compared with liquid and powdered detergents currently on the market. Therefore, the consumer can feel confident in saving money and doing laundry in cold water using his or her current detergent if the textiles are not heavily soiled or if they have not been exposed to some bacterial or viral contaminant that would threaten the wearer’s health if not removed.

Extension educators and teachers need the assistance provided by this research and the research suggested for further study to advise their students and other people with whom they work on consumer issues. They need evidence to provide consumers that can help them choose between certain types of laundry detergent, depending on such information as not only the water hardness but also the conditions unique to each family or individual such as the ages of the family members, the activities/work of those family members, and where they live.

Note

1. $\text{WI} = Y + (\text{WI}_x)(x_n - x) + (\text{WI}_y)(y_n - y)$

where $Y$, $x$, $y$ are the luminance factor and the chromaticity coordinates of the specimen; $x_n$ and $y_n$ are the chromaticity coordinates of the Commission Internationale de l’Eclairage standard illuminant and source used; and $\text{WI}_x$ and $\text{WI}_y$ are numerical coefficients.

REFERENCES

Detergents—Wash day winners. (2003). Consumer Reports, 68(8), 42.
McCoy, M. (2000). Soap and detergents: If a box or bottle of laundry detergent says new or improved on the label, chances are that a chemical company had a role bringing it to market. Chemical and Engineering News, 81(3), 37-52.