The cleaning effect of soap nuts, laundry balls, washing pellets and laundry magnets has been tested and compared with washing with conventional compact powder detergent for coloured textiles, and washing with water only. The cleaning effect was evaluated by measuring the tristimulus Y reflection values of pre-soiled fabric strips after they were washed according to standard EN 60456 at 40°C. The results showed that the cleaning effect of the four alternative laundry products was equal to that of water alone. Conventional compact detergent showed significantly better cleaning effect at all tested soil types. However, the results also indicate that water alone already has a substantial cleaning effect.

INTRODUCTION

Washing of textiles has major environmental impacts as energy, water and different chemicals are used. Several Life Cycle Assessment (LCA) studies demonstrate that use phase of detergents, washing machines as well as clothing dominate the environmental contribution [1-4]. Therefore, any improvements in the laundry process such as reducing washing temperature, filling the washing machine to its full capacity, correct detergent dosing, less frequent washing and avoiding tumble drying can reduce the environmental effects of laundering (5). Compact detergents are environmentally preferable compared to the traditional detergents due to lower use of chemicals as well as advantages in transportation, packaging and storage needs [6]. The benefits include reductions in aquatic toxicity, eutrophication, ozone depletion and photochemical smog (1). The detergent industry is also working to increase sustainability by using less harmful chemicals and more bio-based, readily degradable ingredients (7). New alternatives to conventional laundry detergents have merged into the market, including soap nuts, laundry balls and laundry magnets, to mention some. The producers of these products make bold marketing claims but the documentation of washing effects are often lacking data and very few scientific studies can be found. Pusic et al have tested primary- and secondary washing effect of the laundry ball (Biowashball®)(8). This type of laundry ball contains ceramic balls in a perforated silicone shell. Primary washing effects are a measure for soil- and stain removal and colour change. Secondary washing effects are the degree of whiteness, ash content, and decrease in breaking strength. The laundry ball was tested by its own at 40°C and with 1/5 regular detergent in the wash, as recommended for very soiled textiles by the producer. Secondary effects were compared with unwashed samples. Pusic et al. showed that laundering with ceramic balls showed stain reducing effect on egg yolk, shoe polish and ketchup, but did not remove red wine stains. The soil removal efficiency was increased on average by 35 %, varying from 3-66 % depending on the soil and fabric type, when adding 1/5 of regular detergent to wash. Results also showed a slight reduction in breaking force after repeated laundering up to 25 cycles. There was no increase in ash content although washing in hard water (22°dH) and the degree of whiteness was not improved (8). Unfortunately, this test only included one product type, and the washing effects were not compared to that of regular detergents or of water alone. Therefore, it is uncertain to which degree the cleaning effect is a result of the laundry ball or of water alone.
Bruce and Thulin tested three different laundry balls according to Nordic eco-labelling criteria for detergents (9) at 40°C, and showed that none of them met the criteria for cleaning effect [10]. The cleaning results of the washing balls were closer to results with only water than washing with standardised reference detergent. Their study did not include soap nuts or laundry magnets, and did not compare laundry balls with regular detergents. As this brief literature review demonstrates, only a few studies have investigated the efficiency of so-called eco-friendly alternative laundry products and compared to the use of conventional detergents and water alone. Therefore, in our test we have compared the cleaning effect of four alternative laundry products with water and a marked leading compact powder detergent for coloured textiles.

EXPERIMENT

The test method for evaluating of cleanliness is partially based on the European standard EN 60456:2005:“Clothes washing machines for household use – Methods for measuring the performance” [11]. Standardised artificially soiled cotton fabric test strips were washed with ballast in domestic washing machines under laboratory conditions. The combined wash test strip consists of five cotton cuts (15x15 cm) joined together into a strip carrying different types of artificial soil: unsoiled, carbon black/mineral oil, blood, cocoa and red wine. The cleaning effect was evaluated by measuring the reflectance value called tristimulus value Y of the washed test strips with a spectrophotometer [12]. Every washed piece was measured twice on both sides. The average reflectance value for each soil type is given as the mean value of the readings for each of the soiled test pieces used in the test.

Laundry products and dosages

Figure 1 shows the products we have tested. The dosages are based on the instructions given on the packages for normally soiled laundry and soft water with hardness of below 1 °dH. Numbered codes for soil swatches were used during the test. When presenting the products, we use the information given by the producers.

Laundry balls are plastic balls that contain small washing pellets inside. Their content is claimed to be non-toxic and hypoallergenic, and includes “higher alkyl sulphate, non-ionic surfactant, sodium metasilicate, calcium carbonate, sodium carbonate, sodium tripolyphosphate, and cellulose gum”. The package comes with a refill that should add another 250 washing cycles. In addition, a tube with stain remover is included. Three laundry balls are to be placed on top of the load in washing drum, and one should not exceed ¾ of filling load of machine to allow the balls to circulate freely. Laundry balls can be used in temperatures between 30°C and 60°C. The selected washing program should not have reduced amount of water, and the washing time should be around 30 minutes. The rinse cycle can be left out. Usually all three balls are to be placed in laundry, but for loads below 2 kg, two laundry balls are sufficient. The producer claims that the laundry balls are to be anti-bacterial, because they raise the water pH above 10. The package claims that the washing effect has been tested to last up to 750 washes, but no reference to the test report is given.

Soap nuts are nutshell that contain saponin, a kind of natural soap (surfactant). They can be used in temperatures between 30°C and 90°C. Four to six half nuts (6-8 g) are to be placed in a cotton bag and washed with the laundry. The instruction state that nuts could be used twice when washed at 30°C - 60°C. We used new nuts in every wash in the test. A colour change from brown to black should indicate that all saponin had been exhausted. As soap nuts do not contain bleaching chemicals, the producer advices to use a natural bleaching agent every third to fourth white laundry load in order to prevent greying of textiles. Difficult stains should be pre-treated with gall soap or some other form of natural stain remover. The nuts are claimed to clean laundry in a natural way without leaving any chemical residues in the textiles.

Washing pellets is a polyamide 6 washing bag with zipper, in aluminium- zinc alloy, containing small washing pellets inside. The pellets have three different colours: yellow, green and dark purple and contains; sodium alkyl sulphate, non ionic surfactant (from coconut oil), disodium disilicate (Na2O5Si2), ligands, pH-regulating agents, water and perfume. All ingredients are claimed to be easily biodegradable and have no known negative ecological effects. The bag is placed in the middle of the laundry, and can be used up to 50 washes when used in a 35 minutes washing cycle. It can be used in temperatures between 30°C and 95°C. It is suitable for all kinds of textiles, but is claimed to work best for cotton. The bags are to be re- filled when the content is reduced to about half. It is claimed to function by creating a reaction in the water with the help of minerals that increase the pH value and activate the water molecules. This in turn should increase the waters natural dissolving effect in cleaning textiles. It does not contain any allergenic substances, and it is antibacterial. The producer claims that the washing pellets clean as well as 30-40 grams of regular detergent of 3-4 kg of textiles, and with less soiled textiles, it should wash up to 5 kg load. The product information states that it has been tested, but no reference to the report can be found.

Laundry magnets are a set of two plastic coated magnets that are placed inside of the washing machine drum on opposite sides. The magnets have lifetime warranty and are guaranteed to perform as long as they are owned, and used according to the instructions. They can be used with all temperatures and washing programs, but hot setting is...
recommend as it has been shown to achieve best results. The producer claims that the product is independently tested and proven and has two patents, but no reference to the test report is given.

**Regular detergent** is a compact powder detergent for coloured textiles for domestic use. The content is 15-30 % zeolite, 5-15 % non-ionic and anionic surfactants and less than 5 % soap, phosphonates, poly carboxylate and perfume. The dosage is 45 ml which corresponds to 43.95g as recommended by the producer for normally soiled laundry and soft water. The detergent is labelled with the official Nordic ecolabel, the Swan. The product information states that the surfactants are easily biodegradable and the powder is phosphate-free. The compact powder is claimed to be so effective that you will receive satisfactory clean laundering results all the way down to 30°C. If the washing temperature is adjusted down from 40°C to 30°C, you will save energy. For heavily soiled textiles or laundries that require hygienic wash, the producer recommends washing at a higher temperature.

**Water,** we used soft tap water with water hardness in between 0.5-0.8 °dH. This water type was used in all tests.

As the laundry pellets and laundry balls are supposed to tolerate a large number of washing cycles, respectively 50 and 750. These products were used in five washing cycles with ballast, but without soiling before the test started. This was done to get a more realistic picture of how these products function during normal use.

**Washing conditions**

We used three identical Miele W 307 domestic washing machines. These machines are labelled with European Union energy efficiency class A for washing performance and B for spin drying performance. The maximum capacity is 5 kg and the maximum spinning speed is 1400 rpm. We rotated the laundry between the washing machines, and rinsed the machines between each repetition.

Each laundry product was tested three times. A normal cotton washing program at 40 °C with two rinse cycles and no pre-wash was used. The total duration of this program is 116 minutes and it uses 45 litres of water per washing cycle. We decided to use regular washing program instead of short program recommended by some of the laundry product producers, because it is more common in use [11] and we wanted to have same washing conditions for all the tested products.

We used cotton ballast as given in standard EN 60456:2005 (12). It includes pre-washed cotton bed sheets, pillowcases and towels with a 3.5 kg total wash load. Test strips were attached to the towels. EMPA 105 standardised artificially soiled cotton fabric test strips were used. The soil types and their use areas are listed in Table 1. We added three pre-soiled test strips in every wash. This way, a total of nine swatches were used in the testing of each laundry product. The size of each soiled patch was 15 ´ 15 cm.

**Measurement of cleaning effect**

The cleaning effect was evaluated by measuring the reflection percentage of the soiled fabric strips after the wash [13]. The cleaner the swatches, the higher the reflection tristimulus value Y thus indicating better cleaning effect. The tristimulus value Y [14] was measured with a Minolta CM-3610d spectrophotometer with D65 illuminant, 10° observer and 25.4 mm measuring diameter. The UV filter was set to 420 nm which excludes the effect of optical brighteners. The reflectance measurement was carried out with four layers of the same washed soiled fabric type in order to avoid the transmission of light. Each piece was measured at four places, and as there were three test strips in each wash and three parallel wash cycles, the total number of measurements per soil type was 72. Based on the 72 measurements, the mean, standard deviation and 95 % confidence limits were calculated for each soil type [13].

**RESULTS**

The cleaning effect results of the compared laundry products and the effect of water alone are given in table 2. The tristimulus value Y results are given separately for each of the soil types. In addition, an average value as well as values for detergency (the average of Carbon black/ mineral oil and cocoa), bleach effect (red wine), and total enzyme activity (the average of blood and cocoa) is calculated. The comparison of average cleaning effect with 95% confidence limits is given in Figure 2.

In general the results show that the tested alternative laundry products have as good washing effect as water alone. The regular detergent shows the best cleaning effect in all measurements with the exception of the bleaching effect. However, none of the detergents in the test are meant to bleach textiles. The largest differences were observed in enzyme activity in removal of blood and cocoa. The results have good reproducibility of the three washing cycles for all agents and all types of soil, with one exception. The effect of the laundry balls when it comes to removal of blood was considerably worsened through the series of washes. According to the information given by the producer, the laundry balls are supposed to tolerate 750-
the washing pellets 50 laundering cycles. The products were weighed when received, after five pre-wash cycles and after the additional three test wash cycles. Both of these products foamed extensively during the five first pre-washing cycles. The warning light on the washing machine lighted up indicating too much foam and with recommendation to control the dosages. Both of these products lost a lot of weight during the eight washing cycles. The washing pellets lost 77%, whereas laundry balls lost 30% of their content. This indicates that there may not be much left to last washes in the claimed product durability, 50 or 750 cycles. Figure 3 shows the visual comparison of colour change of the soiled swatches. The differences between regular detergent and the alternatives are easy to observe with the naked eye. The test scope was limited to the testing of the primary washing effect. The secondary effects such as greying, fibre damages and calcareous deposits were not taken into account, neither the hygienic effect. As microbes often adhered to the soil, a measurement of the cleaning effect can give some slight indications of bacterial reduction. Many of the laundry products suggest using either stain removal or bleach in addition to the product itself. The use of these additional products would most likely have improved their washing result.

DISCUSSION AND CONCLUSIONS

Our results showed that the cleaning effect of the four alternative laundry products was equal to that of water alone. These results support partly the findings of Pusic et al. as well as Bruce and Thulin (8, 10). Conventional compact detergent showed significantly better cleaning effect at all tested soil types. The study also shows the importance of establishing a reference point by comparing the cleaning effect of detergents to that of water alone, as it has a substantial cleaning effect in itself. This also means that consumers that wash only slightly stained textiles could be satisfied with the washing result either without detergent, with an alternative laundry product, or with a reduced amount of regular detergents.

In addition to the technical aspects of laundry, social aspects and consumer behaviour has great potential to influence the environmental impacts (15, 16). Although the results showed that these products are not necessary supplements in the market, it is possible that replacing regular detergent with an alternative laundry product might be possible, as long as no other contradictory changes in laundry process are made and the consumers receive satisfactory clean laundering results of their only slightly soiled laundry. However, many of these laundry products suggest making changes in the laundering process that can increase water and/or energy consumption, such as only filling the machine ¾ of full capacity or using hot water. In that case, it is more likely that using regular detergent but at low temperature and at full capacity of the machine is the environmentally preferable alternative. Not getting the laundry satisfactory clean can lead to shortened textile lifecycles and thereby increased consumption and waste. Other alternatives to improve laundering system without replacing detergents, include detergent dosage systems that ensure correct dosing, improved textile care labelling, machine program selection (such as suggesting lower temperature and eco-program), machine filling grade indicators, and textile material choices that get easily clean (11).

For further studies, we suggest to test the effect of water hardness, as well as to evaluate the potential bacterial reduction and evaluating cleaning effect by other techniques in order to corroborate the obtained data. Such potential future study could also include content analysis and an evaluation of the chemicals used in such alternative products in order to evaluate whether they are less harmful to the environment than regular detergents.

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REFERENCES AND NOTES

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